GEORGIA INSTITUTE OF TECHNOLOGY
School of Mechanical Engineering
Atlanta, Georgia

SPACE RADIATOR SIMULATION

MANUAL FOR COMPUTER CODE

Contract No. NAS 9-10415

by
William Z. Black and Wolfgang Wulff

Sponsored by the
Power Generation Branch
Manned Spacecraft Center
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Houston, Texas

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FOREWORD

This report constitutes the Users Manual that accompanies the computer simulation of a space radiator system. It summarizes a two year project carried out by the School of Mechanical Engineering at the Georgia Institute of Technology, Atlanta, Georgia for the NASA Manned Spacecraft Center, Houston, Texas under Contract No. NAS 9-10415. The results of the analysis phase of the program are contained in a separate report entitled "Space Radiator Simulation - System Analysis". A third report submitted under this contract covers the development of a simplified system simulation and the initial phases of a system optimization procedure.

The contract was entitled "Study of Design Parameters of Space Base and Space Shuttle Heat Rejection Systems". The work was monitored by Dr. W. E. Simon of the Power Generation Branch of NASA MSC, Houston, Texas, and was carried out by Dr. W. Z. Black and Dr. W. Wulff as Co-Investigators and Mr. S. M. Morcos, Mr. S. L. Yao and Mr. R. M. Hinson graduate students in the School of Mechanical Engineering under the direction of Dr. S. P. Kezios. Mr. C. R. Caldarale of the Rich Electronic Computing Center also contributed to this report.

The Work carried out by Dr. W. Z. Black is reflected in Section B.2 a and b and Section B.3, d through f, of the Permanent Part of the program. The program units of the Selective part described in Section B.3 were completed by Mr. Morcos under the direction of the Co-Investigators.

Dr. Black is responsible for the coding of programs No. 14 through 22, for the supervision of coding programs No. 23 through 30 which was carried out by Mr. Caldarale and Mr. Hinson and for the supervision of coding programs No. 51 through 60 which was carried out by Mr. Morcos. Dr. W. Wulff is responsible for the general program structure described in Section B.1 and the program units described in the Sections B.3a through c and B.3g of the Permanent Part of the program. Dr. Wulff coded programs 1 through 7, 31 through 38 and 40 through 42 and supervised Mr. Yao in the coding of programs No. 8 through 13 and No. 39 and supervised Mr. Morcos in the coding of programs No. 43 through 50 and No. 61 and 62.

SUMMARY

This manual describes a computer program that simulates the performance of a space radiator. The program basically consists of a rigorous analysis which analyzes a symmetrical fin panel and an approximate analysis that predicts system characteristics for cases of non-symmetrical operation. The rigorous analysis accounts for both transient and steady state performance including aerodynamic and radiant heating of the radiator system. The approximate analysis considers only steady state operation with no aerodynamic heating.

The first section of this manual contains a description of the radiator system and instructions to the user for program operation. The input required for the execution of all program options is described. Several examples of program output are contained in this section. Sample output includes the radiator performance during ascent, reentry and orbit.

The second section of the user's manual describes the structure of the entire program as well as the function of each program unit. All interfaces between the various program units are described so that the user may remove a single unit or group of program units that have general utility for use in other analyses. This section concludes with a program listing.

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A. USERS INSTRUCTIONS

1. Program Objectives and Capabilities

The program units described in this manual constitute a transient heat transfer analysis of a space radiatior heat rejection system. The analysis is intended to simulate the radiator system of the space base and the space shuttle for conditions of arbitrarily prescribed combinations of aerodynamic heating and incident solar, earth albedo and planetary irradiation.

An exact analysis is performed for the radiator system consisting of equally spaced parallel coolant channels existing in one plane connected by plane fin panels of trapezoidal cross-section. The midplane between tubes and a parallel plane passing through the tube axis are assumed to be planes of symmetry for the purpose of the exact analysis. The program results are extended over the entire radiator panel on the basis of this symmetry.

An approximate analysis is used to extend the exact program simulation to cover the situation of the non-symmetrical radiator panel. This extension predicts on the assumption of one-dimensional analysis, the system performance when the radiator panel is curved and when the tubes are unequally spaced, non-symmetrically loaded or U-shaped.

The exact system analysis predicts both transient and steady-state, two-dimensional temperature profiles, local and total heat transfer rates and coolant fluid temperature and pressure profiles in the flow channel. The analysis also predicts the protection layer thickness which covers the coolant channel and the inlet and exit manifold tubing. Total system mass and projected area are calculated.

The program units described in this manual serve to simulate the radiator system performance. Even though successive runs with system parameter variations are feasible, the task of system optimization is dealt with in the simplified analysis which is described in detail in the Simplified Analysis Manual.

The purpose of this manual is to describe the program units that make up the computer simulation, the necessary input parameters for program execution and the typical program output for simulated radiator operation. The deck composition is described in part 2, and the input data set is explained in part 3. Part 4 is devoted to a description of the program output and part 5 gives examples of typical radiator performance for ascent, reentry and orbital conditions. Section B describes each subprogram in detail by describing their input and output variables as well as the function of each program unit.

The simulation program is separated into modular units or subprograms so that units of general utility may be removed and run separately. This arrangement also facilitates program modifications if future changes are required. The subprogram concept also reduces the extent of program checking when new program units are added to the existing program package.

The entire program consists of 62 separate program units and the Data Set. The source language is FORTRAN V. The program is executed from catalogued files, using temporary data files as batch processing on the UNIVAC 1108 computer operating under EXEC 8, Version 27.20.143, at the Georgia Tech Rich Electronic Computer Center.

Except for the control statements necessary to collect the program into elements to be stored on mass storage for subsequent program execution from mass storage, the Executive Control Statements are not discussed. Control statements may be freely chosen by the user in accordance with the Executive Control Language. All statements are in 026 key punch code.

a. System Description

The exact simulation program predicts the performance characteristics of the typical coolant channel and fin segment shown in Fig. 1. The fin profile has a trapezoidal cross-sectional area. The parallel plane passing through the tube axis and the plane bisecting two adjacent tubes are assumed to be planes of symmetry.

The program has property options that allow the user to select from a number of different coolant fluids, structural and meteoroid protection materials and surface coatings. The materials available for the protection layer, tube and fin are beryllium, copper or aluminum in any combination. The coolant fluids may be selected from a gas, several liquids or a liquid metal.

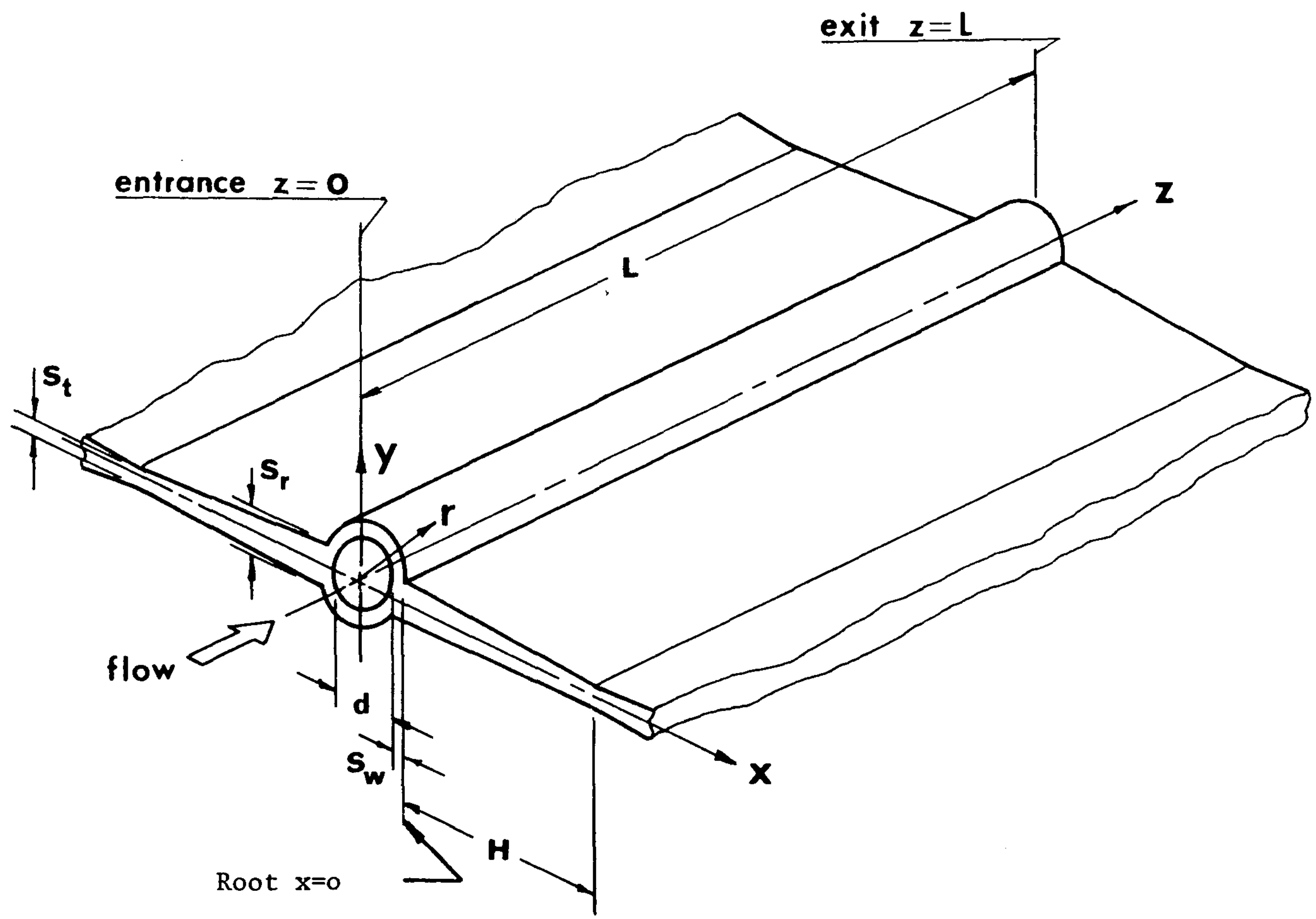


Fig. 1 Typical Fin Element for Exact Analysis

Possible choices are helium, silicon oil, the two fluorochemicals FC-43 and FC-75 and the liquid metal NaK. The entire radiator system is covered with the same passive thermal coating Z-93 which has optically diffuse but wavelength and temperature dependent optical properties.

The approximate analysis predicts the performance of the non-symmetrical radiator panels shown in Fig. 2. This one-dimensional analysis predicts the approximate location of the adiabatic plane separating two adjacent coolant channels when the radiator panel is curved (Fig. 2a) or the coolant channels are shaped in form of the letter U (Fig. 2b). Other situations which the approximate analysis is capable of treating involve the radiator panel with non-uniformly spaced coolant channels and coolant channels that do not all have identical inlet fluid mass flow rates or identical inlet fluid temperatures.

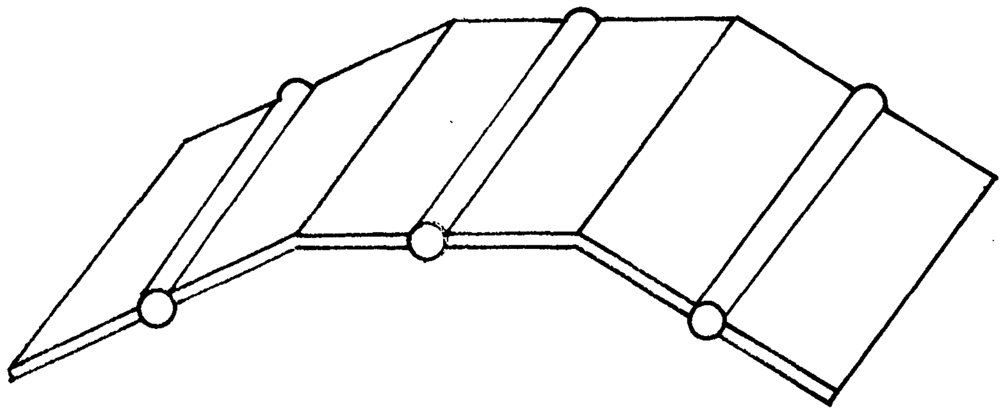
b. <u>Operating Conditions</u>

The program simulates radiator characteristics for ascent and reentry of the shuttle radiator system as well as orbital conditions for the shuttle and space base radiator. Typical system performance for these conditions are shown in part 5 of this manual.

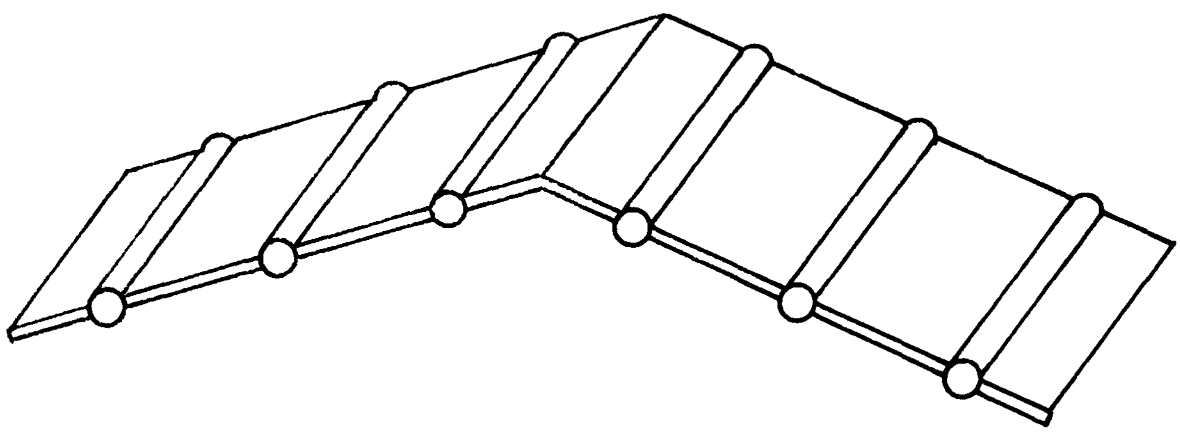
The altitude and velocity profiles of the shuttle vehicle during ascent and reentry are supplied by the user. These profiles are read into the program from card images.

The irradiation data to be supplied by the user is subdivided into three basic categories: solar, earth albedo and planetary irradiation. This data may be either read from card images or from a previously prepared data file which contains the irradiation data in the format specified by the MRI radiant flux program.

The program is capable of system simulation for both transient and steady state conditions. Under the steady state option, integration of the system differential equations proceeds from the user supplied initial condition until steady state is reached. All environmental conditions such as incident radiant flux remain constant during the integration process. Under the transient option, the environmental conditions are allowed to change with time as the integration process proceeds.



(a) Curved Radiator Panel



(b) U Shaped Coolant Channels

Fig. 2 Radiator Panel For Approximate Analysis

ß

Provision has been made within the program to allow for the variation in coolant fluid temperature and mass flow at the inlet plane of the coolant channel. These variations must be supplied by the user as sets of discrete data values punched on cards.

2. The Deck Composition

The program structure is dictated by the calling sequence of the Runge-Kutta-Simpson integration procedure (see Section III-2 of the System Analysis Manual). The Source Deck consists of two parts. The first part, referred to as the Permanent Part, requires no attention from the user unless he plans major program modifications, for instance to accommodate geometrical configurations other than the one considered here. The Permanent Part contains the first 42 program units.

The second part, called the Selective Part, is assembled from case to case by the user in accordance with his choice of the

(i) coolant fluid
(ii) flow channel material
(iii) meteoroid protection layer material
(iv) fin panel material
(v) thermal control coating

There are always 20 program units in the Selective Part.

Following the Source Deck is the Data Set which is discussed in Section A-3. It consists of six groups, one for each of the following input specifications:

(i) parameters which specify non-symmetrical radiator panel
(ii) ascent and reentry profiles
(iii) solar, albedo and planetary irradiation
(iv) coolant fluid inlet temperature and mass flux histories
(v) system specifications
(vi) program options.

Most of the user's activities will be reflected in his manipulation of the Data Set, especially of the data in groups (v) and (vi) above.

3. The Input Data Set

Input data are divided into six groups and assembled in the order of increasing frequency of changes so that data records most likely to be changed are at the end of the Data Set. This enables the user to keep large portions of the Job Deck on mass storage. The six groups in the Data Set define

(i) the parameters which specify the non-symmetrical radiator panel
(ii) the ascent and reentry profiles
(iii) the incident thermal radiant flux as a function of time
(iv) the coolant fluid inlet temperature and mass flux histories
(v) the system specifications, other than material selections
(vi) the options of program execution.

The program may be executed successively after reading new data records beginning at any of the six data groups listed above. Provisons have been also made for restarting the program by reading new data records from one group and skipping the following data group or only skipping portions of the succeeding data groups. The restart options are determined by the value of the restart integer MRSTRT. A description of this integer is given in part (f) of this section.

None of the data groups contains a fixed number of records. The number of records in groups (ii), (iii) and (iv) are determined and specified to the computer by the user. Groups (i), (v) and (vi) contain a minimum of records as specified below; the number of additional records in these groups and of additional sets of groups (ii), (iii) and (iv) depend on the number of additional executions and parameter variations during the same job. In the description of data records (card images) the numbering starts from one in each group.

a) Alphabetical List of Input Data

All input variables needed for program operation are listed below with their units and a brief description of the meaning of the variable.

VARIABLE NAME	UNITS	REFERENCED IN	DESCRIPTION
ABEMF		FINA	ratio of solar absorptivity to infrared emissivity of coating material
AL	ft	TUBEA	array of tube lengths
ALIMIT		RUNØPT	absolute error limit per integration step
ALPHA	gm/(day ft^2)	PRØTLR	constant relating meteoroid flux to mass
ALTA	ft	ascent and reentry data	elements in altitude array used for ascent altitude profile of shuttle
ALTR	ft	ascent and reentry data	elements in altitude array used for reentry altitude profile of shuttle
AMAN	ft^2	MANIFD	total manifold area projected into plane of fin
AN		PROTLR	see equation 8.6 System Analysis Manual
ATK		PRØTLR	see equation 8.8 in System Analysis Manual
BTA		PRØTLR	constant relating meteoroid flux to mass
D	in	TUBEA	tube internal diameter
DITBI	in	TUBE	internal tube diameter
DTWRTE	hr	RUNØPT	fixed time interval between data printout
GAMMA		PRØTLR	constant used to adjust observed to predicted meteoroid penetration depth

H	in	FINA	array of fin heights
HFNI	in	FIN	fin height from root to tip
ICASE		QNML,MRI	integer value which specifies set of irradiation values on MRI file
ISYM		SYSTEM	integer which specifies type of non-symmetrical loading of tubes
ITAPE		QNML,MRI	integer value to specify card input (= 0) or MRI file input (≠ 0) for irradiation data
LFLD		RUNØPT	control integer used to select between variable or fixed inlet fluid properties
LIMWRT		RUNØPT	maximum number of data recordings during integration toward steady state
LTS		RUNØPT	control integer used to select initial system temperature
LTT		RUNØPT	control integer used to select between temperature dependent or independent surface coating properties
M	lbm/hr	FLUIDA	array of mass flow rates at inlets to tubes
MDØTI	lbm/hr	FLØW	total coolant mass flow rate
MRSTRT		GINPT	control integer used for selection of reentry point for restarting program
MSTØTR		RUNØPT	control integer for selecting transient or steady state computation
MZ		TUBE	number of nodal points along tube axis ($\leq$ 10)
NA		ascent and reentry data	number of instances for specified ascent velocity and altitude data
NCØNV		RUNØPT	control integer for selection of orbit, ascent or reentry

NFLD		inlet coolant fluid history	number of mass flow rate and temperature data values
NR		ascent and reentry data	number of instances for specified reentry velocity and altitude data
NRMP		PRØTLR	number of radial nodal points in the protection layer ($\leq$ 5)
NRTBI		TUBE	number of radial nodal points in tube wall ($\leq$ 5)
NSRD		SYSTEM	number of sides of the radiator panel which radiate (1 or 2)
NT		SYSTEM	number of flat symmetrically loaded panels
NTBS		TUBE	number of flow channels
NTM		QNML,MRI	number of instances for specified irradiation data (< 100)
NX		FIN	number of nodal points on fin perpendicular to flow channel ($\leq$ 10)
PHI		PROTLR	see equation 8.1 System Analysis Manual
PHIN	degrees	MRI	array of angles that relate fin panel orientation with MRI data
PHN	degrees	QNML	angle of panel relative to MRI data
PIN	lbf/ft^2	FLUIDA	array of pressures at inlet to tubes
PO	lbf/ft^2	FLØW	entrance pressure into flow channel
PRØB		PRØTLR	probability of no damage caused by meteoroid impact
RHØFNI	lbm/ft^3	FIN	fin material density
RHØMET	g/cm^3	PRØTLR	meteoroid density
RHØMPI	lbm/ft^3	PRØTLR	protection layer density

RHØTBI	lbm/ft^3	TUBE	tube wall density
RLIMIT		RUNØPT	relative error per integration step
SRØØTI	in	FIN	fin root thickness
STAGX	ft	FIN	distance from stagnation point on shuttle to center of radiator panel along a streamline
STBI	in	TUBE	tube wall thickness
STIPI	in	FIN	fin tip thickness
TA	sec	ascent and reentry data	elements in time array used for ascent velocity and elevation profiles
TAU	days	PRØTLR	time radiator is exposed to meteoroid environment
TEND	hr	RUNØPT	termination time for transient performance calculation
TH	in	FINA	array of fin thickness
THETA		PRØTLR	see equation 8.1 System Analysis Manual
TI	R	RUNØPT	initial system temperature
TIFLD	R	coolant fluid inlet temperature history	array of coolant fluid inlet temperatures
TIN	R	FLUIDA	array of temperatures at inlets to tubes
TO	R	FLØW	entrance temperature into flow channel
TØ	min	QNML,MRI	time in minutes at which irradiation data is required
TR	sec	ascent and reentry data	elements in time array used for reentry velocity and elevation profiles
TSTAR	R	SYSTEM	array of sink temperatures

VELA	ft/sec	ascent and reentry data	elements in velocity array used for ascent velocity profile of shuttle
VELM	ft/sec	PRØTLR	average meteoroid velocity
VELR	ft/sec	ascent and reentry data	elements in velocity array used for reentry velocity profile of shuttle
VERTX	ft	FIN	total dimension of radiator panel in direction parallel to acceleration of gravity
W1	in	TUBEA	array of distances between side segments of tubes when U-shaped
W2	in	TUBEA	array of distances between base segments of tubes when U-shaped
WIFLD	lbm/hr	coolant fluid inlet mass flow rate history	array of coolant fluid inlet mass flow rates
XL	ft	TUBE	tube length

b) Parameters Specifying Non-Symmetrical Radiator Panels

Normal program operation assumes that radiator conditions are symmetrical about each coolant fluid channel. Several factors may destroy this symmetry. One may be non-uniform spacing of the tubes. Another factor may be different inlet temperatures or mass flow rates into adjacent tubes. A third factor could be attributed to a curved panel resulting in a variation to sink temperature between adjacent fin segments. These factors are specified in the NAMELIST's that follow.

Numerical values for a non-symmetrical panel, for irradiation data and for system specifications are read into the computer in NAMELIST format, one NAMELIST each with name and input data as follows:

i) for non-symmetrical panel specifications (see Section (b))

SYSTEM	for selection of system parameters when panels and/or flow conditions are non-symmetrical
TUBEA	for non-symmetrical tube specifications
FINA	for non-symmetrical fin specifications
FLUIDA	for non-symmetrical fluid specifications
MRI	for non-symmetrical irradiation data

ii) for irradiation specifications (see Section (c))

QNML	for irradiation data under symmetrical radiator panel conditions

iii) for system specifications (see Section (f))

TUBE	for flow channel specifications
FLØW	for coolant fluid flow specifications
FIN	for fin parameter specifications
PRØTLR	for the protection layer specifications
MANIFD	for the manifold input data.

Each input data record under NAMELIST format has

(i) a blank in its first column,

(ii) a $ - sign in its second column,

(iii) the NAMELIST name, starting in the third column, followed by one or more blanks,

(iv) the string of data in free field format as follows:

A = b ,

where (A) is the variable name and (b) is a number; imbedded blanks between (A), (=), (b), (,) and a following (A) are permissible,

(v) the comma of the last datum is to be placed by a $ - sign which delimits the NAMELIST data string.

For more details concerning NAMELIST formating, the reader may consult standard texts on FORTRAN PROGRAMMING. The NAMELIST data strings must be sequenced in the order in which they are listed above.

i) NAMELIST/SYSTEM/contains 4 variables

NT — number of flat symmetrically loaded panels, each panel containing NTBS symmetrically loaded tubes (see Fig. 3)

NSRD = 1 for one side of the panel radiating

= 2 for both sides of the panel radiating
Note: if panel is curved NSRD is set equal to 1

ISYM = 0 for symmetrical panel in one plane and straight parallel equally spaced tubes

= 1 for non-symmetrical curved panel consisting of straight fin segments and straight parallel tubes

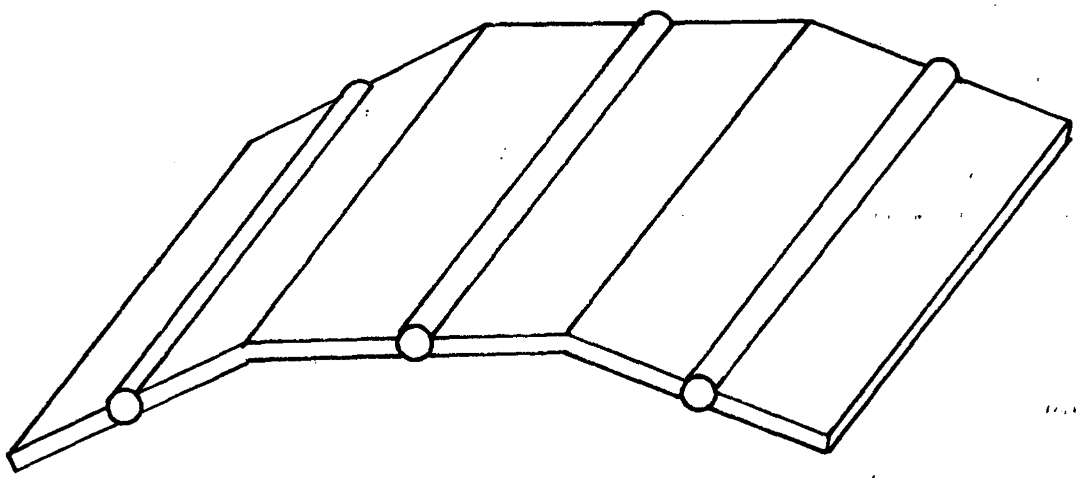
= 2 for non-symmetrical panel in one plane with U-shaped tubes

= 3 for non-symmetrical curved panel consisting of straight fin segments and U-shaped tubes

= 4 for non-symmetrical panel in one plane with straight parallel tubes but non-symmetrical loading

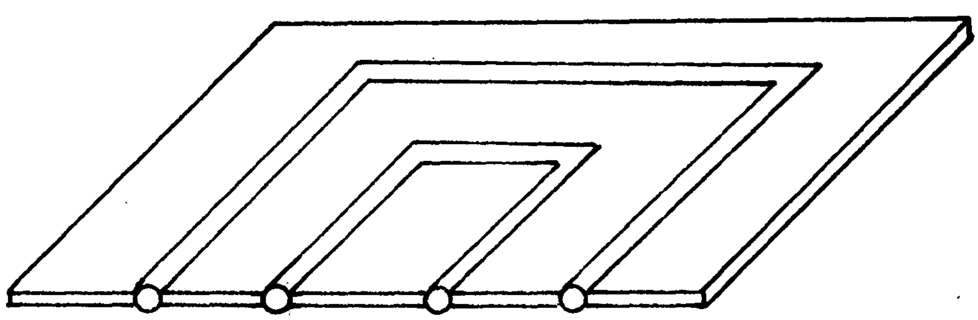
TSTAR — an (NT,3) array of sink temperatures in °R. These values are ignored if MRI file is used for incident flux data (see Section (d)). Also: If the radiator panel is flat only (1, NSRD) of the array is required.

The following four NAMELIST's are not read and should not be placed in the program if ISYM = 0. If ISYM ≠ 0 these four NAMELIST's should appear in the order shown.



NT = 3

NTBS = 1



NT = 2

NTBS = 3

Fig. 3

Examples of the Input Parameters NT and NTBS

ii) NAMELIST/TUBEA/contains 4 variables

D	the single value of all tube internal diameters in inches
AL	an array of NT tube lengths in feet. These values are used only for straight tubes. For curved tubes, the lengths are calculated from the values of W1 and W2 which are read in below
W1	distance between U-shaped tubes along inlet and exit portion of the tube in inches (i.e., both side segments of the U) NT + 1 values
W2	distance between U-shaped tubes along bottom segment of U in inches, NT + 1 values (see Fig. 4 for details of dimensions W1 and W2)

iii) NAMELIST/FINA/contains 3 variables

H	NT + 1 values of the fin height in inches from tube centerline to midplane between tubes. This value is used on for the case of straight tubes. Fin height for cases of the U tube is calculated from W1 and W2 in NAMELIST TUBEA
TH	NT values for the fin thickness in inches
ABEMF	ratio of the solar absorptivity to infrared emissivity of the surface of the radiator system

iv) NAMELIST/FLUIDA/contains 3 variables

TIN	NT values for the inlet fluid temperatures in R
PIN	NT values for the inlet fluid pressure in lbf/ft^2
M	NT values for the inlet fluid mass flow rate in lbm/hr

v) NAMELIST/MRI/contains 5 variables

ITAPE	= 0	to read irradiation data from cards
	> 0	to read irradiation data from MRI file. Value of ITAPE designates the input unit used to read file data
ICASE		integer used to designate the case number of stored data to be used for input. ICASE = 3, for example, would designate the third set of data stored on the MRI file to be used for current input. If ITAPE = 0, this integer is ignored.

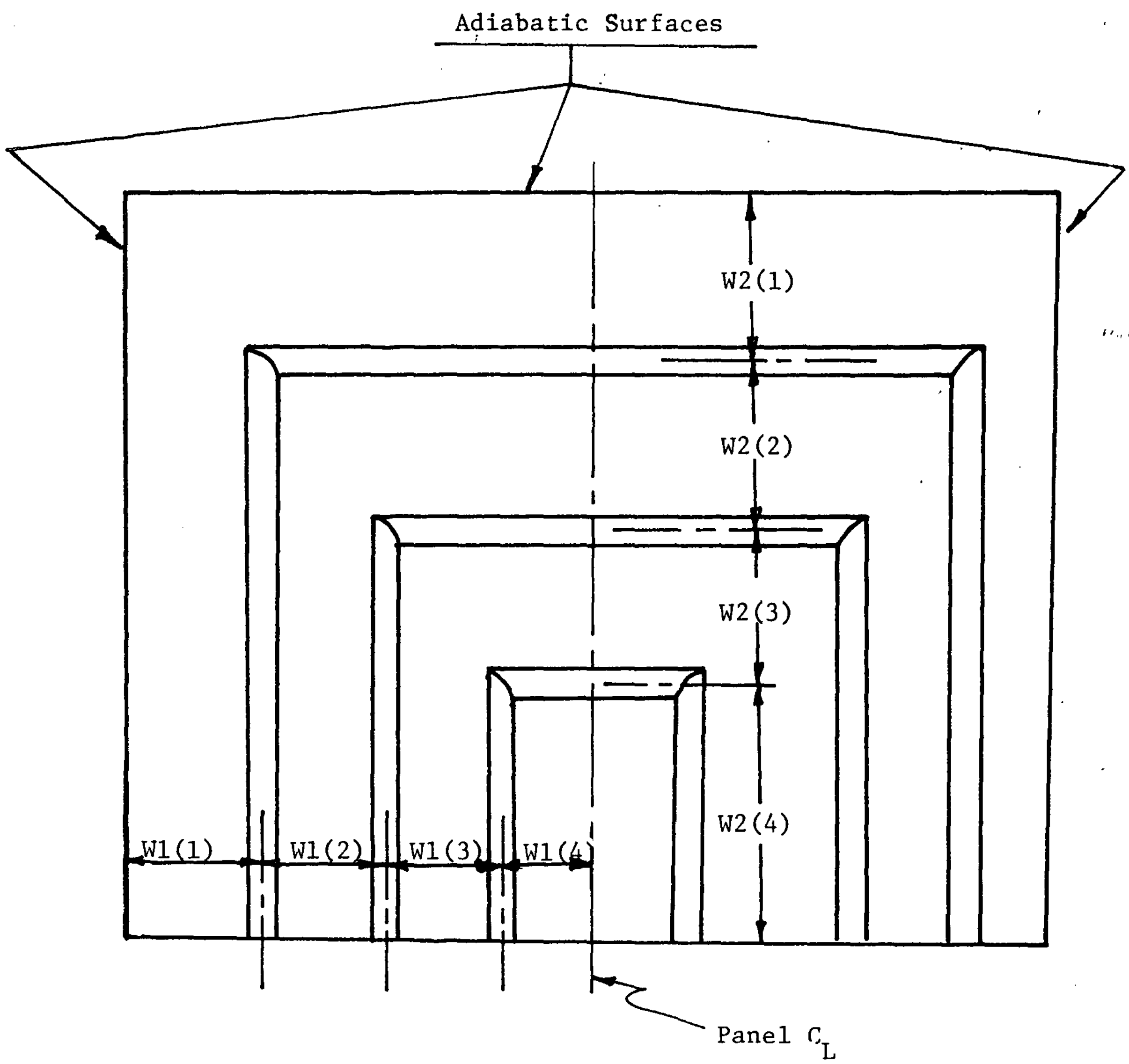


Fig. 4 The Dimensions W1(I) and W2(I) for U Shaped Coolant Channels

NTM	number of instances at which incident flux values on to be specified if either card or file data is used; NTM $\leq$ 100. If ITAPE > 0, NTM must be the number of data values stored on the MRI file
TØ	time in minutes during orbit at which irradiation data is required. Time is measured from zero time specified on MRI output data. If ITAPE = 0 this value is ignored
PHIN	array of NT values of the angles in degrees between the normals to the NT flat radiator segments and the reference line used as the zero angle reference on the MRI program

c) Ascent and Reentry Data

Velocity and altitude profiles for the shuttle vehicle during both ascent and reentry are read from cards which have the format listed in the table below. Selection of ascent or reentry phases is determined by the control integer NCØNV (see Section (e) which explains the Execution Control Options).

Card No.	FØRMAT	Variable
1	2I10	NA,NR the number of ordered pairs of elements in the velocity-time and altitude-time arrays for ascent and reentry profiles, respectively
2 through INT*(NA/10 + 0.9) + 1 = N_1	10F8.3	TA, elements of time array (NA values) in seconds, selected for ascent velocity and elevation profiles
N_1+ 1 through N_1+ INT(NR/10+0.9) = N_2	10F8.3	TR, elements of time array (NR values) in seconds, selected for reentry velocity and elevation profiles

*INT(x) = Integer part of x

N_2+ 1 through N_2+ INT(NA/8+0.875) = N_3	8E10.3	VELA, elements of velocity array (NA values) in ft/sec, selected for ascent velocity profile of orbiter
N_3+ 1 through N_3+ INT(NR/8+0.875) = N_4	8E10.3	VELR, elements of velocity array (NR values) in ft/sec, selected for reentry velocity profile of orbiter
N_4+ 1 through N_4+ INT(NA/8+0.875) = N_5	8E10.3	ALTA, elements of altitude array (NA values) in ft, selected for ascent elevation profile of orbiter
N_5 + 1 through N_5+ INT(NR/8+0.875)	8E10.3	ALTR, elements of altitude array (NR values) in ft, selected for reentry elevation profile of orbiter

d) Irradiation Data

Incident radiant flux on the space base during orbit may be either read from card images or it may be read from a user supplied data file (MRI program). The selection of card or file input is determined by the value of the control integer ITAPE. If ITAPE = 0, the irradiation data is read from cards in the format shown below. If ITAPE > 0, the irradiation data is read from unit ITAPE. The data is assumed to be in the format specified in the MRI manual "Orbiting Satellite Surface Temperature Prediction and Analysis," MRI Project No. NAS9-1059.

The input variables used to input the irradiation data are to be supplied in the NAMELIST format called QNML, if ISYM = 0. The input strings must be in the sequence shown below. If ISYM ≠ 0, these values are supplied from the NAMELIST called MRI

NAMELIST/QNML/contains 5 variables

ITAPE = 0 to read irradiation data from cards

> 0 to read irradiation data from MRI tape. Value of ITAPE designates the input unit used to read file data

ICASE integer used to designate the case number of stored data to be used for input. ICASE = 3, for example, would designate the third set of data stored on the MRI file as the irradiation data to be used for current input. If ITAPE = 0, this integer is ignored

NTM number of instances at which incident fluxes are to be specified if either card or file data is used; NTM ≤ 100. If ITAPE > 0, NTM must be the number of data values stored on the MRI file

TØ time in minutes during orbit at which irradiation data is required. Time is measured from zero time specified on MRI output data. If ITAPE = 0 this value is ignored

PHN single angle in degrees between normal to panel and reference line used as a zero angle reference in MRI program.

If the irradiation data is to be read from cards, it must be in the format shown below with the cards immediately following the NAMELIST input cards for QNML.

Card No.	FØRMAT	Variable
1 through NTM	10F8.3	On each card: (i) time TM in seconds (ii) 3 values of solar } irradiation (iii) 3 values of albedo } (Btu/hr ft^2) (iv) 3 values of planetary Incident at TM and each coming from one of three directions in this order: (i) -30° } from the panel (ii) 0° } normal (upper side) (iii) +30°
NTM + 1 through 2*NTM	10F8.3	Same data as above, now for lower fin panel side, only if NSRAD = 2

e) Coolant Fluid Temperature and Mass Flux Histories

When the temperature and mass flow rates entering the coolant channels vary with respect to time, the variation in these quantities are entered from cards in the format indicated below.

Card No.	FØRMAT	Variable
1	I10	NFLDTA the number of data values of temperature and mass flow rate to be entered on each card:
2 through NFLD + 1	3F20.6	i) TMEFLD the time in hours corresponding to the given temperature and mass flow rate ii) TIFLD coolant fluid temperature in R at time NFLDTA iii) WIFLD coolant mass flow rate in lbm/hr at time NFLDTA

f) System Specifications

The system specifications define the radiator system and follow immediately after the ascent and coolant fluid temperature and mass flux histories.

The first four cards in the group of the system specification data contain the names of

(i) the tube material
(ii) the fin material
(iii) the coolant fluid
(iv) the meteoroid protection layer material

in alphanumeric form, beginning with an alphabetic character. Each name is punched on a separate card, beginning in the first column and extending no further than through the first twelve columns. These names serve to identify the printout of results. The user must supply these names in agreement with the composition of the Selective Part described in Chapter I.A. The subsequent data records contain numerical data.

(i) NAMELIST/TUBE/contains 7 variables

DITBI	internal (hydraulic) tube diameter, in inch,
STBI	tube wall thickness, in inch,
XL	tube length, in ft,
RHØTBI	tube wall density, in lbm/ft^3,
MZ	number of nodal points along the tube axis (no. of intervals plus one), $\leq$ 10,
NRTBI	number of nodal points in radial direction, in the tube wall, $\leq$ 5,
NTBS	number of flow channels.

(ii) NAMELIST/FLOW/contains 3 variables

MDØTI	total coolant mass flow rate, in lbm/hr,
TO	entrance (and reference) temperature in degrees R,
PO	entrance (and reference) pressure in lbf/ft^2.

(iii) NAMELIST/FIN/contains 7 variables

NX	number of nodal points on the fin, perpendicular to the channel axis, NX $\leq$ 10,
SRØØTI	fin root thickness, in inch,
HFNI	fin height, from root to tip, in inch,
STIPI	fin tip thickness, in inch,
RHØFNI	fin material density, in lbm/ft^3,
STAGX	distance from stagnation point on shuttle vehicle to the center of radiator system measured along a streamline, in ft,
VERTX	total dimension of radiator panel in the direction parallel to the acceleration of gravity, in ft.

(iv) NAMELIST/PRØTLR/contains 13 variables

NRMP	number of radial nodal points in the protection layer, $\leq$ 5,
RHØMPI	protection layer material density, in lbm/ft^3,
RHØMET	meteoroid density in g/cm^3,
VELM	meteoroid velocity in ft/sec,
TAU	time that vulnerable area is exposed to meteoroid environment, in days,
PRØB	probability of no damage caused by meteoroid impacts, dimensionless,

ALPHA	experimental constant that relates meteoroid flux and mass (see Eq. 8.4) in gm/(day ft^2),
BTA	experimental constant that relates meteoroid flux and mass (see Eq. 8.4) dimensionless,
GAMMA	empirical constant used to adjust predicted penetration depths to one observed experimentally (see Eq. 8.1) dimensionless,
PHI	empirical constant (see Eq. 8.1) dimensionless,
THETA	empirical constant (see Eq. 8.1) dimensionless,
ATK	empirical constant used to account for spalling on a target of finite thickness (see Eq. 8.8) dimensionless,
AN	experimental constant that describes penetration depth as a function of angle of incidence (see Eq. 8.6) dimensionless.

(v) NAMELIST/MANIFD/contains

AMAN	total manifold area, projected into the fin plane, in ft^2.

Any one of these variables may be changed for successive program executions by entering them in NAMELIST/GINPT/ as discussed below.

g) Execution Control Options

The user has the choice of options for the execution of the first as well as successive computer runs.

Two data records are considered to be execution controls: RUNØPT and GINPT.

(vi) NAMELIST/RUNØPT/contains 11variables

MSTØTR = 1	to compute steady state conditions
= 2	to simulate transient system performance,
DTWRTE	fixed time interval, in hr, between data printout during integration,
TEND	termination time, in hr, for transient performance calculation,
ALIMIT	absolute error limit per integration step, see Eq. 15.3, in Systems Analysis Manual

RLIMIT		relative error limit per integration step, see Eq. 15.3, in Systems Analysis Manual.
TI		initial temperature, in degrees R,
LIMWRT		maximum number of data recording during integration toward steady state, exclusive of initial conditions record and steady state record,
NCØNV	= 0	no aerodynamic heating
	= 1	ascent
	= 2	reentry,
LTT	= 0	optical properties of the surface coating are independent of temperature
	= 1	optical properties of the surface coating are dependent on temperature
	= 2	irradiation on fin on tube is zero but subroutine QINCID is called,
LFLD	= 1	coolant fluid inlet temperature and mass flow rate are constant
	= 2	temperature and mass flow rate of inlet coolant fluid is variable,
LTS	= 0	uniform initial system temperature equal to TI
	= 1	initial system temperature taken to be equal to previously obtained values.

(vii) NAMELIST/GINPT/contains every variable name listed in items (i) through (vi) in addition to NSRD and the following control integer.

MRSTRT	= 1	new velocity and altitude profiles
	= 2	new irradiation history
	= 3	both new velocity, altitude profiles plus new irradiation history
	= 4	new coolant fluid inlet conditions
	= 5	new coolant fluid inlet conditions, plus new velocity and altitude profiles
	= 6	new coolant fluid inlet conditions, plus new irradiation history
	= 7	new coolant fluid inlet conditions, plus new velocity and altitude profiles, plus new irradiation history
	= 8	the only new input variables are those specified in GINPT.

There may be as many NAMELIST/GINPT/ records as computing time permits. If GINPT is omitted, the program will terminate.

4. Results

a. Information Produced

The results produced by the program can be divided into three categories each of which is listed on a separate output page. All input variables that specify the system and select the program options are printed on the first page of output (see Fig. 5). The second page contains all initial line conditions and system parameters which remain constant during the integration process (see Fig. 6). The succeeding pages contain the current system description printed during the integration process (see Fig.7). If the system is non-symmetrical an additional page of output is printed. This page (see Fig. 8) lists system parameters when the radiator panel is curved, the flow channels are not identically loaded, or the flow channels are U-shaped.

b. Output Format

The first output record consists of the list of all system specifications and execution control data as listed in Sections 3(d) and 3(e). This output appears with all of the variables in the NAMELISTS TUBE, FLØW, FIN, PRØTLR, MANIFD and RUNØPT listed in the NAMELIST format. A sample of this output is shown in Fig. 5 .

On the second page of output the initial coolant fluid flow properties are printed in non-dimensional form (see Fig. 6). This information includes non-dimensional pressure, velocity, temperature, and tube wall temperature. The reference quantities are listed below the initial line conditions. They are inlet fluid pressure, velocity and temperature. Next are printed several dimensionless parameters such as the Reynold's number, Prandtl number and Nusselt number for the initial coolant fluid flow conditions. The quantity DELTA is the ratio of the internal tube diameter to the tube length. The relative pressure is given by equation 3.31 in the System Analysis Manual. The Biot number of the tube is also printed.

```
@XQT N.VERI
 $TUBE
 DITBI    =    .25000000E+00
 STBI     =    .10000000E+00
 XL       =    .20000000E+01
 RHOTBI   =    .16859200E+03
 MZ       =               +5
 NRTBI    =               +3
 NTBS     =              +12

 $END
 $FLOW
 MDOTI    =    .50000000E+03
 TO       =    .70000000E+03
 PO       =    .25000000E+04

 $END
 $FIN
 NX       =               +5
 SROOTI   =    .50000000E-01
 HFNI     =    .12000000E+02
 STIPI    =    .50000000E-01
 RHOFNI   =    .16859200E+03
 STAGX    =    .20000000E+02
 VERTX    =    .10000000E+02

 $END
 $PROTLR
 NRMP     =               +3
 RHOMPI   =    .11357400E+03
 RHOMET   =    .50000000E+00
 VELM     =    .65600000E+05
 TAU      =    .36500000E+04
 PROB     =    .99000000E+00
 ALPHA    =    .18800000E-09
 BTA      =    .12130000E+01
 GAMMA    =    .15000000E+01
 PHI      =    .50000000E+00
 THETA    =    .66666700E+00
 ATK      =    .17500000E+01
 AN       =    .10000000E+01

 $END
 $MANIFD
 AMAN     =    .43000000E+02

 $END
 $RUNOPT
 MSTOTR   =               +2
 DTWRTE   =    .83330000E-02
 TEND     =    .20000000E+00
 ALIMIT   =    .50000000E-04
 RLIMIT   =    .10000000E-04
 TI       =    .66000000E+03
 LIMWRT   =              +20
 NCONV    =               +0
 LTT      =               +0
```

FIGURE 5

INPUT VARIABLES

```
 LFLD    =          +2
 LTS     =          +0
02
 $END
```

```
INITIAL LINE CONDITIONS
******* **** **********
              (ALL QUANTITIES ARE NORMALIZED)
```

PT.NO.	POSITION Z	PRESSURE P	VELOCITY W	FLUID TEMPERATURE T	WALL TEMPERATURE TWI
1	.000	1.000000	.974335	.942857	.942857
2	.250	.998340	.974339	.942857	.942857
3	.500	.996680	.974342	.942858	.942857
4	.750	.995020	.974346	.942858	.942857
5	1.000	.993359	.974350	.942858	.942857

```
INLET PRESSURE     PO  =    2500.000  LBF/SQ.FT
REF.  VELOCITY     WO  =      .69331  FT/SEC
REF. TEMPERATURE TOO   =     700.000  R

      REYNOLDS NO      =              .13191+03
      PRANDTL  NO      =             95.079041
      DELTA            =               .010417
      REL.PRESSURE IS                 .170849+04

INIT. NUSSELT NO. NU   =              .768940+01
WALL BIOT NO.     BI   =              .362036-02

           SYSTEM PARAMETERS
           *****************

TUBE LENGTH ,                   XL =      2.000 FT
     INTERNAL DIAMETER ,      DITB =       .250 IN
     WALL THICKNESS ,          STB =       .100 IN
     MATERIAL                         ALUMINUM
     MASS   (ALL TUBES) ,      MTB =     3.0896 LBM
     NUMBER OF TUBES,         NTBS =         12

FIN  HEIGHT ,                  HFN =     12.000 IN
     THICKNESS AT ROOT ,     SROOT =       .050 IN
     THICKNESS AT TIP ,       STIP =       .050 IN
     MATERIAL                         ALUMINUM
     MASS (ALL FINS) ,         MFN =    33.7184 LBM
     NO. OF FIN SIDES RADIATING    =          1

COOLANT FLUID IS                      SILICONE OIL
     MASS (IN ALL TUBES) ,     MFL =     4.9345 LBM

 PROTECTION LAYER THICKNESS,   SMP =       .063 IN
     MASS,                     MMP =      1.804 LBM
     MATERIAL IS                      BERYLLIUM

TOTAL MASS (EXCL. MANIFLD.) MTOT =      43.5462 LBM
TOTAL AREA (SINGLE NORMAL PROJECTION) ,
                              ATOT =    48.9000 SQ FT
```

FIGURE 6

INITIAL LINE CONDITIONS AND SYSTEM PARAMETERS

```
ELAPSED TIME IS          .0000 HR
RELATIVE TIME IS         .0000          **IN ORBIT**          1 INTEGR. STEPS

FIN TEMPERATURE DISTRIBUTION AND RADIANT HEAT REJECTION
*************************************************************

REFERENCE TEMPERATURE,     TOO   =   700.000 R          ,
REF. RADIANT HEAT FLUX                                       INCIDENT SOLAR FLUX,       QSOLR  =  .1000+03 BTU/(HR SQ FT)
   PER UNIT AXIAL LENGTH, QREF   =  .9877+04 BTU/(HR FT),    INCIDENT INFRARED FLUX,    QIRED  =  .2000+01 BTU/(HR SQ FT)
TOT. RADIANT REJECTION    QTOT   =  .1295+05 BTU/HR     ,    AERODYN. HEATING POWER,    QCONV  =  .0000    BTU/HR
COND. FROM MANIFOLDS,     CONDMF =  .0000    BTU/HR     ,    ENERGY STORAGE RATE,       STORG  = -.1295+05 BTU/HR
```

AXIAL DIST. Z	RELATIVE RAD. HEAT REJECTION Q	RELATIVE TEMPERATURE OF FIN, T — DISTANCE NORMAL TO FLOW DIRECTION X: .00000	.25000	.50000	.75000	1.00000
.000	.6564	.9429	.9429	.9429	.9429	.9429
.250	.6552	.9429	.9429	.9429	.9429	.9429
.500	.6551	.9429	.9429	.9429	.9429	.9429
.750	.6552	.9429	.9429	.9429	.9429	.9429
1.000 (EXIT)	.6564	.9429	.9429	.9429	.9429	.9429

```
FLUID PROPERTIES AND SURFACE TEMPERATURE OF METEOROID PROTECTION LAYER
*********************************************************************

REFERENCE TEMPERATURE, TOO      =       700.000 R
REFERENCE PRESSURE,    POO      =      2500.000 LBF/SQ.FT
REFERENCE VELOCITY,    WOO      =          .693 FT/SEC
COOLANT POWER, INLET  AT T=TO  HO = .433766+05 BTU/HR          INLET CURRENTLY  HI = .361472+05 BTU/HR
               EXIT  CURRENTLY EI = .361473+05 BTU/HR          TOT. REJECTION   DH = -.108887+00 BTU/HR
```

AXIAL DIST.	PRESSURE P	VELOCITY W	FLUID TEMPERATURES TF	WALL TEMPERATURES TWI	PROTECT. LAYER TEMPERATURES TMP	ENTHALPY REJECTION PER UNIT TUBE LENGTH BTU/(HR FT)	ENTHALPY REJECTION FRACTION OF TOTAL
.000	1.00000	.9743	.9429	.9429	.9429	-.000057	.00000
.250	.99834	.9743	.9429	.9429	.9429	.000283	.05725
.500	.99668	.9743	.9429	.9429	.9429	.000548	.25331
.750	.99502	.9743	.9429	.9429	.9429	.000803	.56830
1.000 (EXIT)	.99336	.9743	.9429	.9429	.9429	.001039	1.00000

FIGURE 7

CURRENT SYSTEM DESCRIPTION

```
ELAPSED TIME IS            .0083 HR
RELATIVE TIME IS          10.3992                **IN ORBIT**                         23 INTEGR. STEPS

            FIN TEMPERATURE DISTRIBUTION AND RADIANT HEAT REJECTION
            *******************************************************

REFERENCE TEMPERATURE,     TOO  =   700.000 R             ,
REF. RADIANT HEAT FLUX                                        INCIDENT SOLAR FLUX,     QSOLR  =  .1000+03 BTU/(HR SQ FT)
   PER UNIT AXIAL LENGTH, QREF  =  .9877+04 BTU/(HR FT),      INCIDENT INFRARED FLUX,  QIRED  =  .2000+01 BTU/(HR SQ FT)
TOT. RADIANT REJECTION    QTOT  =  .1198+05 BTU/HR        ,   AERODYN. HEATING POWER,  QCONV  =  .0000    BTU/HR
COND. FROM MANIFOLDS,   CONDMF  =  .4641+03 BTU/HR        ,   ENERGY STORAGE RATE,     STORG  = -.1085+05 BTU/HR
```

AXIAL DIST. Z	RELATIVE RAD. HEAT REJECTION Q	RELATIVE TEMPERATURE OF FIN, T — DISTANCE NORMAL TO FLOW DIRECTION X: .00000	.25000	.50000	.75000	1.00000
.000	.6304	.9342	.9342	.9342	.9342	.9342
.250	.6024	.9332	.9248	.9233	.9232	.9233
.500	.6010	.9331	.9244	.9228	.9226	.9228
.750	.6022	.9331	.9248	.9233	.9232	.9233
1.000 (EXIT)	.6292	.9338	.9338	.9338	.9338	.9338

```
            FLUID PROPERTIES AND SURFACE TEMPERATURE OF METEOROID PROTECTION LAYER
            **********************************************************************

        REFERENCE TEMPERATURE, TOO      =        700.000 R
        REFERENCE PRESSURE,    POO      =       2500.000 LBF/SQ.FT
        REFERENCE VELOCITY,    WOO      =           .693 FT/SEC
    COOLANT POWER, INLET  AT T=TO  HO =  .433766+05 BTU/HR                 INLET CURRENTLY  HI =  .385222+05 BTU/HR
                   EXIT  CURRENTLY EI =  .378522+05 BTU/HR                 TOT. REJECTION   DH =  .670021+03 BTU/HR
```

AXIAL DIST.	PRESSURE P	VELOCITY W	FLUID TEMPERATURES TF	WALL TEMPERATURES TWI	PROTECT. LAYER TEMPERATURES TMP	ENTHALPY REJECTION PER UNIT TUBE LENGTH BTU/(HR FT)	ENTHALPY REJECTION FRACTION OF TOTAL
.000	1.00000	1.0046	.9539	.9342	.9342	25.000915	.00000
.250	.99824	1.0046	.9525	.9332	.9332	24.412890	.27294
.500	.99648	1.0046	.9512	.9331	.9331	22.919608	.53364
.750	.99473	1.0046	.9499	.9331	.9331	21.380966	.77689
1.000 (EXIT)	.99297	1.0046	.9488	.9338	.9338	18.983883	1.00000

FIGURE 7 CONCLUDED

FLAT PANEL
3 STRAIGHT TUBES
2 RADIATING SIDES

TUBE SPECIFICATIONS 2.5000-01 INCHES INSIDE DIAMETER

TUBE LENGTH (FEET)
2.0000+00 2.0000+00 2.0000+00

FIN SPECIFICATIONS

FIN THICKNESS (INCHES)
5.0000-02 5.0000-02 5.0000-02

FIN HALF-WIDTH (INCHES)
1.1000+01 1.1500+01 1.2000+01 1.2500+01

SINK TEMPERATURE (DEGREES R)
4.9391+02 4.9391+02 4.9391+02
5.8736+02 5.8736+02 5.8736+02

FLUID SPECIFICATIONS

INLET TEMPERATURE (DEGREES R)
7.0000+02 7.0000+02 7.0000+02

INLET PRESSURE (LBF/SQ.FT.)
2.5000+03 2.5000+03 2.5000+03

MASS FLOW RATE (LBM/HR)
5.0000+02 5.0000+02 5.0000+02

TUBE	BULK TEMP DEG R	INCHES TO ADIABATIC PLANE LEFT	RIGHT	PER CENT FIN EFFICIENCY LEFT	RIGHT	FIN TIP TEMP DEG R LEFT	RIGHT	OUTLET TEMP DEG R	HEAT REJECTED BTU/HR
1	6.0619+02	1.1000+01	1.1531+01	5.9360+01	5.7589+01	5.7493+02	5.7314+02	6.0619+02	1.4465+03
2	6.0570+02	1.1469+01	1.2028+01	5.7816+01	5.6025+01	5.7314+02	5.7135+02	6.0570+02	1.4542+03
3	6.0524+02	1.1972+01	1.2500+01	5.6226+01	5.4593+01	5.7135+02	5.6975+02	6.0524+02	1.4613+03

FIGURE 8
SYSTEM PARAMETERS FOR NON-SYMMETRICAL HEATING

A listing of system parameters follows the initial line condition. The system parameters include the pertinent geometry parameters, the materials and the mass of the tube, fin, coolant fluid and protection layer materials. In addition, the thickness of the meteoroid protection layer, the total system mass excluding the mass of the manifolds and the total projected areas are listed at the bottom of the page.

Following the preliminary results is a series of current system descriptions printed out during the integration process (see Fig.7). The first items printed are the current real time and the relative time which is the ratio of the current time to the time required for a fluid particle to pass through the flow channel. If the calculations are for the space base in orbit, the words "in orbit" are printed at the top of the page. If the calculations are for either ascent or reentry of the space shuttle, the current shuttle velocity and altitude are printed along with the current atmospheric temperature. For either the sub-orbital or orbital case, the cummulative number of integration steps from the initial conditions is printed at the top of the page.

The next data printed are a summary of the heat flux terms and a listing of the non-dimensional fin temperature distribution. The reference temperature is the inlet fluid temperature and the reference radiant heat flux is the black body emissive power at the inlet coolant fluid temperature evaluated for a unit length of fin and tube segment. The total radiant rejection and the conduction into the fin from both the inlet and exit manifolds for the entire radiator system are also printed. The external heat fluxes incident on the system that are printed are the infrared irradiation from earth albedo, solar irradiation and the convective flux on the radiator system of the shuttle vehicle during ascent and reentry. The energy storage rate for the entire system is also listed along with the external heat fluxes.

The final table listed on the page contains coolant fluid properties as functions of axial distance as well as the local cooling rates. All properties are tabulated in non-dimensional form and the table is preceded by a list of the necessary reference quantities. Properties of the coolant fluid that are printed are pressure, velocity and bulk temperature. The non-dimensional interior tube wall temperature and the normalized temperature of the meteoroid protection layer temperature are also listed as functions of axial distance down the tube. The enthalpy rejection of the fluid and fraction of the total enthalpy drop are listed as functions down the tube. The latter parameter is helpful in determining the effectiveness of the various segments of the tube length in their capacity to reject heat. Below the reference properties used for the fluid properties are the inlet and exit fluid stagnation enthalpies as well as the total change in stagnation enthalpy. These quantities are labeled respectively, HI, HE and DH. Also for comparison is listed the enthalpy flux at the reference state (T_o,P_o) and the reference velocity W_o.

The last table of current output data constitutes either the system conditions at the specified termination time, TEND in hours, or the steady state condition depending on whether MSTØTR = 1 or MSTØTR = 2, respectively. For conditions of steady state, the words "STEADY STATE IS REACHED" are printed after the final data printout.

When input parameters lead to a condition for which the tube centerline or the midplane separating two tubes are not lines of symmetry, then a single page of output is printed prior to all other output. This page contains a written description of tube arrangement on the radiator and a printout describing the panel as either flat or curved. The number of non-symmetrical tubes and the number of sides of the panel radiating are also printed at the top of the page.

The next output consists of a description of the sink temperature data including orientation of the fin segments relative to the reference vector used in the MRI program.

The tube specifications follow the sink temperature data. The data listed are the internal tube diameter and the tube lengths when the tubes are straight. If the tubes are U-shaped, the spacings at the inlet and outlet segments as well as the crossover segments of the tubes are listed instead of the tube lengths.

The fin specifications follow the tube data. The data listed are fin thicknesses and the distance between the tube centerline and the midplane separating two tubes. The effective sink temperature for each fin segment is also printed under fin specifications. When both sides of the panel radiate, two lines of sink temperatures are printed corresponding to the sink temperature both radiator sides.

The coolant fluid specifications follow the fin data. Inlet fluid temperature, pressure and mass flow rates are printed for each non-symmetrical tube.

The final data to be printed on the page is a summary of the system conditions for all of the non-symmetrical fin segments. The data printed includes the fin bulk temperature, position of the adiabatic plane, the fin effectiveness, fin tip temperature, fluid outlet temperature and total heat rejected by the fluid in each of the tubes.

This single page of output is then followed by the usual system printout as described above, repeated once for each non-symmetrical tube.

c. Output Listing

Figures 5, 6 and 7 in this section are typical output listings produced by the simulation program. Figure 5 provides a listing of all input parameters that appear in the NAMELIST format. Figure 6 shows initial line conditions and system parameters and Figure 7 shows a typical printout of the current radiator system parameters. These three figures are typical of program output when the radiator panel is symmetrical about each flow channel. If non-symmetrical conditions exist, output similar to that shown in Figure 8 is produced.

5. Typical Radiator System Performance

This section summarizes typical program results for expected radiator input conditions during ascent and reentry for the shuttle vehicle and during both transient and steady state performance of the radiator system in a simulated orbit.

a. Ascent

(i) Mission Description

The ascent altitude and velocity profiles used for the system output shown in Figures 10 and 11 is given in Figure 9. Other input parameters were selected as reasonable conditions expected for a typical space shuttle radiator system. The total fin area of 124.5 ft^2 is subdivided by 10 equally spaced 12-foot long flow channels. The total fin height between flow channels is 1 ft. The inlet coolant fluid temperature and pressure are 200 F and 60 lb_f/in^2, respectively. The system materials are aluminum tubes, fins and meteoroid protection material with silicon oil as the coolant fluid. Other system parameters are printed as input listing which precedes the current system parameters shown in Figure 10a. The panel radiates only from one side. Incident radiant fluxes are constant during ascent at 100 Btu/hr ft^2 for solar irradiation, 2.0 Btu/hr ft^2 for earth albedo. There is no infrared earth irradiation.

(ii) System Response

The response of the radiator system during ascent is summarized in Figures 10 and 11. A selected number of output listings of current system parameters during ascent are shown in Figure 10a. Figure 10b is a plot of the total heat rejection from the entire radiator surface during ascent as well as the outlet coolant fluid temperature. Figure 11 is a plot of the aerodynamic heating at various times during the ascent phase of the mission.

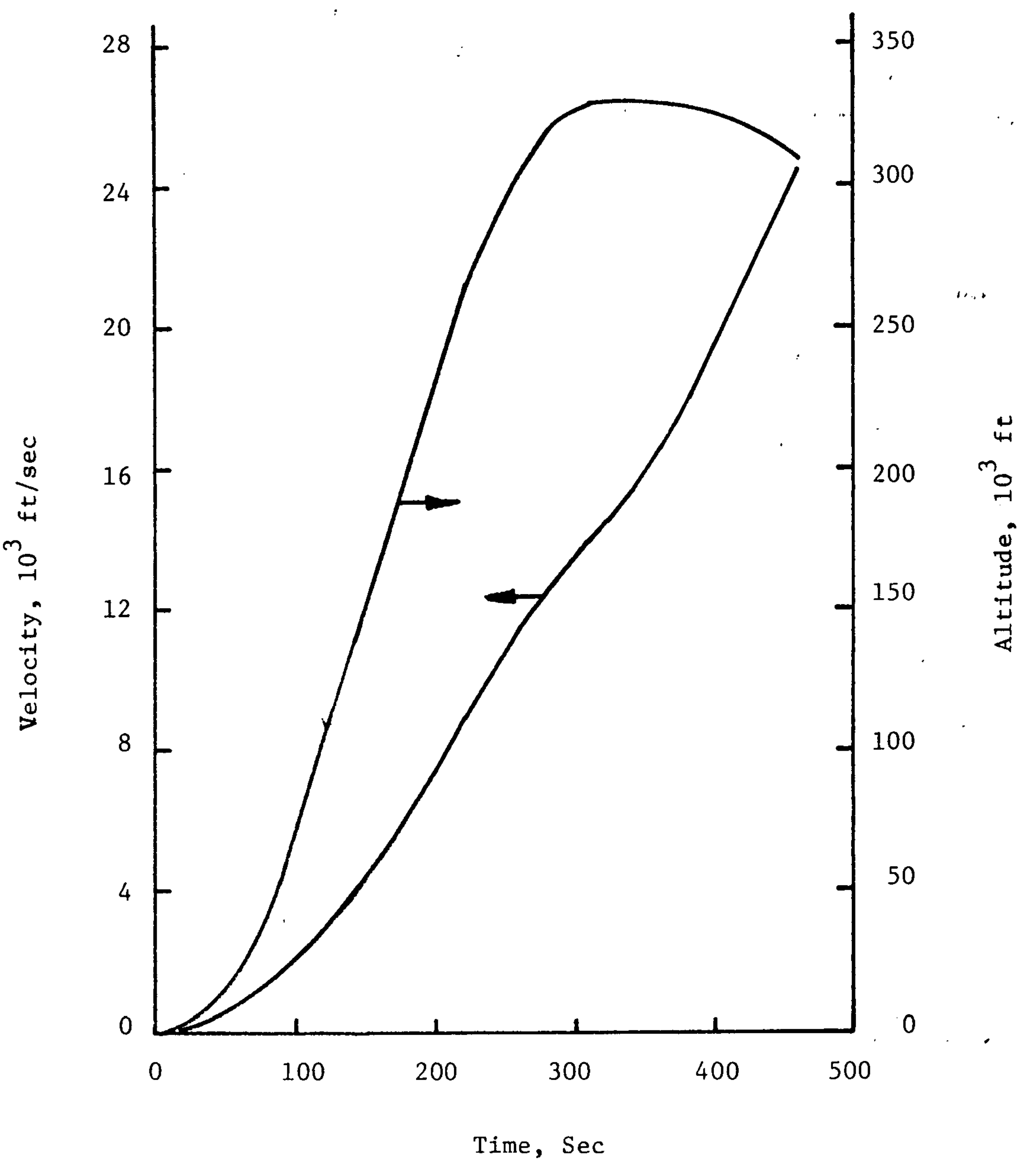


Fig. 9 Ascent Velocity and Altitude Profiles

```
$QNML
ITAPE   =          +0
ICASE   =          +0
NTM     =          +4
TO      =   .00000000E+00
PHN     =   .00000000E+00

$END
$TUBE
DITBI   =   .25000000E+00
STBI    =   .10000000E+00
XL      =   .12000000E+02
RHOTBI  =   .16859200E+03
NZ      =          +9
NRTBI   =          +3
NTBS    =         +10

$END
$FLOW
MDOTI   =   .50000000E+03
TO      =   .65967000E+03
PO      =   .86400000E+04

$END
$FIN
NX      =          +5
SROOTI  =   .50000000E-01
HFNI    =   .60000000E+01
STIPI   =   .50000000E-01
RHOFNI  =   .16859200E+03
STAGX   =   .20000000E+02
VERTX   =   .10000000E+02

$END
$PROTLR
NRMP    =          +3
RHOMPI  =   .16859200E+03
RHOMET  =   .50000000E+00
VELM    =   .65600000E+05
TAU     =   .36500000E+04
PROB    =   .99000000E+00
ALPHA   =   .18800000E-09
BTA     =   .12130000E+01
GAMMA   =   .15000000E+01
PHI     =   .50000000E+00
THETA   =   .66666700E+00
ATK     =   .17500000E+01
AN      =   .10000000E+01

$END
$MANIFD
AMAN    =   .43000000E+02

$END
$RUNOPT
MSTOTR  =          +2
```

FIGURE 10(A) SYSTEM RESPONSE FOR ASCENT
PROGRAM OUTPUT

39

```
 DTWRTE  =     .83330000E-02
 TEND    =     .12700000E+00
 ALIMIT  =     .50000000E-04
 RLIMIT  =     .10000000E-04
 T1      =     .65967000E+03
 LIMWRT  =               +25
 NCONV   =                +1
 LTT     =                +0
 LFLD    =                +1
 LTS     =                +0

 $END
```

FIGURE 10(A) CONTINUED

11297

```
INITIAL LINE CONDITIONS
******* **** **********
              (ALL QUANTITIES ARE NORMALIZED)
                                                                    FLUID           WALL
 PT.NO.  POSITION         PRESSURE          VELOCITY         TEMPERATURE     TEMPERATURE
            Z                 P                 W                 T              TWI

     1    .000            1.000000          1.000000          1.000000        1.000000
     2    .125             .999810          1.000000          1.000000        1.000000
     3    .250             .999621          1.000001          1.000000        1.000000
     4    .375             .999431          1.000001          1.000000        1.000000
     5    .500             .999241          1.000001          1.000000        1.000000
     6    .625             .999052          1.000001          1.000000        1.000000
     7    .750             .998862          1.000001          1.000000        1.000000
     8    .875             .998673          1.000002          1.000000        1.000000
     9   1.000             .998483          1.000002          1.000000        1.000000

INLET PRESSURE     P0  =   8640.000  LBF/SQ.FT
REF.  VELOCITY     W0  =     .87128  FT/SEC
REF. TEMPERATURE T00  =    659.670  R

      REYNOLDS NO      =          .30017+04
      PRANDTL  NO      =          8.628066
      DELTA            =           .001736
      REL.PRESSURE IS             .391534+04

INIT. NUSSELT NO. NU  =           .201856+02
WALL BIOT NO.     BI  =           .485314-02

        SYSTEM PARAMETERS
        *****************

TUBE LENGTH ,                 XL =     12.000 FT
      INTERNAL DIAMETER ,   DITB =       .250 IN
      WALL THICKNESS ,       STB =       .100 IN
      MATERIAL                     ALUMINUM
      MASS   (ALL TUBES) ,   MTB =    15.4480 LBM
      NUMBER OF TUBES,      NTBS =         10

FIN  HEIGHT ,                HFN =      6.000 IN
      THICKNESS AT ROOT ,  SROOT =       .050 IN
      THICKNESS AT TIP ,    STIP =       .050 IN
      MATERIAL                     ALUMINUM
      MASS (ALL FINS) ,      MFN =    84.2960 LBM
      NO. OF FIN SIDES RADIATING =          1

COOLANT FLUID IS                   SILICONE OIL
      MASS (IN ALL TUBES) ,  MFL =    19.1289 LBM

 PROTECTION LAYER THICKNESS,  SMP =       .011 IN
      MASS,                  MMP =      2.038 LBM
      MATERIAL IS                  BERYLLIUM

TOTAL MASS (EXCL. MANIFLD.) MTOT =   120.9104 LBM
```

FIGURE 10(A) CONTINUED

TOTAL AREA (SINGLE NORMAL PROJECTION) ,
ATOT = 124.5000 SQ FT

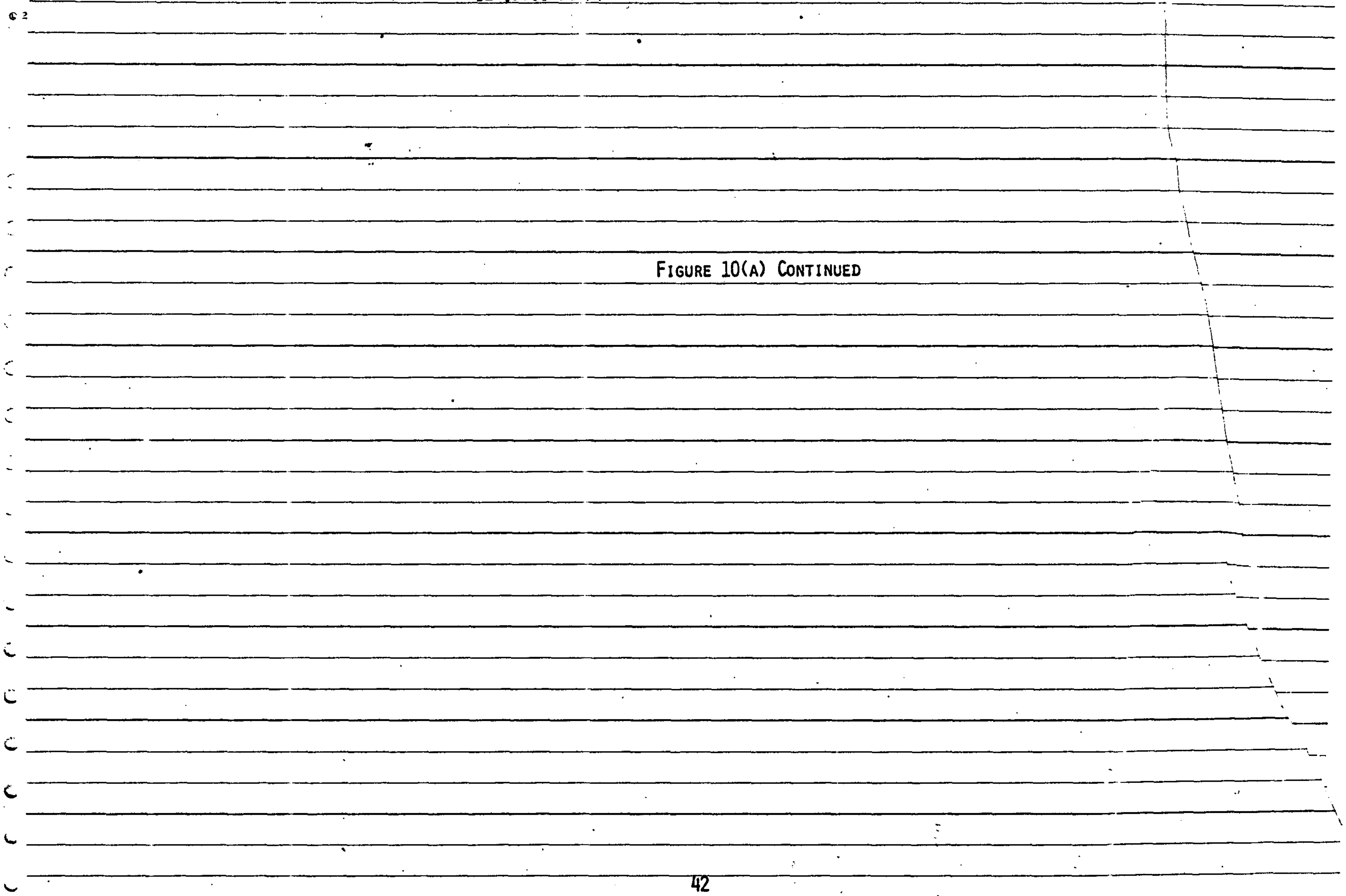


FIGURE 10(A) CONTINUED

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ELAPSED TIME IS .0000 HR , RELATIVE TIME IS .0000 1 INTEGR. STEPS
ALTITUDE IS .00 FT , VELOCITY IS .00 FT/SEC , ATM. TEMPERATURE IS 518.67 R

FIN TEMPERATURE DISTRIBUTION AND RADIANT HEAT REJECTION
****

REFERENCE TEMPERATURE, T00 = 659.670 R ,
REF. RADIANT HEAT FLUX PER UNIT AXIAL LENGTH, QREF = .3246+04 BTU/(HR FT),
TOT. RADIANT REJECTION QTOT = .3289+05 BTU/HR ,
COND. FROM MANIFOLDS, CONDMF = .0000 BTU/HR ,

INCIDENT SOLAR FLUX, QSOLR = .1000+03 BTU/(HR SQ FT)
INCIDENT INFRARED FLUX, QIRED = .2000+01 BTU/(HR SQ FT)
AERODYN. HEATING POWER, QCONV = -.1924+05 BTU/HR
ENERGY STORAGE RATE, STORG = -.5213+05 BTU/HR

AXIAL DIST. Z	RELATIVE RAD. HEAT REJECTION Q	RELATIVE TEMPERATURE OF FIN, T — DISTANCE NORMAL TO FLOW DIRECTION X: .00000	.25000	.50000	.75000	1.00000
.000	.8477	1.0000	1.0000	1.0000	1.0000	1.0000
.125	.8451	1.0000	1.0000	1.0000	1.0000	1.0000
.250	.8436	1.0000	1.0000	1.0000	1.0000	1.0000
.375	.8436	1.0000	1.0000	1.0000	1.0000	1.0000
.500	.8436	1.0000	1.0000	1.0000	1.0000	1.0000
.625	.8430	1.0000	1.0000	1.0000	1.0000	1.0000
.750	.8436	1.0000	1.0000	1.0000	1.0000	1.0000
.875	.8451	1.0000	1.0000	1.0000	1.0000	1.0000
1.000 (EXIT)	.8477	1.0000	1.0000	1.0000	1.0000	1.0000

FLUID PROPERTIES AND SURFACE TEMPERATURE OF METEOROID PROTECTION LAYER
****

REFERENCE TEMPERATURE, T00 = 659.670 R
REFERENCE PRESSURE, P00 = 8640.000 LBF/SQ.FT
REFERENCE VELOCITY, W00 = .871 FT/SEC
COOLANT POWER, INLET AT T=T0 H0 = .276867+05 BTU/HR
EXIT CURRENTLY EI = .276866+05 BTU/HR

INLET CURRENTLY HI = .276867+05 BTU/HR
TOT. REJECTION DH = .500488-01 BTU/HR

AXIAL DIST.	PRESSURE P	VELOCITY W	FLUID TEMPERATURES TF	WALL TEMPERATURES TWI	PROTECT. LAYER TEMPERATURES TMP	ENTHALPY REJECTION PER UNIT TUBE LENGTH BTU/(HR FT)	ENTHALPY REJECTION FRACTION OF TOTAL
.000	1.00000	1.0000	1.0000	1.0000	1.0000	.000000	.00000
.125	.99981	1.0000	1.0000	1.0000	1.0000	.000138	.02563
.250	.99962	1.0000	1.0000	1.0000	1.0000	.000242	.09431
.375	.99943	1.0000	1.0000	1.0000	1.0000	.000311	.19375
.500	.99924	1.0000	1.0000	1.0000	1.0000	.000380	.31625
.625	.99905	1.0000	1.0000	1.0000	1.0000	.000450	.46386
.750	.99886	1.0000	1.0000	1.0000	1.0000	.000484	.63147
.875	.99867	1.0000	1.0000	1.0000	1.0000	.000519	.80933
1.000 (EXIT)	.99848	1.0000	1.0000	1.0000	1.0000	.000553	1.00000

FIGURE 10(A) CONTINUED

ELAPSED TIME IS .0250 HR , RELATIVE TIME IS 6.5344 38 INTEGR. STEPS
ALTITUDE IS 56495.86 FT , VELOCITY IS 1449.87 FT/SEC , ATM. TEMPERATURE IS 389.97 R

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FIN TEMPERATURE DISTRIBUTION AND RADIANT HEAT REJECTION
****

REFERENCE TEMPERATURE, T00 = 659.670 R ,
REF. RADIANT HEAT FLUX PER UNIT AXIAL LENGTH, QREF = .3246+04 BTU/(HR FT),
TOT. RADIANT REJECTION QTOT = .2115+05 BTU/HR ,
CONU. FROM MANIFOLDS, CONDMF = .2443+04 BTU/HR ,

INCIDENT SOLAR FLUX, QSOLR = .1000+03 BTU/(HR SQ FT)
INCIDENT INFRARED FLUX, QIRED = .2000+01 BTU/(HR SQ FT)
AERODYN. HEATING POWER, QCONV = -.1634+05 BTU/HR
ENERGY STORAGE RATE, STORG = -.3076+05 BTU/HR

AXIAL DIST. Z	RELATIVE RAD. HEAT REJECTION Q	RELATIVE TEMPERATURE OF FIN, T — DISTANCE NORMAL TO FLOW DIRECTION X: .00000	.25000	.50000	.75000	1.00000
.000	1.2195	1.0879	1.0879	1.0879	1.0879	1.0879
.125	.6981	.9517	.8626	.8047	.7764	.7689
.250	.3854	.9572	.8687	.8112	.7832	.7759
.375	.3856	.9550	.8680	.8110	.7832	.7758
.500	.3860	.9574	.8691	.8115	.7834	.7760
.625	.2817	.9560	.8704	.8141	.7866	.7793
.750	.3870	.9585	.8697	.8117	.7835	.7760
.875	.7019	.9489	.8620	.8044	.7762	.7687
1.000 (EXIT)	1.2263	1.0893	1.0893	1.0893	1.0893	1.0893

FLUID PROPERTIES AND SURFACE TEMPERATURE OF METEOROID PROTECTION LAYER
****

REFERENCE TEMPERATURE, T00 = 659.670 R
REFERENCE PRESSURE, P00 = 8640.000 LBF/SQ.FT
REFERENCE VELOCITY, W00 = .871 FT/SEC
COOLANT POWER, INLET AT T=T0 H0 = .276867+05 BTU/HR
EXIT CURRENTLY EI = .234041+05 BTU/HR

INLET CURRENTLY HI = .276867+05 BTU/HR
TOT. REJECTION DH = .428260+04 BTU/HR

AXIAL DIST.	PRESSURE P	VELOCITY W	FLUID TEMPERATURES TF	WALL TEMPERATURES TWI	PROTECT. LAYER TEMPERATURES TMP	ENTHALPY REJECTION PER UNIT TUBE LENGTH BTU/(HR FT)	ENTHALPY REJECTION FRACTION OF TOTAL
.000	1.00000	1.0000	1.0000	1.0879	1.0879	-186.124290	.00000
.125	.99981	.9956	.9867	.9517	.9517	74.285834	-.11604
.250	.99962	.9928	.9871	.9572	.9572	63.325497	.30202
.375	.99942	.9913	.9760	.9550	.9550	44.420708	.52840
.500	.99923	.9896	.9815	.9574	.9574	50.998492	.75807
.625	.99904	.9891	.9689	.9560	.9560	27.315979	.98675
.750	.99885	.9881	.9807	.9585	.9585	46.887507	1.14491
.875	.99866	.9868	.9641	.9489	.9489	32.308490	1.38225
1.000 (EXIT)	.99847	.9970	.9754	1.0893	1.0893	-241.334110	1.00000

FIGURE 10(A) CONTINUED

ELAPSED TIME IS .0500 HR , RELATIVE TIME IS 13.0687 55 INTEGR. STEPS
ALTITUDE IS 194986.66 FT , VELOCITY IS 6199.57 FT/SEC , ATM. TEMPERATURE IS 462.40 R

FIN TEMPERATURE DISTRIBUTION AND RADIANT HEAT REJECTION

REFERENCE TEMPERATURE, T00 = 659.670 R ,
REF. RADIANT HEAT FLUX
PER UNIT AXIAL LENGTH, QREF = .3246+04 BTU/(HR FT),
TOT. RADIANT REJECTION QTOT = .2358+05 BTU/HR ,
COND. FROM MANIFOLDS, CONDMF = .2680+03 BTU/HR ,

INCIDENT SOLAR FLUX, QSOLR = .1000+03 BTU/(HR SQ FT)
INCIDENT INFRARED FLUX, QIRED = .2000+01 BTU/(HR SQ FT)
AERODYN. HEATING POWER, QCONV = .2487+05 BTU/HR
ENERGY STORAGE RATE, STORG = .1333+05 BTU/HR

AXIAL DIST. Z	RELATIVE RAD. HEAT REJECTION Q	RELATIVE TEMPERATURE OF FIN, T — DISTANCE NORMAL TO FLOW DIRECTION X: .00000	.25000	.50000	.75000	1.00000
.000	.7697	.9783	.9783	.9783	.9783	.9783
.125	.6604	.9172	.9160	.9160	.9152	.9147
.250	.5928	.9214	.9231	.9249	.9252	.9250
.375	.5873	.9133	.9177	.9216	.9231	.9233
.500	.5825	.9130	.9182	.9223	.9238	.9240
.625	.5725	.9076	.9160	.9225	.9254	.9261
.750	.5751	.9070	.9147	.9204	.9227	.9231
.875	.5904	.8927	.9012	.9077	.9106	.9112
1.000 (EXIT)	.6184	.9315	.9315	.9315	.9315	.9315

FIGURE 10(A) CONTINUED

FLUID PROPERTIES AND SURFACE TEMPERATURE OF METEOROID PROTECTION LAYER

REFERENCE TEMPERATURE, T00 = 659.670 R
REFERENCE PRESSURE, P00 = 8640.000 LBF/SQ.FT
REFERENCE VELOCITY, W00 = .871 FT/SEC
COOLANT POWER, INLET AT T=T0 H0 = .276867+05 BTU/HR
EXIT CURRENTLY EI = .159106+05 BTU/HR

INLET CURRENTLY HI = .276867+05 BTU/HR
TOT. REJECTION DH = .117761+05 BTU/HR

AXIAL DIST.	PRESSURE P	VELOCITY W	FLUID TEMPERATURES TF	WALL TEMPERATURES TWI	PROTECT. LAYER TEMPERATURES TMP	ENTHALPY REJECTION PER UNIT TUBE LENGTH BTU/(HR FT)	ENTHALPY REJECTION FRACTION OF TOTAL
.000	1.00000	1.0000	1.0000	.9783	.9783	42.947949	.00000
.125	.99981	.9927	.9814	.9172	.9172	126.966851	.14939
.250	.99961	.9874	.9750	.9214	.9214	106.037679	.33239
.375	.99942	.9827	.9603	.9133	.9133	92.991148	.47533
.500	.99923	.9784	.9561	.9130	.9130	85.266257	.61012
.625	.99904	.9748	.9429	.9076	.9076	69.837278	.72965
.750	.99885	.9714	.9416	.9070	.9070	68.399486	.83144
.875	.99866	.9677	.9290	.8927	.8927	71.936090	.93790
1.000 (EXIT)	.99847	.9672	.9252	.9315	.9315	-12.536525	1.00000

ELAPSED TIME IS .0750 HR , RELATIVE TIME IS 19.6031 80 INTEGR. STEPS
ALTITUDE IS 308492.96 FT , VELOCITY IS 11899.46 FT/SEC , ATM. TEMPERATURE IS 334.32 R

FIN TEMPERATURE DISTRIBUTION AND RADIANT HEAT REJECTION
****

REFERENCE TEMPERATURE, T00 = 659.670 R
REF. RADIANT HEAT FLUX PER UNIT AXIAL LENGTH, QREF = .3246+04 BTU/(HR FT),
TOT. RADIANT REJECTION QTOT = .2231+05 BTU/HR ,
COND. FROM MANIFOLDS, CONDMF = .2343+03 BTU/HR ,

INCIDENT SOLAR FLUX, QSOLR = .1000+03 BTU/(HR SQ FT)
INCIDENT INFRARED FLUX, QIRED = .2000+01 BTU/(HR SQ FT)
AERODYN. HEATING POWER, QCONV = .6611+04 BTU/HR
ENERGY STORAGE RATE, STORG = -.4995+04 BTU/HR

AXIAL DIST. Z	RELATIVE RAD. HEAT REJECTION Q	RELATIVE TEMPERATURE OF FIN, T — DISTANCE NORMAL TO FLOW DIRECTION X: .00000	.25000	.50000	.75000	1.00000
.000	.7313	.9671	.9671	.9671	.9671	.9671
.125	.6328	.9301	.9147	.9054	.9007	.8993
.250	.5703	.9322	.9199	.9128	.9093	.9084
.375	.5614	.9246	.9138	.9078	.9051	.9044
.500	.5533	.9224	.9127	.9075	.9051	.9046
.625	.5419	.9172	.9092	.9053	.9039	.9035
.750	.5395	.9146	.9068	.9030	.9015	.9012
.875	.5462	.9035	.8954	.8913	.8897	.8894
1.000 (EXIT)	.5620	.9121	.9121	.9121	.9121	.9121

FIGURE 10(A) CONTINUED

FLUID PROPERTIES AND SURFACE TEMPERATURE OF METEOROID PROTECTION LAYER
****

REFERENCE TEMPERATURE, T00 = 659.670 R
REFERENCE PRESSURE, P00 = 8640.000 LBF/SQ.FT
REFERENCE VELOCITY, W00 = .871 FT/SEC
COOLANT POWER, INLET AT T=T0 H0 = .276867+05 BTU/HR INLET CURRENTLY HI = .276867+05 BTU/HR
EXIT CURRENTLY EI = .172146+05 BTU/HR TOT. REJECTION DH = .104721+05 BTU/HR

AXIAL DIST.	PRESSURE P	VELOCITY W	FLUID TEMPERATURES TF	WALL TEMPERATURES TWI	PROTECT. LAYER TEMPERATURES TMP	ENTHALPY REJECTION PER UNIT TUBE LENGTH BTU/(HR FT)	ENTHALPY REJECTION FRACTION OF TOTAL
.000	1.00000	1.0000	1.0000	.9671	.9671	67.116564	.00000
.125	.99981	.9939	.9852	.9301	.9301	112.356394	.15252
.250	.99961	.9892	.9780	.9322	.9322	93.483206	.31570
.375	.99942	.9850	.9670	.9246	.9246	86.350813	.44687
.500	.99923	.9811	.9610	.9224	.9224	78.735278	.57788
.625	.99904	.9778	.9515	.9172	.9172	69.991269	.69352
.750	.99885	.9746	.9473	.9146	.9146	66.729493	.79852
.875	.99866	.9712	.9386	.9035	.9035	71.472905	.90460
1.000 (EXIT)	.99847	.9690	.9329	.9121	.9121	42.267320	1.00000

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```
ELAPSED TIME IS        .1000 HR ,     RELATIVE TIME IS       26.1375              96 INTEGR. STEPS
ALTITUDE IS        330000.00   FT ,   VELOCITY IS        16499.06 FT/SEC ,      ATM. TEMPERATURE IS     376.50 R
```

FIN TEMPERATURE DISTRIBUTION AND RADIANT HEAT REJECTION

```
REFERENCE TEMPERATURE,        T00  =   659.670 R            ,
REF. RADIANT HEAT FLUX                                          INCIDENT SOLAR FLUX,      QSOLR  =  .1000+03 BTU/(HR SQ FT)
   PER UNIT AXIAL LENGTH, QREF  =   .3246+04 BTU/(HR FT),       INCIDENT INFRARED FLUX,   QIRED  =  .2000+01 BTU/(HR SQ FT)
TOT. RADIANT REJECTION     QTOT  =   .2110+05 BTU/HR       ,    AERODYN. HEATING POWER,   QCONV  =  .8142+04 BTU/HR
COND. FROM MANIFOLDS,    CONDMF  =   .2680+03 BTU/HR       ,    ENERGY STORAGE RATE,      STORG  = -.1412+04 BTU/HR
```

AXIAL DIST. Z	RELATIVE RAD. HEAT REJECTION Q	RELATIVE TEMPERATURE OF FIN, T — DISTANCE NORMAL TO FLOW DIRECTION X: .00000	.25000	.50000	.75000	1.00000
.000	.7192	.9634	.9634	.9634	.9634	.9634
.125	.6096	.9257	.9074	.8948	.8876	.8852
.250	.5396	.9264	.9112	.9010	.8951	.8933
.375	.5289	.9186	.9048	.8955	.8902	.8885
.500	.5189	.9153	.9026	.8941	.8892	.8876
.625	.5029	.9096	.8984	.8910	.8867	.8854
.750	.5014	.9060	.8952	.8880	.8838	.8825
.875	.5144	.8959	.8848	.8772	.8728	.8714
1.000 (EXIT)	.542	.9050	.9050	.9050	.9050	.9050

FIGURE 10(A) CONTINUED

FLUID PROPERTIES AND SURFACE TEMPERATURE OF METEOROID PROTECTION LAYER

```
        REFERENCE TEMPERATURE, T00     =        659.670 R
        REFERENCE PRESSURE,    P00     =       8640.000 LBF/SQ.FT
        REFERENCE VELOCITY,    W00     =           .871 FT/SEC
COOLANT POWER, INLET AT T=T0  H0 =  .276867+05 BTU/HR          INLET CURRENTLY   HI =  .276867+05 BTU/HR
               EXIT CURRENTLY EI =  .164041+05 BTU/HR          TOT. REJECTION    DH =  .112826+05 BTU/HR
```

AXIAL DIST.	PRESSURE P	VELOCITY W	FLUID TEMPERATURES TF	WALL TEMPERATURES TWI	PROTECT. LAYER TEMPERATURES TMP	ENTHALPY REJECTION PER UNIT TUBE LENGTH BTU/(HR FT)	ENTHALPY REJECTION FRACTION OF TOTAL
.000	1.00000	1.0000	1.0000	.9634	.9634	73.935921	.00000
.125	.99981	.9936	.9850	.9257	.9257	119.899873	.15022
.250	.99961	.9885	.9766	.9264	.9264	101.527077	.31116
.375	.99942	.9840	.9651	.9186	.9186	94.038617	.44474
.500	.99923	.9798	.9582	.9153	.9153	86.704713	.57414
.625	.99904	.9760	.9482	.9096	.9096	78.045426	.69177
.750	.99885	.9726	.9429	.9060	.9060	74.709270	.79958
.875	.99866	.9690	.9337	.8959	.8959	76.516509	.90673
1.000 (EXIT)	.99847	.9666	.9276	.9050	.9050	45.841238	1.00000

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```
ELAPSED TIME IS        .1250 HR ,     RELATIVE TIME IS        32.6718           108 INTEGR. STEPS
ALTITUDE IS        313506.32   FT ,     VELOCITY IS        23548.28 FT/SEC ,     ATM. TEMPERATURE IS     341.94 R
```

FIN TEMPERATURE DISTRIBUTION AND RADIANT HEAT REJECTION
****

```
REFERENCE TEMPERATURE,      TOO  =   659.670 R          ,
REF. RADIANT HEAT FLUX                                          INCIDENT SOLAR FLUX,      QSOLR  =  .1000+03 BTU/(HR SQ FT)
   PER UNIT AXIAL LENGTH, QREF  =  .3246+04 BTU/(HR FT),       INCIDENT INFRARED FLUX,   QIRED  =  .2000+01 BTU/(HR SQ FT)
TOT. RADIANT REJECTION     QTOT  =  .2112+05 BTU/HR     ,       AERODYN. HEATING POWER,   QCONV  =  .2673+05 BTU/HR
COND. FROM MANIFOLDS,     CONDMF =  .2058+03 BTU/HR     ,       ENERGY STORAGE RATE,      STORG  =  .1783+05 BTU/HR
```

AXIAL DIST. Z	RELATIVE RAD. HEAT REJECTION Q	RELATIVE TEMPERATURE OF FIN, T — DISTANCE NORMAL TO FLOW DIRECTION X: .00000	.25000	.50000	.75000	1.00000
.000	.7023	.9583	.9583	.9583	.9583	.9583
.125	.6094	.9225	.9108	.9011	.8948	.8926
.250	.5488	.9222	.9136	.9061	.9013	.8995
.375	.5362	.9141	.9067	.9002	.8959	.8943
.500	.5244	.9098	.9036	.8979	.8940	.8926
.625	.5097	.9035	.8988	.8941	.8909	.8897
.750	.5033	.8991	.8949	.8905	.8874	.8862
.875	.5052	.8892	.8849	.8803	.8771	.8759
1.000 (EXIT)	.5154	.8951	.8951	.8951	.8951	.8951

FIGURE 10(A) CONTINUED

FLUID PROPERTIES AND SURFACE TEMPERATURE OF METEOROID PROTECTION LAYER
****

```
      REFERENCE TEMPERATURE, TOO    =        659.670 R
      REFERENCE PRESSURE,    POO    =       8640.000 LBF/SQ.FT
      REFERENCE VELOCITY,    WOO    =           .871 FT/SEC
COOLANT POWER, INLET  AT T=TO  HO =  .276867+05 BTU/HR        INLET CURRENTLY  HI =  .276867+05 BTU/HR
               EXIT  CURRENTLY EI =  .156841+05 BTU/HR        TOT. REJECTION   DH =  .120026+05 BTU/HR
```

AXIAL DIST.	PRESSURE P	VELOCITY W	FLUID TEMPERATURES TF	WALL TEMPERATURES TWI	PROTECT. LAYER TEMPERATURES TMP	ENTHALPY REJECTION PER UNIT TUBE LENGTH BTU/(HR FT)	ENTHALPY REJECTION FRACTION OF TOTAL
.000	1.00000	1.0000	1.0000	.9583	.9583	83.797215	.00000
.125	.99981	.9934	.9847	.9225	.9225	124.993712	.14961
.250	.99961	.9880	.9755	.9222	.9222	107.109274	.30702
.375	.99942	.9832	.9637	.9141	.9141	99.836724	.43992
.500	.99923	.9787	.9559	.9098	.9098	92.636692	.56879
.625	.99904	.9747	.9455	.9035	.9035	84.442323	.68700
.750	.99885	.9709	.9393	.8991	.8991	80.657710	.79626
.875	.99866	.9670	.9298	.8892	.8892	81.486121	.90382
1.000 (EXIT)	.99847	.9642	.9229	.8951	.8951	55.786302	1.00000

```
ELAPSED TIME IS          .1270 HR ,      RELATIVE TIME IS          33.1959              110 INTEGR. STEPS
ALTITUDE IS          310980.00   FT ,    VELOCITY IS           24234.00 FT/SEC ,       ATM. TEMPERATURE IS     337.93 R
```

FIN TEMPERATURE DISTRIBUTION AND RADIANT HEAT REJECTION
****

```
REFERENCE TEMPERATURE,      T00  =   659.670 R
REF. RADIANT HEAT FLUX                                              INCIDENT SOLAR FLUX,       QSOLR  =  .1000+03 BTU/(HR SQ FT)
   PER UNIT AXIAL LENGTH, QREF  =  .3246+04 BTU/(HR FT),           INCIDENT INFRARED FLUX,    QIRED  =  .2000+01 BTU/(HR SQ FT)
TOT. RADIANT REJECTION    QTOT  =  .2123+05 BTU/HR     ,           AERODYN. HEATING POWER,    QCONV  =  .3037+05 BTU/HR
COND. FROM MANIFOLDS,    CONDMF =  .1911+03 BTU/HR     ,           ENERGY STORAGE RATE,       STORG  =  .2135+05 BTU/HR
```

AXIAL DIST. Z	RELATIVE RAD. HEAT REJECTION Q	RELATIVE TEMPERATURE OF FIN, T — DISTANCE NORMAL TO FLOW DIRECTION X: .00000	.25000	.50000	.75000	1.00000
.000	.7001	.9576	.9576	.9576	.9576	.9576
.125	.6115	.9226	.9122	.9032	.8973	.8951
.250	.5534	.9222	.9149	.9081	.9036	.9019
.375	.5406	.9140	.9081	.9022	.8982	.8967
.500	.5286	.9097	.9049	.8998	.8962	.8949
.625	.5145	.9034	.9000	.8960	.8930	.8919
.750	.5072	.8989	.8961	.8923	.8895	.8884
.875	.5066	.8891	.8862	.8823	.8793	.8782
1.000 (EXIT)	.5127	.8941	.8941	.8941	.8941	.8941

FIGURE 10(A) CONCLUDED

FLUID PROPERTIES AND SURFACE TEMPERATURE OF METEOROID PROTECTION LAYER
****

```
REFERENCE TEMPERATURE, T00   =      659.670 R
REFERENCE PRESSURE,    P00   =     8640.000 LBF/SQ.FT
REFERENCE VELOCITY,    W00   =         .871 FT/SEC
COOLANT POWER, INLET  AT T=T0  H0 =  .276867+05 BTU/HR             INLET CURRENTLY  HI =  .276867+05 BTU/HR
               EXIT  CURRENTLY  EI =  .156649+05 BTU/HR             TOT. REJECTION   DH =  .120218+05 BTU/HR
```

AXIAL DIST.	PRESSURE P	VELOCITY W	FLUID TEMPERATURES TF	WALL TEMPERATURES TWI	PROTECT. LAYER TEMPERATURES TMP	ENTHALPY REJECTION PER UNIT TUBE LENGTH BTU/(HR FT)	ENTHALPY REJECTION FRACTION OF TOTAL
.000	1.00000	1.0000	1.0000	.9576	.9576	85.173653	.00000
.125	.99981	.9934	.9847	.9226	.9226	124.974236	.14983
.250	.99961	.9880	.9755	.9222	.9222	107.177940	.30672
.375	.99942	.9832	.9638	.9140	.9140	99.976870	.43945
.500	.99923	.9787	.9558	.9097	.9097	92.755548	.56813
.625	.99904	.9746	.9455	.9034	.9034	84.717443	.68622
.750	.99885	.9708	.9392	.8989	.8989	80.865383	.79553
.875	.99866	.9670	.9297	.8891	.8891	81.721740	.90304
1.000 (EXIT)	.99847	.9641	.9227	.8941	.8941	57.510110	1.00000

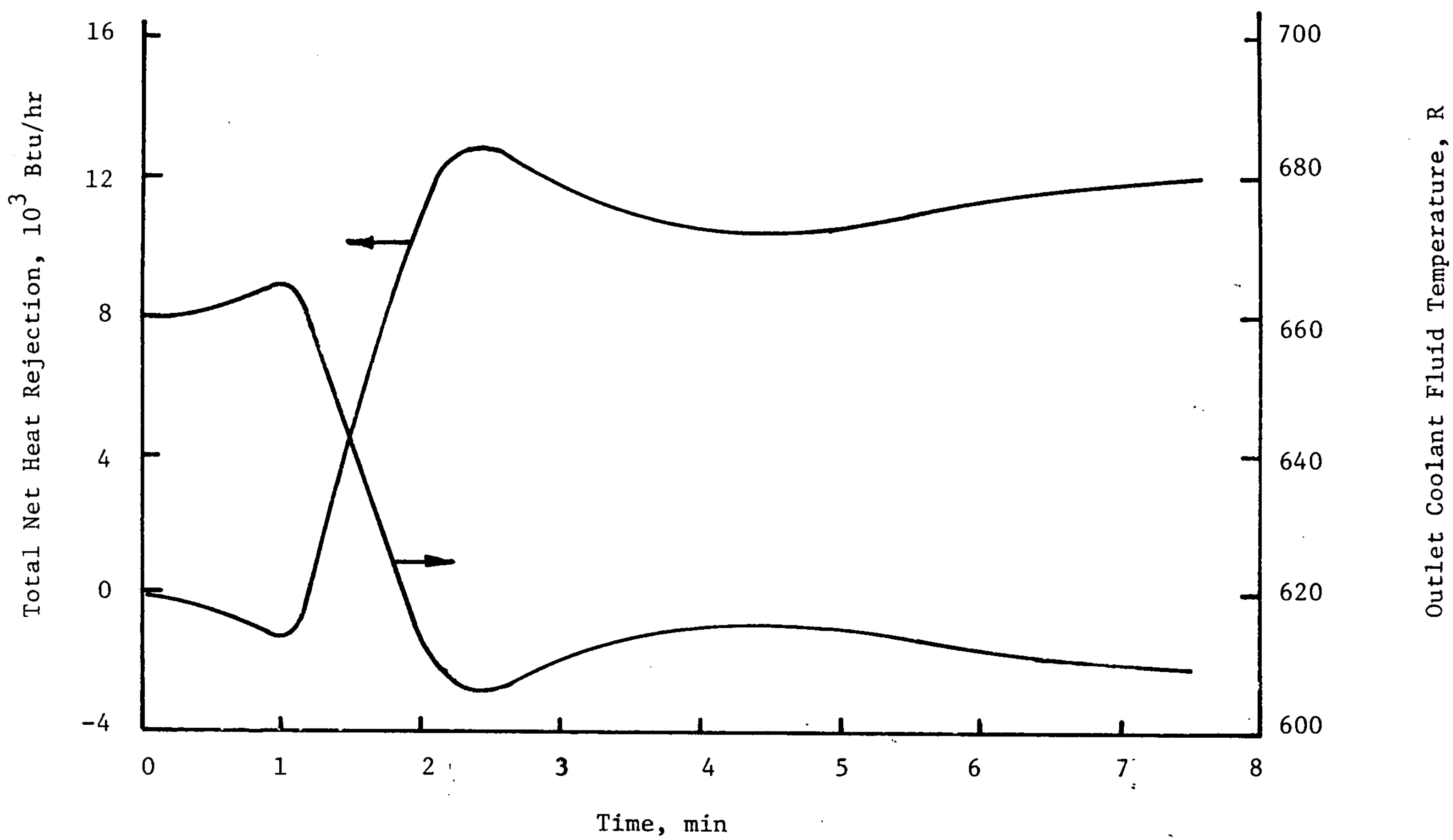

Fig. 10(b) System Response For Ascent-System Heat Rejection And Outlet Fluid Temperature

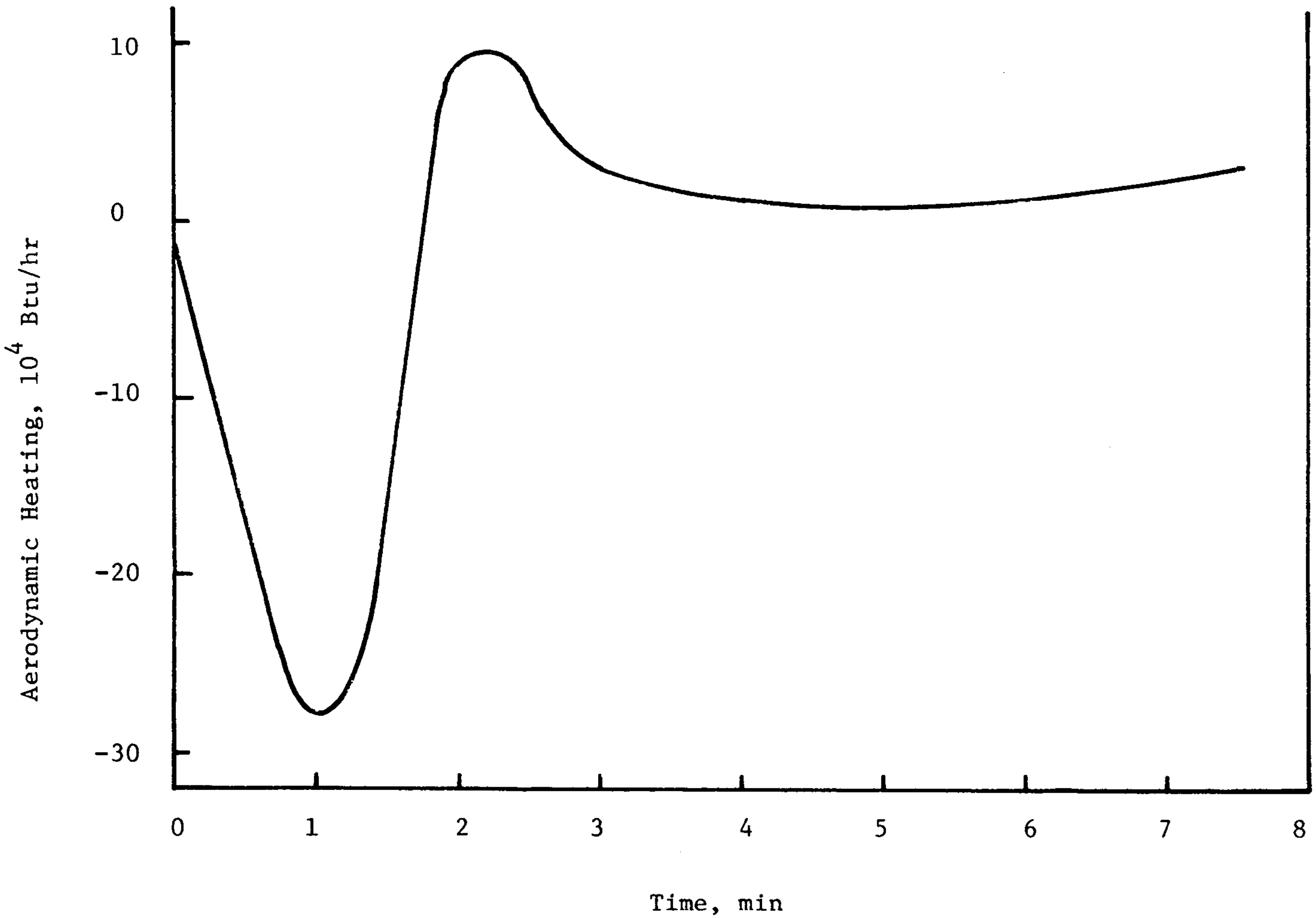

Fig. 11 Aerodynamic Heating For Ascent

b. Reentry

(i) Mission Description

The reentry altitude and velocity profiles used for the system output shown in Figures 13 and 14 are given in Figure 12.
Input parameters for reentry are identical to those given in the mission description for ascent except for ICØNV which is set equal to 2 to designate reentry. The system parameters for reentry are printed prior to the current system output shown in Figure 13a.

(ii) System Response

The response of the radiator system during reentry is summarized in Figures 13 and 14. Figure 13 (a) provides selected program output showing current system conditions at various times during the reentry phase of the mission. Figure 13 (b) is a plot of the total heat rejection from the radiator system and the temperature of the coolant fluid at the exit plane of the flow channel. Figure 14 is a graph of the aerodynamic heating of the system as a function of time during the reentry phase of the mission.

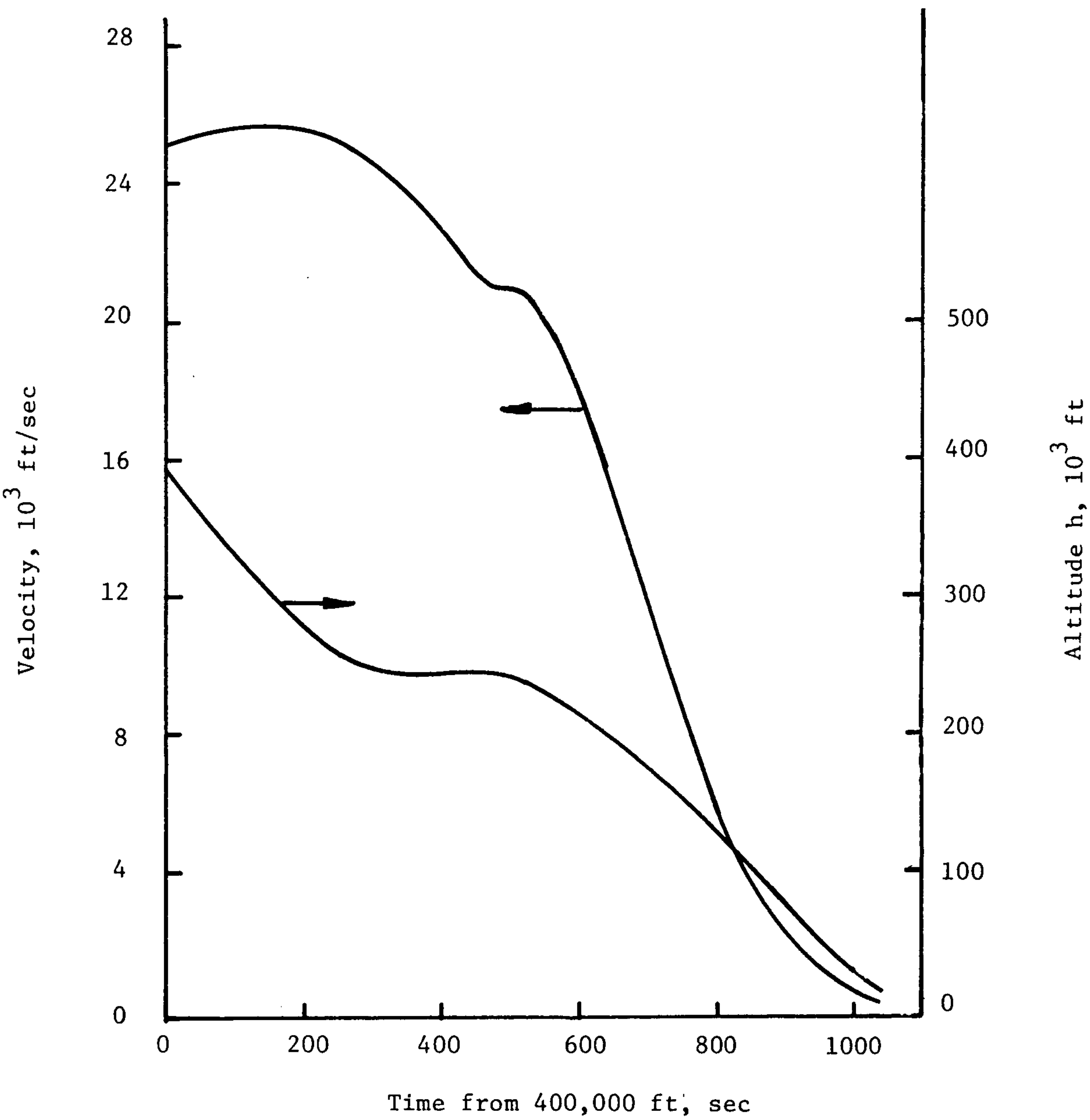

Fig. 12 Reentry Velocity and Altitude Profiles

```
02
$QNML
ITAPE   =              +0
ICASE   =              +0
NTM     =              +4
TO      =    .00000000E+00
PHN     =    .00000000E+00

$END
$TUBE
DITBI   =    .25000000E+00
STBI    =    .10000000E+00
XL      =    .12000000E+02
RHOTBI  =    .16859200E+03
MZ      =              +9
NRTBI   =              +3
NTBS    =             +10

$END
$FLOW
MDOTI   =    .50000000E+03
TO      =    .65967000E+03
PO      =    .86400000E+04

$END
$FIN
NX      =              +5
SROOTI  =    .50000000E-01
HFNI    =    .60000000E+01
STIFI   =    .50000000E-01
RHOFNI  =    .16859200E+03
STAGX   =    .20000000E+02
VERTX   =    .10000000E+02

$END
$PROTLR
NRMP    =              +3
RHOMPI  =    .16859200E+03
RHOMET  =    .50000000E+00
VELM    =    .65600000E+05
TAU     =    .36500000E+04
PROB    =    .99000000E+00
ALPHA   =    .18800000E-09
BTA     =    .12130000E+01
GAMMA   =    .15000000E+01
PHI     =    .50000000E+00
THETA   =    .66666700E+00
AIK     =    .17500000E+01
AN      =    .10000000E+01

$END
$MANIFD
AMAN    =    .43000000E+02

$END
$RUNOPT
MSTOTR  =              +2
```

Figure 13(a) System Response For Reentry Program Output

```
DTWRTE  =     .16667000E-01
TEND    =     .29400000E+00
ALIMIT  =     .50000000E-04
RLIMIT  =     .10000000E-04
TI      =     .65967000E+03
LIMWRT  =               +25
NCONV   =                +2
LTT     =                +0
LFLD    =                +1
LTS     =                +0

$END
```

FIGURE 13(A) CONTINUED

```
         INITIAL LINE CONDITIONS
         ******* **** **********
              (ALL QUANTITIES ARE NORMALIZED)
                                                                       FLUID            WALL
       PT.NO.  POSITION        PRESSURE         VELOCITY       TEMPERATURE      TEMPERATURE
                  Z               P                W                T               TWI

          1     .000          1.000000         1.000000         1.000000        1.000000
          2     .125           .999810         1.000000         1.000000        1.000000
          3     .250           .999621         1.000001         1.000000        1.000000
          4     .375           .999431         1.000001         1.000000        1.000000
          5     .500           .999241         1.000001         1.000000        1.000000
          6     .625           .999052         1.000001         1.000000        1.000000
          7     .750           .998862         1.000001         1.000000        1.000000
          8     .875           .998673         1.000002         1.000000        1.000000
          9    1.000           .998483         1.000002         1.000000        1.000000

INLET PRESSURE    PO  =   8640.000  LBF/SQ.FT
REF.  VELOCITY    WO  =     .87128  FT/SEC
REF. TEMPERATURE TOO  =    659.670  R

      REYNOLDS NO     =            .30017+04
      PRANDTL  NO     =            8.628066
      DELTA           =             .001736
      REL.PRESSURE IS              .391534+04

INIT. NUSSELT NO. NU  =            .201856+02
WALL BIOT NO.     BI  =            .485314-02

         SYSTEM PARAMETERS
         *****************

TUBE LENGTH ,                  XL =       12.000 FT
     INTERNAL DIAMETER ,     DITB =         .250 IN
     WALL THICKNESS ,         STB =         .100 IN
     MATERIAL                          ALUMINUM
     MASS   (ALL TUBES) ,     MTB =      15.4480 LBM
     NUMBER OF TUBES,        NTBS =           10

FIN  HEIGHT ,                 HFN =        6.000 IN
     THICKNESS AT ROOT ,    SROOT =         .050 IN
     THICKNESS AT TIP ,      STIP =         .050 IN
     MATERIAL                          ALUMINUM
     MASS (ALL FINS) ,        MFN =      84.2960 LBM
     NO. OF FIN SIDES RADIATING   =            1

COOLANT FLUID IS                       SILICONE OIL
     MASS (IN ALL TUBES) ,    MFL =      19.1289 LBM

 PROTECTION LAYER THICKNESS,  SMP =         .011 IN
     MASS,                    MMP =        2.038 LBM
     MATERIAL IS                       BERYLLIUM

TOTAL MASS (EXCL. MANIFLD.) MTOT =     120.9104 LBM
```

FIGURE 13(A) CONTINUED

```
TOTAL AREA (SINGLE NORMAL PROJECTION) ,
                        ATOT =   124.5000 SQ FT
02
```

FIGURE 13(A) CONTINUED

```
ELAPSED TIME IS          .0000 HR ,     RELATIVE TIME IS          .0000              1 INTEGR. STEPS
ALTITUDE IS         394000.00  FT ,     VELOCITY IS         25400.00 FT/SEC ,        ATM. TEMPERATURE IS      661.41 R
```

02

FIN TEMPERATURE DISTRIBUTION AND RADIANT HEAT REJECTION
****

```
REFERENCE TEMPERATURE,     TOO  =   659.670 R        ,
REF. RADIANT HEAT FLUX                                      INCIDENT SOLAR FLUX,       QSOLR  =  .1000+03 BTU/(HR SQ FT)
  PER UNIT AXIAL LENGTH,   QREF =  .3246+04 BTU/(HR FT),    INCIDENT INFRARED FLUX,    QIRED  =  .2000+01 BTU/(HR SQ FT)
TOT. RADIANT REJECTION     QTOT =  .3289+05 BTU/HR   ,      AERODYN. HEATING POWER,    QCONV  =  .6237+04 BTU/HR
COND. FROM MANIFOLDS,      CONDMF = .0000   BTU/HR   ,      ENERGY STORAGE RATE,       STORG  = -.2665+05 BTU/HR
```

AXIAL DIST. Z	RELATIVE RAD. HEAT REJECTION Q	RELATIVE TEMPERATURE OF FIN, T — DISTANCE NORMAL TO FLOW DIRECTION X: .00000	.25000	.50000	.75000	1.00000
.000	.8477	1.0000	1.0000	1.0000	1.0000	1.0000
.125	.8451	1.0000	1.0000	1.0000	1.0000	1.0000
.250	.8436	1.0000	1.0000	1.0000	1.0000	1.0000
.375	.8436	1.0000	1.0000	1.0000	1.0000	1.0000
.500	.8436	1.0000	1.0000	1.0000	1.0000	1.0000
.625	.8430	1.0000	1.0000	1.0000	1.0000	1.0000
.750	.8436	1.0000	1.0000	1.0000	1.0000	1.0000
.875	.8451	1.0000	1.0000	1.0000	1.0000	1.0000
1.000 (EXIT)	.8477	1.0000	1.0000	1.0000	1.0000	1.0000

FIGURE 13(A) CONTINUED

FLUID PROPERTIES AND SURFACE TEMPERATURE OF METEOROID PROTECTION LAYER
****

```
REFERENCE TEMPERATURE, TOO      =        659.670 R
REFERENCE PRESSURE,    POO      =        8640.000 LBF/SQ.FT
REFERENCE VELOCITY,    WOO      =        .871 FT/SEC
COOLANT POWER, INLET  AT T=TO  HO =  .276867+05 BTU/HR          INLET CURRENTLY  HI =  .276867+05 BTU/HR
               EXIT  CURRENTLY  EI =  .276866+05 BTU/HR          TOT. REJECTION   DH =  .500488-01 BTU/HR
```

AXIAL DIST.	PRESSURE P	VELOCITY W	FLUID TEMPERATURES TF	WALL TEMPERATURES TWI	PROTECT. LAYER TEMPERATURES TMP	ENTHALPY REJECTION PER UNIT TUBE LENGTH BTU/(HR FT)	ENTHALPY REJECTION FRACTION OF TOTAL
.000	1.00000	1.0000	1.0000	1.0000	1.0000	.000000	.00000
.125	.99981	1.0000	1.0000	1.0000	1.0000	.000138	.02563
.250	.99962	1.0000	1.0000	1.0000	1.0000	.000242	.09431
.375	.99943	1.0000	1.0000	1.0000	1.0000	.000311	.19375
.500	.99924	1.0000	1.0000	1.0000	1.0000	.000380	.31625
.625	.99905	1.0000	1.0000	1.0000	1.0000	.000450	.46386
.750	.99886	1.0000	1.0000	1.0000	1.0000	.000484	.63147
.875	.99867	1.0000	1.0000	1.0000	1.0000	.000519	.80933
1.000 (EXIT)	.99848	1.0000	1.0000	1.0000	1.0000	.000553	1.00000

ELAPSED TIME IS .0500 HR , RELATIVE TIME IS 13.0695 36 INTEGR. STEPS
ALTITUDE IS 292998.55 FT , VELOCITY IS 25799.98 FT/SEC , ATM. TEMPERATURE IS 325.17 R

FIN TEMPERATURE DISTRIBUTION AND RADIANT HEAT REJECTION
****

REFERENCE TEMPERATURE, T00 = 659.670 R ,
REF. RADIANT HEAT FLUX PER UNIT AXIAL LENGTH, QREF = .3246+04 BTU/(HR FT),
TOT. RADIANT REJECTION QTOT = .2773+05 BTU/HR ,
COND. FROM MANIFOLDS, CONDMF = -.9819+02 BTU/HR ,

INCIDENT SOLAR FLUX, QSOLR = .1000+03 BTU/(HR SQ FT)
INCIDENT INFRARED FLUX, QIRED = .2000+01 BTU/(HR SQ FT)
AERODYN. HEATING POWER, QCONV = .5638+05 BTU/HR
ENERGY STORAGE RATE, STORG = .3510+05 BTU/HR

AXIAL DIST. Z	RELATIVE RAD. HEAT REJECTION Q	RELATIVE TEMPERATURE OF FIN, T — DISTANCE NORMAL TO FLOW DIRECTION X: .00000	.25000	.50000	.75000	1.00000
.000	.7159	.9625	.9625	.9625	.9625	.9625
.125	.7255	.9584	.9678	.9711	.9720	.9719
.250	.7293	.9556	.9662	.9703	.9716	.9717
.375	.7242	.9527	.9643	.9690	.9707	.9709
.500	.7198	.9500	.9626	.9679	.9699	.9702
.625	.7259	.9478	.9610	.9668	.9691	.9694
.750	.7126	.9458	.9598	.9662	.9687	.9691
.875	.6797	.9441	.9589	.9657	.9684	.9690
1.000 (EXIT)	.6273	.9345	.9345	.9345	.9345	.9345

FIGURE 13(A) CONTINUED

FLUID PROPERTIES AND SURFACE TEMPERATURE OF METEOROID PROTECTION LAYER
****

REFERENCE TEMPERATURE, T00 = 659.670 R
REFERENCE PRESSURE, P00 = 8640.000 LBF/SQ.FT
REFERENCE VELOCITY, W00 = .871 FT/SEC
COOLANT POWER, INLET AT T=T0 H0 = .276867+05 BTU/HR
EXIT CURRENTLY EI = .211383+05 BTU/HR

INLET CURRENTLY HI = .276867+05 BTU/HR
TOT. REJECTION DH = .654839+04 BTU/HR

AXIAL DIST.	PRESSURE P	VELOCITY W	FLUID TF (TEMPERATURES)	WALL TWI (TEMPERATURES)	PROTECT. LAYER TMP (TEMPERATURES)	ENTHALPY REJECTION PER UNIT TUBE LENGTH BTU/(HR FT)	ENTHALPY REJECTION FRACTION OF TOTAL
.000	1.00000	1.0000	1.0000	.9625	.9625	80.776558	.00000
.125	.99981	.9963	.9925	.9584	.9584	73.419073	.17633
.250	.99962	.9931	.9856	.9556	.9556	64.706697	.33361
.375	.99943	.9902	.9799	.9527	.9527	58.594118	.47323
.500	.99924	.9877	.9742	.9500	.9500	51.918591	.59957
.625	.99905	.9854	.9698	.9478	.9478	47.317073	.71200
.750	.99886	.9834	.9649	.9458	.9458	41.271317	.81355
.875	.99867	.9816	.9619	.9441	.9441	38.321868	.90322
1.000 (EXIT)	.99848	.9794	.9578	.9345	.9345	50.009891	1.00000

ELAPSED TIME IS .1000 HR , RELATIVE TIME IS 26.1390 60 INTEGR. STEPS
ALTITUDE IS 245000.71 FT , VELOCITY IS 23799.82 FT/SEC , ATM. TEMPERATURE IS 362.54 R

FIN TEMPERATURE DISTRIBUTION AND RADIANT HEAT REJECTION

REFERENCE TEMPERATURE, TOO = 659.670 R ,
REF. RADIANT HEAT FLUX PER UNIT AXIAL LENGTH, QREF = .3246+04 BTU/(HR FT),
TOT. RADIANT REJECTION QTOT = .5506+05 BTU/HR ,
CONU. FROM MANIFOLDS, CONDMF = -.1573+03 BTU/HR ,

INCIDENT SOLAR FLUX, QSOLR = .1000+03 BTU/(HR SQ FT)
INCIDENT INFRARED FLUX, QIRED = .2000+01 BTU/(HR SQ FT)
AERODYN. HEATING POWER, QCONV = .1775+06 BTU/HR
ENERGY STORAGE RATE, STORG = .1193+06 BTU/HR

AXIAL DIST. Z	RELATIVE RAD. HEAT REJECTION Q	RELATIVE TEMPERATURE OF FIN, T — DISTANCE NORMAL TO FLOW DIRECTION X: .00000	.25000	.50000	.75000	1.00000
.000	.6299	.9354	.9354	.9354	.9354	.9354
.125	1.2481	1.0371	1.1389	1.2022	1.2359	1.2459
.250	1.6155	1.0278	1.1252	1.1849	1.2163	1.2254
.375	1.6061	1.0297	1.1254	1.1843	1.2153	1.2243
.500	1.5974	1.0254	1.1221	1.1816	1.2130	1.2222
.625	1.7098	1.0252	1.1178	1.1745	1.2043	1.2130
.750	1.5816	1.0219	1.1189	1.1789	1.2106	1.2200
.875	1.2127	1.0341	1.1332	1.1958	1.2296	1.2398
1.000 (EXIT)	.6032	.9265	.9265	.9265	.9265	.9265

FIGURE 13(A) CONTINUED

FLUID PROPERTIES AND SURFACE TEMPERATURE OF METEOROID PROTECTION LAYER

REFERENCE TEMPERATURE, TOO = 659.670 R
REFERENCE PRESSURE, POO = 8640.000 LBF/SQ.FT
REFERENCE VELOCITY, WOO = .871 FT/SEC
COOLANT POWER, INLET AT T=TO HO = .276867+05 BTU/HR
EXIT CURRENTLY EI = .307355+05 BTU/HR

INLET CURRENTLY HI = .276867+05 BTU/HR
TOT. REJECTION DH = -.304877+04 BTU/HR

AXIAL DIST.	PRESSURE P	VELOCITY W	FLUID TEMPERATURES TF	WALL TEMPERATURES TWI	PROTECT. LAYER TEMPERATURES TMP	ENTHALPY REJECTION PER UNIT TUBE LENGTH BTU/(HR FT)	ENTHALPY REJECTION FRACTION OF TOTAL
.000	1.00000	1.0000	1.0000	.9354	.9354	160.289324	.00000
.125	.99981	1.0040	1.0125	1.0371	1.0371	-61.108924	-.30040
.250	.99962	1.0060	1.0110	1.0278	1.0278	-41.625156	.64967
.375	.99944	1.0070	1.0198	1.0297	1.0297	-24.422209	1.00147
.500	.99925	1.0081	1.0143	1.0254	1.0254	-27.635271	1.36675
.625	.99906	1.0079	1.0242	1.0252	1.0252	-2.552186	1.66864
.750	.99887	1.0084	1.0127	1.0219	1.0219	-23.023775	1.76029
.875	.99868	1.0095	1.0268	1.0341	1.0341	-18.077758	2.15741
1.000 (EXIT)	.99850	1.0004	1.0171	.9265	.9265	224.826389	1.00000

ELAPSED TIME IS .1500 HR , RELATIVE TIME IS 39.2085 86 INTEGR. STEPS
ALTITUDE IS 234996.24 FT , VELOCITY IS 20199.73 FT/SEC , ATM. TEMPERATURE IS 384.00 R

02

FIN TEMPERATURE DISTRIBUTION AND RADIANT HEAT REJECTION
****

REFERENCE TEMPERATURE, T00 = 659.670 R ,
REF. RADIANT HEAT FLUX PER UNIT AXIAL LENGTH, QREF = .3246+04 BTU/(HR FT),
TOT. RADIANT REJECTION QTOT = .6486+05 BTU/HR ,
COND. FROM MANIFOLDS, CONDMF = .4866+03 BTU/HR ,

INCIDENT SOLAR FLUX, QSOLR = .1000+03 BTU/(HR SQ FT)
INCIDENT INFRARED FLUX, QIRED = .2000+01 BTU/(HR SQ FT)
AERODYN. HEATING POWER, QCONV = .1582+06 BTU/HR
ENERGY STORAGE RATE, STORG = .8051+05 BTU/HR

AXIAL DIST. Z	RELATIVE RAD. HEAT REJECTION Q	RELATIVE TEMPERATURE OF FIN, T — DISTANCE NORMAL TO FLOW DIRECTION X: .00000	.25000	.50000	.75000	1.00000
.000	.7198	.9636	.9636	.9636	.9636	.9636
.125	1.4150	1.0926	1.1935	1.2578	1.2935	1.3045
.250	1.8367	1.0752	1.1646	1.2196	1.2491	1.2579
.375	1.8485	1.0866	1.1724	1.2249	1.2530	1.2614
.500	1.8592	1.0847	1.1701	1.2224	1.2504	1.2587
.625	1.9854	1.0895	1.1675	1.2141	1.2385	1.2456
.750	1.8776	1.0901	1.1738	1.2249	1.2523	1.2605
.875	1.5358	1.1232	1.2130	1.2699	1.3012	1.3108
1.000 (EXIT)	.9599	1.0290	1.0290	1.0290	1.0290	1.0290

FIGURE 13(A) CONTINUED

FLUID PROPERTIES AND SURFACE TEMPERATURE OF METEOROID PROTECTION LAYER
****

REFERENCE TEMPERATURE, T00 = 659.670 R
REFERENCE PRESSURE, P00 = 8640.000 LBF/SQ.FT
REFERENCE VELOCITY, W00 = .871 FT/SEC
COOLANT POWER, INLET AT T=T0 H0 = .276867+05 BTU/HR
EXIT CURRENTLY EI = .410317+05 BTU/HR

INLET CURRENTLY HI = .276867+05 BTU/HR
TOT. REJECTION DH = -.133450+05 BTU/HR

AXIAL DIST.	PRESSURE P	VELOCITY W	FLUID TEMPERATURES TF	WALL TEMPERATURES TWI	PROTECT. LAYER TEMPERATURES TMP	ENTHALPY REJECTION PER UNIT TUBE LENGTH BTU/(HR FT)	ENTHALPY REJECTION FRACTION OF TOTAL
.000	1.00000	1.0000	1.0000	.9636	.9636	99.048074	.00000
.125	.99982	1.0106	1.0293	1.0926	1.0926	-172.390614	.11927
.250	.99963	1.0168	1.0327	1.0752	1.0752	-115.685914	.35437
.375	.99944	1.0217	1.0514	1.0866	1.0866	-95.888686	.48609
.500	.99926	1.0265	1.0507	1.0847	1.0847	-92.660016	.62721
.625	.99907	1.0295	1.0694	1.0895	1.0895	-54.798841	.74575
.750	.99888	1.0332	1.0604	1.0901	1.0901	-80.840606	.83365
.875	.99869	1.0390	1.0841	1.1232	1.1232	-106.374774	.97867
1.000 (EXIT)	.99850	1.0341	1.0833	1.0290	1.0290	147.963610	1.00000

ELAPSED TIME IS .2000 HR , RELATIVE TIME IS 52.2780 112 INTEGR. STEPS
ALTITUDE IS 171993.57 FT , VELOCITY IS 10399.29 FT/SEC , ATM. TEMPERATURE IS 487.17 R

FIN TEMPERATURE DISTRIBUTION AND RADIANT HEAT REJECTION

REFERENCE TEMPERATURE, T00 = 659.670 R

REF. RADIANT HEAT FLUX PER UNIT AXIAL LENGTH,	QREF	= .3246+04 BTU/(HR FT),	INCIDENT SOLAR FLUX,	QSOLR	=	.1000+03 BTU/(HR SQ FT)
			INCIDENT INFRARED FLUX,	QIRED	=	.2000+01 BTU/(HR SQ FT)
TOT. RADIANT REJECTION	QTOT	= .7602+05 BTU/HR	AERODYN. HEATING POWER,	QCONV	=	.1290+06 BTU/HR
COND. FROM MANIFOLDS,	CONDMF	= .6873+03 BTU/HR	ENERGY STORAGE RATE,	STORG	=	.3334+05 BTU/HR

AXIAL DIST. Z	RELATIVE RAD. HEAT REJECTION Q	RELATIVE TEMPERATURE OF FIN, T — DISTANCE NORMAL TO FLOW DIRECTION X: .00000	.25000	.50000	.75000	1.00000
.000	.7486	.9722	.9722	.9722	.9722	.9722
.125	1.6110	1.1342	1.2450	1.3218	1.3667	1.3813
.250	2.1382	1.1092	1.2023	1.2645	1.2997	1.3108
.375	2.1632	1.1263	1.2145	1.2735	1.3069	1.3174
.500	2.1871	1.1246	1.2119	1.2703	1.3035	1.3139
.625	2.3489	1.1324	1.2094	1.2598	1.2879	1.2966
.750	2.2311	1.1341	1.2190	1.2759	1.3083	1.3186
.875	1.8337	1.1830	1.2782	1.3448	1.3840	1.3968
1.000 (EXIT)	1.1567	1.0745	1.0745	1.0745	1.0745	1.0745

FIGURE 13(A) CONTINUED

FLUID PROPERTIES AND SURFACE TEMPERATURE OF METEOROID PROTECTION LAYER

REFERENCE TEMPERATURE, T00 = 659.670 R
REFERENCE PRESSURE, P00 = 8640.000 LBF/SQ.FT
REFERENCE VELOCITY, W00 = .871 FT/SEC
COOLANT POWER, INLET AT T=T0 H0 = .276867+05 BTU/HR INLET CURRENTLY HI = .276867+05 BTU/HR
EXIT CURRENTLY EI = .479690+05 BTU/HR TOT. REJECTION DH = -.202823+05 BTU/HR

AXIAL DIST.	PRESSURE P	VELOCITY W	FLUID TEMPERATURES TF	WALL TEMPERATURES TWI	PROTECT. LAYER TEMPERATURES TMP	ENTHALPY REJECTION PER UNIT TUBE LENGTH BTU/(HR FT)	ENTHALPY REJECTION FRACTION OF TOTAL
.000	1.00000	1.0000	1.0000	.9722	.9722	81.004254	.00000
.125	.99982	1.0161	1.0436	1.1342	1.1342	-263.760815	.13900
.250	.99963	1.0255	1.0499	1.1092	1.1092	-172.715717	.35778
.375	.99945	1.0330	1.0764	1.1263	1.1263	-145.424294	.48221
.500	.99926	1.0403	1.0770	1.1246	1.1246	-138.439034	.61517
.625	.99907	1.0450	1.1030	1.1324	1.1324	-85.539244	.72615
.750	.99889	1.0508	1.0923	1.1341	1.1341	-121.559476	.81088
.875	.99870	1.0600	1.1250	1.1830	1.1830	-168.841410	.94894
1.000 (EXIT)	.99851	1.0553	1.1270	1.0745	1.0745	152.930897	1.00000

ELAPSED TIME IS .2500 HR , RELATIVE TIME IS 65.3475 138 INTEGR. STEPS
ALTITUDE IS 74990.18 FT , VELOCITY IS 2199.64 FT/SEC , ATM. TEMPERATURE IS 394.97 R

FIN TEMPERATURE DISTRIBUTION AND RADIANT HEAT REJECTION
****

```
REFERENCE TEMPERATURE,         TOO    =  659.670 R              ,
REF. RADIANT HEAT FLUX                                             INCIDENT SOLAR FLUX,       QSOLR  =  .1000+03 BTU/(HR SQ FT)
   PER UNIT AXIAL LENGTH,      QREF   =  .3246+04 BTU/(HR FT),     INCIDENT INFRARED FLUX,    QIRED  =  .2000+01 BTU/(HR SQ FT)
TOT. RADIANT REJECTION         QTOT   =  .6239+05 BTU/HR      ,    AERODYN. HEATING POWER,    QCONV  = -.2252+05 BTU/HR
COND. FROM MANIFOLDS,          CONDMF =  .1221+04 BTU/HR      ,    ENERGY STORAGE RATE,       STORG  = -.1037+06 BTU/HR
```

AXIAL DIST. Z	RELATIVE RAD. HEAT REJECTION Q	RELATIVE TEMPERATURE OF FIN, T — DISTANCE NORMAL TO FLOW DIRECTION X: .00000	.25000	.50000	.75000	1.00000
.000	.7413	.9700	.9700	.9700	.9700	.9700
.125	1.3374	1.1293	1.1889	1.2386	1.2700	1.2810
.250	1.7043	1.1026	1.1505	1.1899	1.2143	1.2227
.375	1.7279	1.1216	1.1633	1.1992	1.2217	1.2295
.500	1.7503	1.1191	1.1605	1.1961	1.2196	1.2263
.625	1.8472	1.1295	1.1613	1.1902	1.2035	1.2149
.750	1.7916	1.1300	1.1681	1.2021	1.2237	1.2313
.875	1.5837	1.1812	1.2224	1.2614	1.2871	1.2965
1.000 (EXIT)	1.2233	1.0887	1.0887	1.0887	1.0887	1.0887

FIGURE 13(A) CONTINUED

FLUID PROPERTIES AND SURFACE TEMPERATURE OF METEOROID PROTECTION LAYER
****

```
REFERENCE TEMPERATURE, TOO     =        659.670 R
REFERENCE PRESSURE,    POO     =       8640.000 LBF/SQ.FT
REFERENCE VELOCITY,    WOO     =           .871 FT/SEC
COOLANT POWER, INLET AT T=TO  HO =  .276867+05 BTU/HR          INLET CURRENTLY  HI =  .276867+05 BTU/HR
               EXIT CURRENTLY EI =  .476853+05 BTU/HR          TOT. REJECTION   DH = -.199986+05 BTU/HR
```

AXIAL DIST.	PRESSURE P	VELOCITY W	FLUID TEMPERATURES TF	WALL TEMPERATURES TWI	PROTECT. LAYER TEMPERATURES TMP	ENTHALPY REJECTION PER UNIT TUBE LENGTH BTU/(HR FT)	ENTHALPY REJECTION FRACTION OF TOTAL
.000	1.00000	1.0000	1.0000	.9700	.9700	86.688877	.00000
.125	.99982	1.0156	1.0433	1.1293	1.1293	-248.916988	.13119
.250	.99963	1.0244	1.0473	1.1026	1.1026	-160.148674	.34140
.375	.99945	1.0316	1.0739	1.1216	1.1216	-138.130276	.45934
.500	.99926	1.0386	1.0735	1.1191	1.1191	-132.202616	.58956
.625	.99907	1.0434	1.0996	1.1295	1.1295	-86.335973	.69966
.750	.99889	1.0491	1.0895	1.1300	1.1300	-117.345061	.78642
.875	.99870	1.0585	1.1210	1.1812	1.1812	-174.303867	.92608
1.000 (EXIT)	.99851	1.0560	1.1255	1.0887	1.0887	106.599895	1.00000

ELAPSED TIME IS .2667 HR , RELATIVE TIME IS 69.7040 148 INTEGR. STEPS
ALTITUDE IS 48989.54 FT , VELOCITY IS 1199.81 FT/SEC , ATM. TEMPERATURE IS 389.97 R

FIN TEMPERATURE DISTRIBUTION AND RADIANT HEAT REJECTION
****

REFERENCE TEMPERATURE, T00 = 659.670 R
REF. RADIANT HEAT FLUX PER UNIT AXIAL LENGTH, QREF = .3246+04 BTU/(HR FT),
TOT. RADIANT REJECTION QTOT = .3745+05 BTU/HR ,
COND. FROM MANIFOLDS, CONDMF = .1843+04 BTU/HR ,

INCIDENT SOLAR FLUX, QSOLR = .1000+03 BTU/(HR SQ FT)
INCIDENT INFRARED FLUX, QIRED = .2000+01 BTU/(HR SQ FT)
AERODYN. HEATING POWER, QCONV = -.1705+06 BTU/HR
ENERGY STORAGE RATE, STORG = -.2212+06 BTU/HR

AXIAL DIST. Z	RELATIVE RAD. HEAT REJECTION Q	RELATIVE TEMPERATURE OF FIN, T — DISTANCE NORMAL TO FLOW DIRECTION X: .00000	.25000	.50000	.75000	1.00000
.000	.8631	1.0041	1.0041	1.0041	1.0041	1.0041
.125	.8816	1.0874	1.0392	1.0268	1.0269	1.0292
.250	.8987	1.0677	1.0163	1.0006	.9982	.9996
.375	.9144	1.0850	1.0277	1.0084	1.0042	1.0050
.500	.9291	1.0834	1.0259	1.0064	1.0022	1.0031
.625	.8896	1.0947	1.0311	1.0076	1.0010	1.0010
.750	.9553	1.0951	1.0334	1.0117	1.0065	1.0070
.875	1.1262	1.1330	1.0672	1.0442	1.0388	1.0396
1.000 (EXIT)	1.4023	1.1242	1.1242	1.1242	1.1242	1.1242

FIGURE 13(A) CONCLUDED

FLUID PROPERTIES AND SURFACE TEMPERATURE OF METEOROID PROTECTION LAYER
****

REFERENCE TEMPERATURE, T00 = 659.670 R
REFERENCE PRESSURE, P00 = 8640.000 LBF/SQ.FT
REFERENCE VELOCITY, W00 = .871 FT/SEC
COOLANT POWER, INLET AT T=T0 H0 = .276867+05 BTU/HR
EXIT CURRENTLY EI = .427089+05 BTU/HR

INLET CURRENTLY HI = .276867+05 BTU/HR
TOT. REJECTION DH = -.150223+05 BTU/HR

AXIAL DIST.	PRESSURE P	VELOCITY W	FLUID TEMPERATURES TF	WALL TEMPERATURES TWI	PROTECT. LAYER TEMPERATURES TMP	ENTHALPY REJECTION PER UNIT TUBE LENGTH BTU/(HR FT)	ENTHALPY REJECTION FRACTION OF TOTAL
.000	1.00000	1.0000	1.0000	1.0041	1.0041	-11.239679	.00000
.125	.99982	1.0103	1.0296	1.0874	1.0874	-156.783590	.13991
.250	.99963	1.0160	1.0308	1.0677	1.0677	-99.922624	.30879
.375	.99944	1.0212	1.0497	1.0850	1.0850	-95.677561	.41267
.500	.99926	1.0262	1.0508	1.0834	1.0834	-88.377534	.53137
.625	.99907	1.0306	1.0683	1.0947	1.0947	-71.594559	.63305
.750	.99888	1.0348	1.0667	1.0951	1.0951	-77.058642	.72233
.875	.99869	1.0421	1.0839	1.1330	1.1330	-133.142769	.84743
1.000 (EXIT)	.99850	1.0474	1.0955	1.1242	1.1242	-78.039950	1.00000

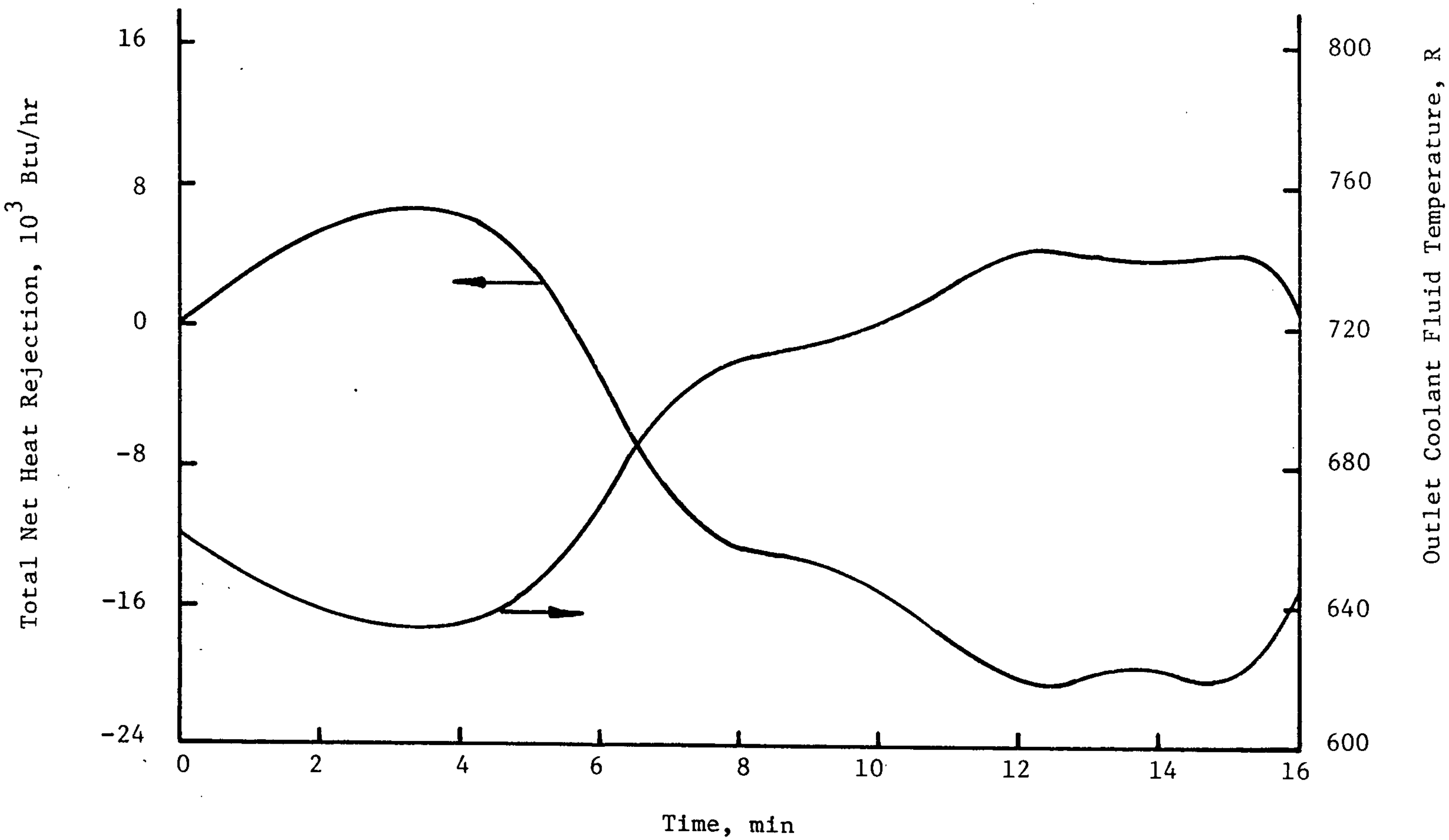

Fig. 13(b) System Response For Reentry-Heat Rejection And Outlet Fluid Temperature

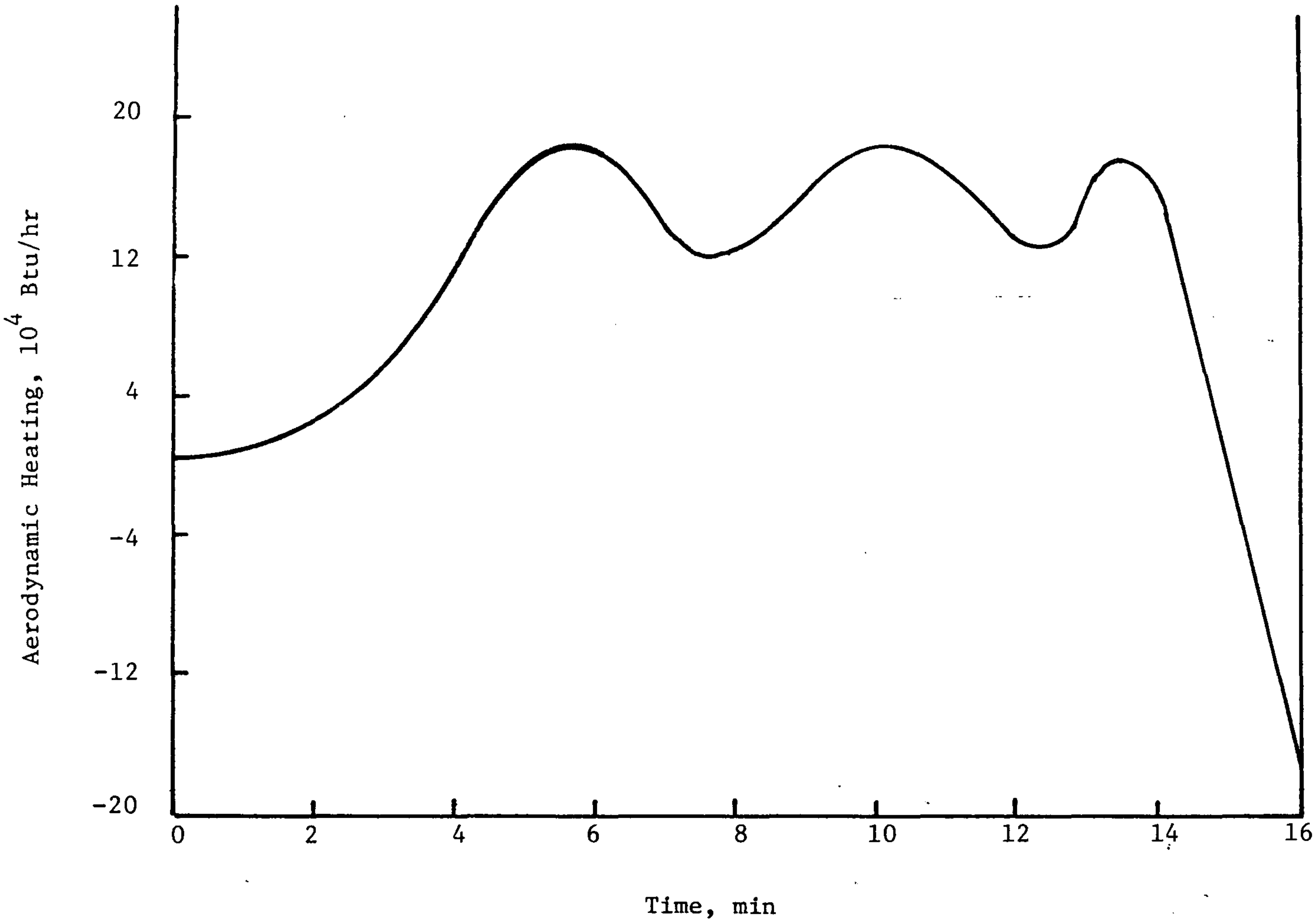

Fig.14 Aerodynamic Heating For Reentry

c. Orbital Mission

(i) Mission Description

Transient system performance is predicted in Figure 16 for a typical space base orbital mission. The mission is described by a 270 nautical mile circular orbit inclined at 55°. Incident flux values for solar irradiation, earth albedo and earth irradiation were supplied by a previously executed MRI program with the flux data being transfered from magnetic tape.

Incident radiant flux values for a typical fin element are plotted as a function of time into orbit in Figure 15. Other input parameters which specify system geometry, material properties and fluid flow conditions are identical to those used for the ascent and reentry phases that were previously reported in sections 5a and 5b.

(ii) System Response

The response of the radiator system during the first twenty minutes of the orbit is summarized in Figures 16(a) and 16(b). Input parameters and a selected number of output listings of current radiator conditions are shown in Figure 16(a). Figure 16(b) graphically summarizes the outlet coolant fluid temperature and the total net heat rejection from the radiator for the same period during orbit.

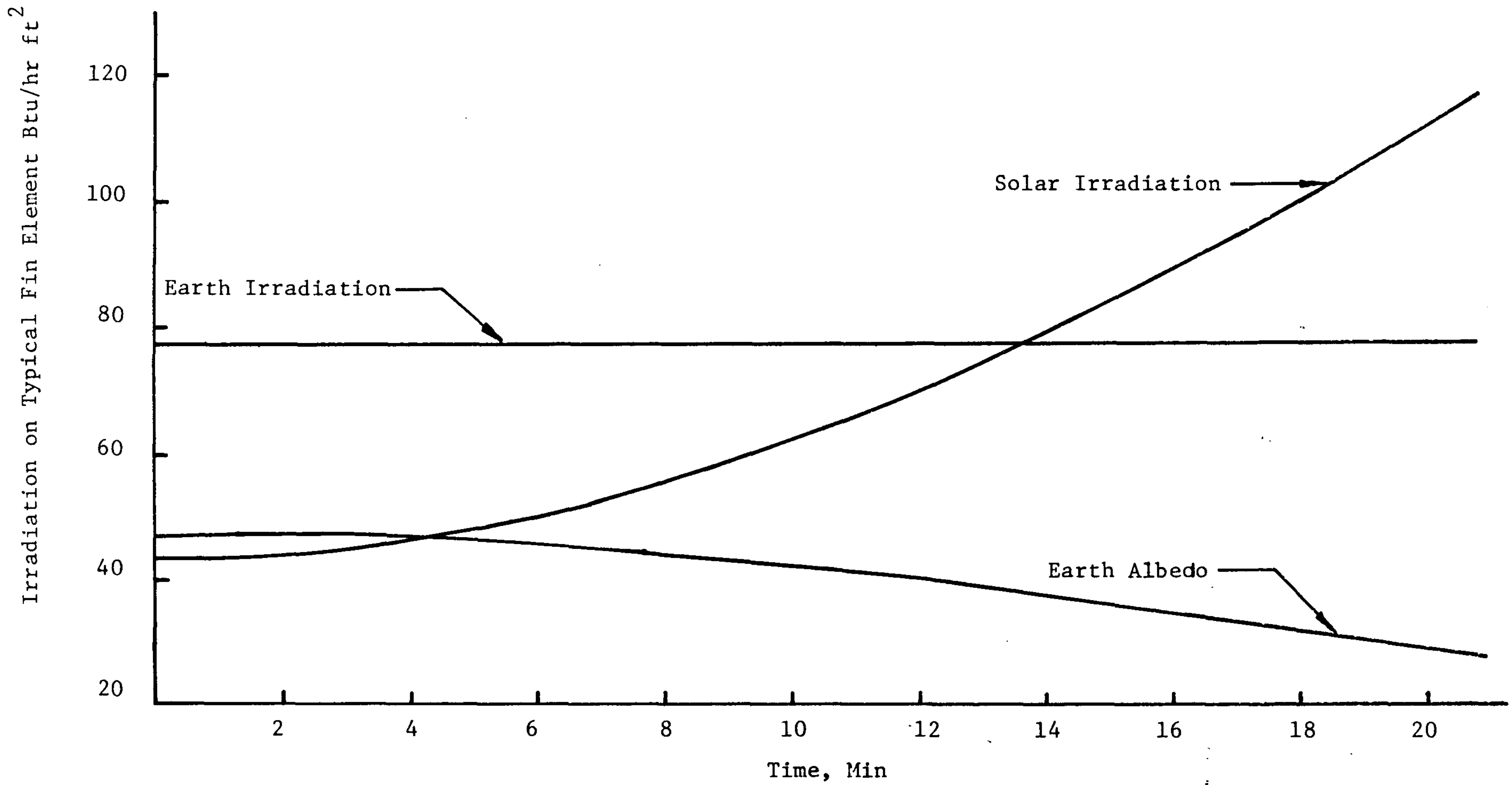

Fig. 15 Orbital Incident Fluxes

```
$QNML
ITAPE   =              +3
ICASE   =              +1
NTM     =             +73
TO      =  .00000000E+00
PHN     =  .00000000E+00

$END
$TUBE
DITBI   =  .25000000E+00
STBI    =  .10000000E+00
XL      =  .12000000E+02
RHOTBI  =  .16859200E+03
MZ      =              +9
NRTBI   =              +3
NTBS    =             +10

$END
$FLOW
MDOTI   =  .50000000E+03
TO      =  .65967000E+03
PO      =  .86400000E+04

$END
$FIN
NX      =              +5
SROOTI  =  .50000000E-01
HFNI    =  .60000000E+01
STIPI   =  .50000000E-01
RHOFNI  =  .16859200E+03
STAGX   =  .20000000E+02
VERTX   =  .10000000E+02

$END
$PROTLR
NRMP    =              +3
RHOMPI  =  .16859200E+03
RHOMET  =  .50000000E+00
VELM    =  .65600000E+05
TAU     =  .36500000E+04
PROB    =  .99000000E+00
ALPHA   =  .18800000E-09
BTA     =  .12130000E+01
GAMMA   =  .15000000E+01
PHI     =  .50000000E+00
THETA   =  .66666700E+00
ATK     =  .17500000E+01
AN      =  .10000000E+01

$END
$MANIFD
AMAN    =  .43000000E+02

$END
$RUNOPT
MSTOTR  =              +2
```

FIGURE 16(A) SYSTEM RESPONSE FOR ORBITAL MISSION

PROGRAM OUTPUT

```
DTWRTE  =    .35000000E-01
TEND    =    .70000000E+00
ALIMIT  =    .50000000E-04
RLIMIT  =    .10000000E-04
T1      =    .65967000E+03
LIMWRT  =              +25
NCONV   =               +0
LTT     =               +0
LFLD    =               +1
LTS     =               +0

$END
```

FIGURE 16(A) CONTINUED

INITIAL LINE CONDITIONS
******* **** **********
(ALL QUANTITIES ARE NORMALIZED)

PT.NO.	POSITION Z	PRESSURE P	VELOCITY W	FLUID TEMPERATURE T	WALL TEMPERATURE TWI
1	.000	1.000000	1.000000	1.000000	1.000000
2	.125	.999810	1.000000	1.000000	1.000000
3	.250	.999621	1.000001	1.000000	1.000000
4	.375	.999431	1.000001	1.000000	1.000000
5	.500	.999241	1.000001	1.000000	1.000000
6	.625	.999052	1.000001	1.000000	1.000000
7	.750	.998862	1.000001	1.000000	1.000000
8	.875	.998673	1.000002	1.000000	1.000000
9	1.000	.998483	1.000002	1.000000	1.000000

```
INLET PRESSURE    P0  =     8640.000  LBF/SQ.FT
REF. VELOCITY     W0  =       .87128  FT/SEC
REF. TEMPERATURE T00  =      659.670  R

     REYNOLDS NO      =            .30017+04
     PRANDTL  NO      =            8.628066
     DELTA            =             .001736
     REL.PRESSURE IS               .391534+04

INIT. NUSSELT NO. NU  =            .201856+02
WALL BIOT NO.     BI  =            .485314-02

         SYSTEM PARAMETERS
         *****************

TUBE LENGTH ,                  XL =     12.000 FT
     INTERNAL DIAMETER ,     DITB =       .250 IN
     WALL THICKNESS ,         STB =       .100 IN
     MATERIAL                         ALUMINUM
     MASS   (ALL TUBES) ,     MTB =    15.4480 LBM
     NUMBER OF TUBES,        NTBS =         10

FIN  HEIGHT ,                 HFN =      6.000 IN
     THICKNESS AT ROOT ,    SROOT =       .050 IN
     THICKNESS AT TIP ,      STIP =       .050 IN
     MATERIAL                         ALUMINUM
     MASS (ALL FINS) ,        MFN =    84.2960 LBM
     NO. OF FIN SIDES RADIATING   =          1

COOLANT FLUID IS                      SILICONE OIL
     MASS (IN ALL TUBES) ,    MFL =    19.1289 LBM

 PROTECTION LAYER THICKNESS,  SMP =       .011 IN
     MASS,                    MMP =      2.038 LBM
     MATERIAL IS                      BERYLLIUM

TOTAL MASS (EXCL. MANIFLD.) MTOT =   120.9104 LBM
```

FIGURE 16(A) CONTINUED

TOTAL AREA (SINGLE NORMAL PROJECTION) ,
ATOT =   124.5000 SQ FT

FIGURE 16(A) CONTINUED

ELAPSED TIME IS .0000 HR
RELATIVE TIME IS .0000 **IN ORBIT** 1 INTEGR. STEPS

FIN TEMPERATURE DISTRIBUTION AND RADIANT HEAT REJECTION
****

REFERENCE TEMPERATURE, T00 = 659.670 R
REF. RADIANT HEAT FLUX
PER UNIT AXIAL LENGTH, QREF = .3246+04 BTU/(HR FT),
TOT. RADIANT REJECTION QTOT = .2114+05 BTU/HR
COND. FROM MANIFOLDS, CONDMF = .0000 BTU/HR

INCIDENT SOLAR FLUX, QSOLR = .4326+03 BTU/(HR SQ FT)
INCIDENT INFRARED FLUX, QIRED = .1380+02 BTU/(HR SQ FT)
AERODYN. HEATING POWER, QCONV = .0000 BTU/HR
ENERGY STORAGE RATE, STORG = -.2114+05 BTU/HR

AXIAL DIST. Z	RELATIVE RAD. HEAT REJECTION Q	RELATIVE TEMPERATURE OF FIN, T — DISTANCE NORMAL TO FLOW DIRECTION X: .00000	.25000	.50000	.75000	1.00000
.000	.5473	1.0000	1.0000	1.0000	1.0000	1.0000
.125	.5439	1.0000	1.0000	1.0000	1.0000	1.0000
.250	.5418	1.0000	1.0000	1.0000	1.0000	1.0000
.375	.5418	1.0000	1.0000	1.0000	1.0000	1.0000
.500	.5418	1.0000	1.0000	1.0000	1.0000	1.0000
.625	.5412	1.0000	1.0000	1.0000	1.0000	1.0000
.750	.5418	1.0000	1.0000	1.0000	1.0000	1.0000
.875	.5439	1.0000	1.0000	1.0000	1.0000	1.0000
1.000 (EXIT)	.5473	1.0000	1.0000	1.0000	1.0000	1.0000

FIGURE 16(A) CONTINUED

FLUID PROPERTIES AND SURFACE TEMPERATURE OF METEOROID PROTECTION LAYER
****

REFERENCE TEMPERATURE, T00 = 659.670 R
REFERENCE PRESSURE, P00 = 8640.000 LBF/SQ.FT
REFERENCE VELOCITY, W00 = .871 FT/SEC
COOLANT POWER, INLET AT T=T0 H0 = .276867+05 BTU/HR
EXIT CURRENTLY EI = .276866+05 BTU/HR
INLET CURRENTLY HI = .276867+05 BTU/HR
TOT. REJECTION DH = .500488-01 BTU/HR

AXIAL DIST.	PRESSURE P	VELOCITY W	FLUID TEMPERATURES TF	WALL TEMPERATURES TWI	PROTECT. LAYER TEMPERATURES TMP	ENTHALPY REJECTION PER UNIT TUBE LENGTH BTU/(HR FT)	ENTHALPY REJECTION FRACTION OF TOTAL
.000	1.00000	1.0000	1.0000	1.0000	1.0000	.000000	.00000
.125	.99981	1.0000	1.0000	1.0000	1.0000	.000138	.02563
.250	.99962	1.0000	1.0000	1.0000	1.0000	.000242	.09431
.375	.99943	1.0000	1.0000	1.0000	1.0000	.000311	.19375
.500	.99924	1.0000	1.0000	1.0000	1.0000	.000380	.31625
.625	.99905	1.0000	1.0000	1.0000	1.0000	.000450	.46386
.750	.99886	1.0000	1.0000	1.0000	1.0000	.000484	.63147
.875	.99867	1.0000	1.0000	1.0000	1.0000	.000519	.80933
1.000 (EXIT)	.99848	1.0000	1.0000	1.0000	1.0000	.000553	1.00000

ELAPSED TIME IS .0700 HR
RELATIVE TIME IS 18.2969 **IN ORBIT** 44 INTEGR. STEPS

FIN TEMPERATURE DISTRIBUTION AND RADIANT HEAT REJECTION
****

REFERENCE TEMPERATURE, T00 = 659.670 R ,
REF. RADIANT HEAT FLUX
PER UNIT AXIAL LENGTH, QREF = .3246+04 BTU/(HR FT),
TOT. RADIANT REJECTION QTOT = .1368+05 BTU/HR ,
COND. FROM MANIFOLDS, CONDMF = .1925+03 BTU/HR ,

INCIDENT SOLAR FLUX, QSOLR = .4326+03 BTU/(HR SQ FT)
INCIDENT INFRARED FLUX, QIRED = .1313+02 BTU/(HR SQ FT)
AERODYN. HEATING POWER, QCONV = .0000 BTU/HR
ENERGY STORAGE RATE, STORG = -.7238+04 BTU/HR

AXIAL DIST. Z	RELATIVE RAD. HEAT REJECTION Q	RELATIVE TEMPERATURE OF FIN, T — DISTANCE NORMAL TO FLOW DIRECTION X: .00000	.25000	.50000	.75000	1.00000
.000	.4812	.9816	.9816	.9816	.9816	.9816
.125	.3944	.9592	.9448	.9351	.9296	.9278
.250	.3403	.9581	.9453	.9368	.9320	.9305
.375	.3352	.9549	.9431	.9352	.9308	.9294
.500	.3306	.9527	.9415	.9341	.9299	.9286
.625	.3178	.9504	.9403	.9337	.9299	.9287
.750	.3230	.9485	.9386	.9320	.9283	.9271
.875	.3463	.9447	.9351	.9287	.9250	.9238
1.000 (EXIT)	.3877	.9538	.9538	.9538	.9538	.9538

FIGURE 16(A) CONTINUED

FLUID PROPERTIES AND SURFACE TEMPERATURE OF METEOROID PROTECTION LAYER
****

REFERENCE TEMPERATURE, T00 = 659.670 R
REFERENCE PRESSURE, P00 = 8640.000 LBF/SQ.FT
REFERENCE VELOCITY, W00 = .871 FT/SEC
COOLANT POWER, INLET AT T=T0 H0 = .276867+05 BTU/HR
EXIT CURRENTLY EI = .214331+05 BTU/HR

INLET CURRENTLY HI = .276867+05 BTU/HR
TOT. REJECTION DH = .625357+04 BTU/HR

AXIAL DIST.	PRESSURE P	VELOCITY W	FLUID TEMPERATURES TF	WALL TEMPERATURES TWI	PROTECT. LAYER TEMPERATURES TMP	ENTHALPY REJECTION PER UNIT TUBE LENGTH BTU/(HR FT)	ENTHALPY REJECTION FRACTION OF TOTAL
.000	1.00000	1.0000	1.0000	.9816	.9816	39.721291	.00000
.125	.99981	.9963	.9919	.9592	.9592	70.315785	.15362
.250	.99962	.9933	.9863	.9581	.9581	60.747243	.32489
.375	.99943	.9907	.9801	.9549	.9549	54.229073	.46643
.500	.99924	.9883	.9758	.9527	.9527	49.817427	.59891
.625	.99905	.9862	.9704	.9504	.9504	43.049000	.71844
.750	.99886	.9842	.9676	.9485	.9485	41.208278	.82419
.875	.99867	.9824	.9626	.9447	.9447	38.468452	.92672
1.000 (EXIT)	.99848	.9816	.9600	.9538	.9538	13.438381	1.00000

1435137

ELAPSED TIME IS .1400 HR
RELATIVE TIME IS 36.5939 **IN ORBIT** 74 INTEGR. STEPS

15

FIN TEMPERATURE DISTRIBUTION AND RADIANT HEAT REJECTION
****

REFERENCE TEMPERATURE, T00 = 659.670 R ,
REF. RADIANT HEAT FLUX
PER UNIT AXIAL LENGTH, QREF = .3246+04 BTU/(HR FT),
TOT. RADIANT REJECTION QTOT = .1151+05 BTU/HR ,
COND. FROM MANIFOLDS, CONDMF = .2601+03 BTU/HR ,

INCIDENT SOLAR FLUX, QSOLR = .4326+03 BTU/(HR SQ FT)
INCIDENT INFRARED FLUX, QIRED = .1164+02 BTU/(HR SQ FT)
AERODYN. HEATING POWER, QCONV = .0000 BTU/HR
ENERGY STORAGE RATE, STORG = -.2599+04 BTU/HR

AXIAL DIST. Z	RELATIVE RAD. HEAT REJECTION Q	RELATIVE TEMPERATURE OF FIN, T — DISTANCE NORMAL TO FLOW DIRECTION X: .00000	.25000	.50000	.75000	1.00000
.000	.4690	.9777	.9777	.9777	.9777	.9777
.125	.3587	.9453	.9273	.9150	.9078	.9054
.250	.2888	.9446	.9290	.9184	.9122	.9102
.375	.2791	.9392	.9247	.9148	.9091	.9072
.500	.2702	.9357	.9219	.9125	.9070	.9053
.625	.2516	.9316	.9191	.9107	.9058	.9043
.750	.2545	.9282	.9157	.9073	.9024	.9008
.875	.2787	.9212	.9089	.9005	.8955	.8940
1.000 (EXIT)	.3245	.9331	.9331	.9331	.9331	.9331

FIGURE 16(A) CONTINUED

FLUID PROPERTIES AND SURFACE TEMPERATURE OF METEOROID PROTECTION LAYER
****

REFERENCE TEMPERATURE, T00 = 659.670 R
REFERENCE PRESSURE, P00 = 8640.000 LBF/SQ.FT
REFERENCE VELOCITY, W00 = .871 FT/SEC
COOLANT POWER, INLET AT T=T0 H0 = .276867+05 BTU/HR
EXIT CURRENTLY EI = .190346+05 BTU/HR

INLET CURRENTLY HI = .276867+05 BTU/HR
TOT. REJECTION DH = .865213+04 BTU/HR

AXIAL DIST.	PRESSURE P	VELOCITY W	FLUID TEMPERATURES TF	WALL TWI	PROTECT. LAYER TMP	ENTHALPY REJECTION PER UNIT TUBE LENGTH BTU/(HR FT)	FRACTION OF TOTAL
.000	1.00000	1.0000	1.0000	.9777	.9777	46.776074	.00000
.125	.99981	.9952	.9889	.9453	.9453	91.621171	.14379
.250	.99962	.9912	.9821	.9446	.9446	78.693769	.30749
.375	.99942	.9877	.9736	.9392	.9392	72.155310	.44290
.500	.99923	.9844	.9680	.9357	.9357	67.887362	.57417
.625	.99904	.9815	.9603	.9316	.9316	60.128966	.69518
.750	.99885	.9787	.9564	.9282	.9282	59.147844	.80515
.875	.99867	.9759	.9488	.9212	.9212	57.910906	.91549
1.000 (EXIT)	.99848	.9745	.9446	.9331	.9331	24.112062	1.00000

ELAPSED TIME IS .2100 HR
RELATIVE TIME IS 54.8908 **IN ORBIT** 107 INTEGR. STEPS

FIN TEMPERATURE DISTRIBUTION AND RADIANT HEAT REJECTION
****

REFERENCE TEMPERATURE, T00 = 659.670 R
REF. RADIANT HEAT FLUX PER UNIT AXIAL LENGTH, QREF = .3246+04 BTU/(HR FT),
TOT. RADIANT REJECTION QTOT = .1081+05 BTU/HR
COND. FROM MANIFOLDS, CONDMF = .2873+03 BTU/HR

INCIDENT SOLAR FLUX, QSOLR = .4326+03 BTU/(HR SQ FT)
INCIDENT INFRARED FLUX, QIRED = .9903+01 BTU/(HR SQ FT)
AERODYN. HEATING POWER, QCONV = .0000 BTU/HR
ENERGY STORAGE RATE, STORG = -.9825+03 BTU/HR

AXIAL DIST. Z	RELATIVE RAD. HEAT REJECTION Q	RELATIVE TEMPERATURE OF FIN, T — DISTANCE NORMAL TO FLOW DIRECTION X: .00000	.25000	.50000	.75000	1.00000
.000	.4659	.9763	.9763	.9763	.9763	.9763
.125	.3485	.9402	.9212	.9079	.9002	.8976
.250	.2736	.9401	.9236	.9123	.9057	.9036
.375	.2620	.9337	.9182	.9077	.9015	.8995
.500	.2510	.9297	.9149	.9048	.8989	.8970
.625	.2295	.9247	.9113	.9022	.8969	.8953
.750	.2309	.9206	.9071	.8979	.8925	.8908
.875	.2552	.9118	.8983	.8889	.8834	.8817
1.000 (EXIT)	.3023	.9252	.9252	.9252	.9252	.9252

FIGURE 16(A) CONTINUED

FLUID PROPERTIES AND SURFACE TEMPERATURE OF METEOROID PROTECTION LAYER
****

REFERENCE TEMPERATURE, T00 = 659.670 R
REFERENCE PRESSURE, P00 = 8640.000 LBF/SQ.FT
REFERENCE VELOCITY, W00 = .871 FT/SEC
COOLANT POWER, INLET AT T=T0 H0 = .276867+05 BTU/HR
EXIT CURRENTLY EI = .181485+05 BTU/HR

INLET CURRENTLY HI = .276867+05 BTU/HR
TOT. REJECTION DH = .953815+04 BTU/HR

AXIAL DIST.	PRESSURE P	VELOCITY W	FLUID TEMPERATURES TF	WALL TEMPERATURES TWI	PROTECT. LAYER TEMPERATURES TMP	ENTHALPY REJECTION PER UNIT TUBE LENGTH BTU/(HR FT)	ENTHALPY REJECTION FRACTION OF TOTAL
.000	1.00000	1.0000	1.0000	.9763	.9763	49.157877	.00000
.125	.99981	.9947	.9878	.9402	.9402	98.755130	.14067
.250	.99962	.9905	.9807	.9401	.9401	84.352570	.30112
.375	.99942	.9867	.9713	.9337	.9337	78.174984	.43370
.500	.99923	.9831	.9654	.9297	.9297	74.254160	.56407
.625	.99904	.9799	.9567	.9247	.9247	66.467727	.68532
.750	.99885	.9768	.9525	.9206	.9206	66.269156	.79686
.875	.99866	.9736	.9438	.9118	.9118	66.394603	.91070
1.000 (EXIT)	.99848	.9719	.9389	.9252	.9252	28.582312	1.00000

ELAPSED TIME IS .2800 HR
RELATIVE TIME IS 73.1878 **IN ORBIT** 136 INTEGR. STEPS

FIN TEMPERATURE DISTRIBUTION AND RADIANT HEAT REJECTION
****

REFERENCE TEMPERATURE, T00 = 659.670 R
REF. RADIANT HEAT FLUX PER UNIT AXIAL LENGTH, QREF = .3246+04 BTU/(HR FT),
TOT. RADIANT REJECTION QTOT = .1059+05 BTU/HR
COND. FROM MANIFOLDS, CONDMF = .2989+03 BTU/HR

INCIDENT SOLAR FLUX, QSOLR = .4326+03 BTU/(HR SQ FT)
INCIDENT INFRARED FLUX, QIRED = .7787+01 BTU/(HR SQ FT)
AERODYN. HEATING POWER, QCONV = .0000 BTU/HR
ENERGY STORAGE RATE, STORG = -.4030+03 BTU/HR

AXIAL DIST. Z	RELATIVE RAD. HEAT REJECTION Q	RELATIVE TEMPERATURE OF FIN, T — DISTANCE NORMAL TO FLOW DIRECTION X: .00000	.25000	.50000	.75000	1.00000
.000	.4658	.9758	.9758	.9758	.9758	.9758
.125	.3461	.9382	.9187	.9051	.8972	.8946
.250	.2695	.9384	.9216	.9101	.9033	.9012
.375	.2570	.9315	.9158	.9049	.8986	.8966
.500	.2451	.9274	.9123	.9019	.8958	.8939
.625	.2224	.9220	.9083	.8989	.8935	.8917
.750	.2230	.9176	.9037	.8941	.8886	.8868
.875	.2472	.9080	.8939	.8841	.8783	.8765
1.000 (EXIT)	.2947	.9219	.9219	.9219	.9219	.9219

FIGURE 16(A) CONTINUED

FLUID PROPERTIES AND SURFACE TEMPERATURE OF METEOROID PROTECTION LAYER
****

REFERENCE TEMPERATURE, T00 = 659.670 R
REFERENCE PRESSURE, P00 = 8640.000 LBF/SQ.FT
REFERENCE VELOCITY, W00 = .871 FT/SEC
COOLANT POWER, INLET AT T=T0 H0 = .276867+05 BTU/HR
EXIT CURRENTLY EI = .177966+05 BTU/HR

INLET CURRENTLY HI = .276867+05 BTU/HR
TOT. REJECTION DH = .989009+04 BTU/HR

AXIAL DIST.	PRESSURE P	VELOCITY W	FLUID TF (TEMPERATURES)	WALL TWI (TEMPERATURES)	PROTECT. LAYER TMP (TEMPERATURES)	ENTHALPY REJECTION PER UNIT TUBE LENGTH BTU/(HR FT)	FRACTION OF TOTAL
.000	1.00000	1.0000	1.0000	.9758	.9758	50.129854	.00000
.125	.99981	.9946	.9873	.9382	.9382	101.470659	.13955
.250	.99961	.9903	.9802	.9384	.9384	86.378242	.29864
.375	.99942	.9863	.9704	.9315	.9315	80.419735	.42994
.500	.99923	.9826	.9644	.9274	.9274	76.643045	.55984
.625	.99904	.9793	.9553	.9220	.9220	68.930267	.68103
.750	.99885	.9760	.9510	.9176	.9176	69.137488	.79315
.875	.99866	.9727	.9418	.9080	.9080	70.083364	.90853
1.000 (EXIT)	.99848	.9708	.9367	.9219	.9219	30.468460	1.00000

ELAPSED TIME IS .3150 HR
RELATIVE TIME IS 82.3363 **IN ORBIT** 151 INTEGR. STEPS

FIN TEMPERATURE DISTRIBUTION AND RADIANT HEAT REJECTION
****

REFERENCE TEMPERATURE, TOQ = 659.670 R ,
REF. RADIANT HEAT FLUX
PER UNIT AXIAL LENGTH, QREF = .3246+04 BTU/(HR FT),
TOT. RADIANT REJECTION QTOT = .1056+05 BTU/HR ,
COND. FROM MANIFOLDS, CONDMF = .3020+03 BTU/HR ,

INCIDENT SOLAR FLUX, QSOLR = .4326+03 BTU/(HR SQ FT)
INCIDENT INFRARED FLUX, QIRED = .6522+01 BTU/(HR SQ FT)
AERODYN. HEATING POWER, QCONV = .0000 BTU/HR
ENERGY STORAGE RATE, STORG = -.2744+03 BTU/HR

AXIAL DIST. Z	RELATIVE RAD. HEAT REJECTION Q	RELATIVE TEMPERATURE OF FIN, T — DISTANCE NORMAL TO FLOW DIRECTION X: .00000	.25000	.50000	.75000	1.00000
.000	.4664	.9756	.9756	.9756	.9756	.9756
.125	.3461	.9377	.9180	.9044	.8954	.8937
.250	.2690	.9380	.9211	.9095	.9027	.9005
.375	.2564	.9309	.9151	.9042	.8979	.8958
.500	.2442	.9268	.9116	.9011	.8950	.8931
.625	.2211	.9213	.9074	.8980	.8925	.8908
.750	.2216	.9168	.9028	.8931	.8875	.8857
.875	.2457	.9069	.8927	.8828	.8770	.8751
1.000 (EXIT)	.2934	.9211	.9211	.9211	.9211	.9211

FIGURE 16(A) CONCLUDED

FLUID PROPERTIES AND SURFACE TEMPERATURE OF METEOROID PROTECTION LAYER
****

REFERENCE TEMPERATURE, T00 = 659.670 R
REFERENCE PRESSURE, P00 = 8640.000 LBF/SQ.FT
REFERENCE VELOCITY, W00 = .871 FT/SEC
COOLANT POWER, INLET AT T=T0 H0 = .276867+05 BTU/HR
EXIT CURRENTLY EI = .177034+05 BTU/HR

INLET CURRENTLY HI = .276867+05 BTU/HR
TOT. REJECTION DH = .998328+04 BTU/HR

AXIAL DIST.	PRESSURE P	VELOCITY W	FLUID TF	WALL TWI	PROTECT. LAYER TMP	ENTHALPY REJECTION PER UNIT TUBE LENGTH BTU/(HR FT)	ENTHALPY REJECTION FRACTION OF TOTAL
			T E M P E R A	T U R E S			
.000	1.00000	1.0000	1.0000	.9756	.9756	50.420656	.00000
.125	.99981	.9945	.9871	.9377	.9377	102.200647	.13930
.250	.99961	.9902	.9800	.9380	.9380	86.914325	.29805
.375	.99942	.9862	.9701	.9309	.9309	81.018184	.42902
.500	.99923	.9825	.9642	.9268	.9268	77.254283	.55679
.625	.99904	.9791	.9549	.9213	.9213	69.565755	.67993
.750	.99885	.9759	.9506	.9168	.9168	69.883926	.79218
.875	.99866	.9724	.9413	.9069	.9069	71.081735	.90794
1.000 (EXIT)	.99848	.9706	.9361	.9211	.9211	30.978268	1.00000

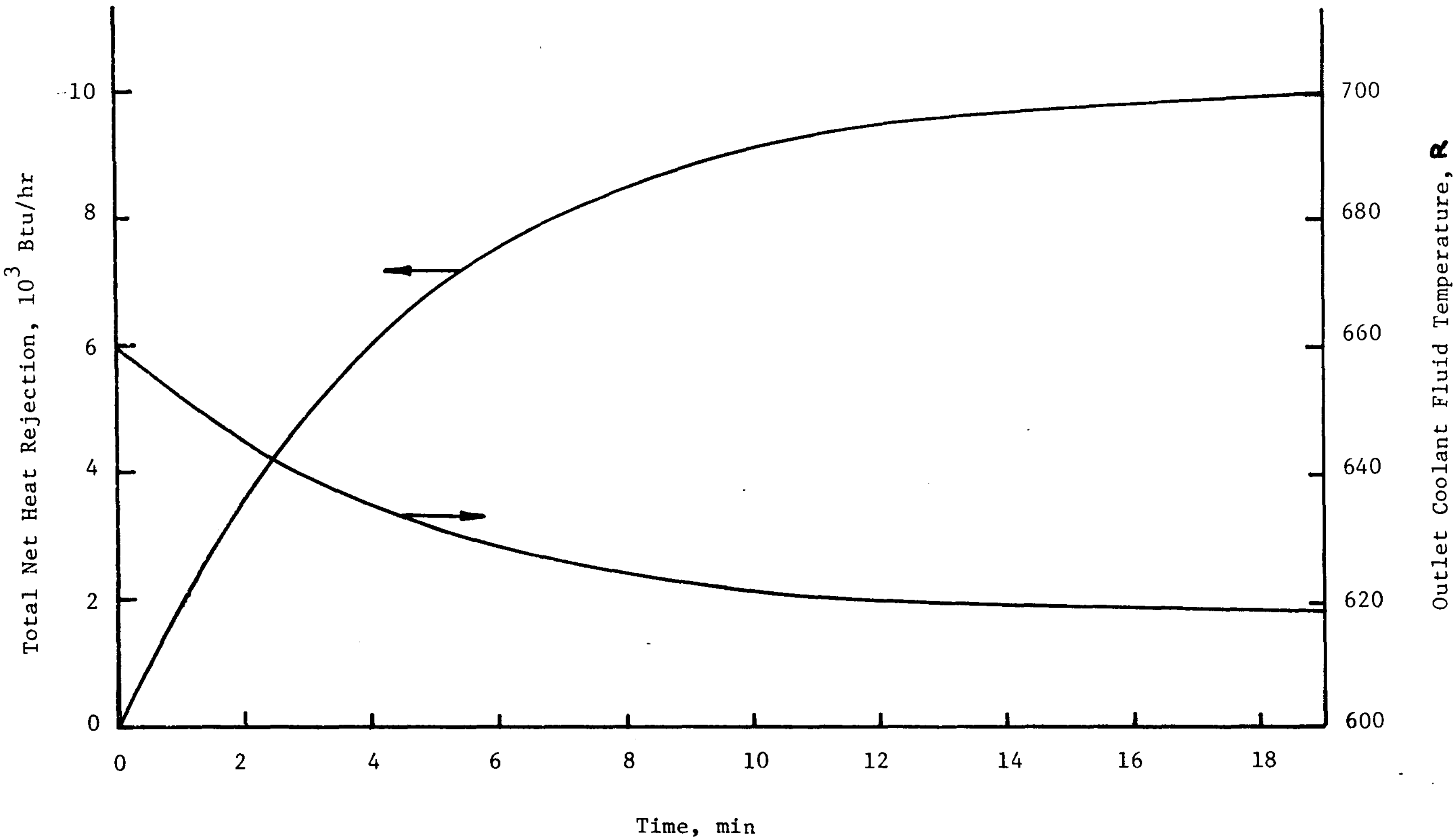

Fig. 16(b) System Response For Orbital Mission-Heat Rejection And Outlet Fluid Temperature

d. Steady State Environment

(i) Description of Environment

Program output has been produced for steady state system performance to a time invariant environmental conditions. The entire radiator system is initially assumed to be at a uniform temperature of 200°F (TI = 659.67R). The integration process is started and it proceeds until steady state operation of the system is achieved. The environmental conditions during the integration process remain constant. For the output of Figure 17, incident radiant flux values were read in from cards according to the format described in section A.3(d). These flux values were 100 Btu/hr. ft.^{2} for solar irradiation, 2.0 Btu/hr. ft.^{2} for earth albedo. There was assumed to be no infrared earth irradiation. There was no aerodynamic heating of the radiator panel. All other input parameters are the same as those used for program output during ascent (see section A.5(a)).

(ii) System Response

The response of the radiator system during the period leading to steady state operation is shown in Figure 17. Figure 17(a) shows the input parameters and a selected number of output listings of the system performance. Figure 17(b) graphically summarizes the resulting outlet coolant fluid temperature and the total heat rejection of the radiator system as the system approaches steady state operation.

```
$QNML
ITAPE   =                +0
ICASE   =                +0
NTM     =                +4
TO      =   .00000000E+00
PHN     =   .00000000E+00

$END
$TUBE
DITBI   =   .25000000E+00
STBI    =   .10000000E+00
XL      =   .12000000E+02
RHOTBI  =   .16859200E+03
MZ      =                +5
NRTBI   =                +3
NTBS    =               +10

$END
$FLOW
MDOTI   =   .50000000E+03
TO      =   .65967000E+03
PO      =   .86400000E+04

$END
$FIN
NX      =                +5
SROOTI  =   .50000000E-01
HFNI    =   .60000000E+01
STIPI   =   .50000000E-01
RHOFNI  =   .16859200E+03
STAGX   =   .20000000E+02
VERTA   =   .10000000E+02

$END
$PROTLR
NRMP    =                +3
RHOMPI  =   .16859200E+03
RHOMET  =   .50000000E+00
VELM    =   .65600000E+05
TAU     =   .36500000E+04
PROB    =   .99000000E+00
ALPHA   =   .18800000E-09
BTA     =   .12130000E+01
GAMMA   =   .15000000E+01
PHI     =   .50000000E+00
THETA   =   .66666700E+00
ATK     =   .17500000E+01
AN      =   .10000000E+01

$END
$MANIFD
AMAN    =   .43000000E+02

$END
$RUNOPT
MSTOTR  =                +1
```

Figure 17(a) System Response for Steady State Environment
Program Output

```
DTWRTE   =     .33333000E-01
TEND     =     .00000000E+00
ALIMIT   =     .50000000E-04
RLIMIT   =     .10000000E-04
TI       =     .65967000E+03
LIMWRT   =               +25
NCONV    =                +0
LTT      =                +0
LFLD     =                +1
LTS      =                +0

SEND
```

FIGURE 17(A) CONTINUED

INITIAL LINE CONDITIONS
******* **** **********
(ALL QUANTITIES ARE NORMALIZED)

PT.NO.	POSITION Z	PRESSURE P	VELOCITY W	FLUID TEMPERATURE T	WALL TEMPERATURE TWI
1	.000	1.000000	1.000000	1.000000	1.000000
2	.250	.999621	1.000001	1.000000	1.000000
3	.500	.999241	1.000001	1.000000	1.000000
4	.750	.998862	1.000001	1.000000	1.000000
5	1.000	.998483	1.000002	1.000000	1.000000

INLET PRESSURE PO = 8640.000 LBF/SQ.FT
REF. VELOCITY WO = .87128 FT/SEC
REF. TEMPERATURE TOO = 659.670 R

REYNOLDS NO = .30017+04
PRANDTL NO = 8.628066
DELTA = .001736
REL.PRESSURE IS .391534+04

INIT. NUSSELT NO. NU = .201856+02
WALL BIOT NO. BI = .485314-02

SYSTEM PARAMETERS
****** **********

TUBE LENGTH , XL = 12.000 FT
INTERNAL DIAMETER , DITB = .250 IN
WALL THICKNESS , STB = .100 IN
MATERIAL ALUMINUM
MASS (ALL TUBES) , MTB = 15.4480 LBM
NUMBER OF TUBES, NTBS = 10

FIN HEIGHT , HFN = 6.000 IN
THICKNESS AT ROOT , SROOT = .050 IN
THICKNESS AT TIP , STIP = .050 IN
MATERIAL ALUMINUM
MASS (ALL FINS) , MFN = 84.2960 LBM
NO. OF FIN SIDES RADIATING = 1

COOLANT FLUID IS SILICONE OIL
MASS (IN ALL TUBES) , MFL = 19.1289 LBM

PROTECTION LAYER THICKNESS, SMP = .011 IN
MASS, MMP = 2.038 LBM
MATERIAL IS BERYLLIUM

TOTAL MASS (EXCL. MANIFLD.) MTOT = 120.9104 LBM
TOTAL AREA (SINGLE NORMAL PROJECTION) ,
ATOT = 124.5000 SQ FT

FIGURE 17(A) CONTINUED

ELAPSED TIME IS .0000 HR
RELATIVE TIME IS .0000 **IN ORBIT** 1 INTEGR. STEPS

FIN TEMPERATURE DISTRIBUTION AND RADIANT HEAT REJECTION
****

REFERENCE TEMPERATURE, T00 = 659.670 R
REF. RADIANT HEAT FLUX
PER UNIT AXIAL LENGTH, QREF = .3246+04 BTU/(HR FT),
TOT. RADIANT REJECTION QTOT = .3288+05 BTU/HR
COND. FROM MANIFOLDS, CONDMF = .0000 BTU/HR

INCIDENT SOLAR FLUX, QSOLR = .1000+03 BTU/(HR SQ FT)
INCIDENT INFRARED FLUX, QIRED = .2000+01 BTU/(HR SQ FT)
AERODYN. HEATING POWER, QCONV = .0000 BTU/HR
ENERGY STORAGE RATE, STORG = -.3288+05 BTU/HR

AXIAL DIST. Z	RELATIVE RAD. HEAT REJECTION Q	RELATIVE TEMPERATURE OF FIN, T — DISTANCE NORMAL TO FLOW DIRECTION X: .00000	.25000	.50000	.75000	1.00000
.000	.8477	1.0000	1.0000	1.0000	1.0000	1.0000
.250	.8436	1.0000	1.0000	1.0000	1.0000	1.0000
.500	.8436	1.0000	1.0000	1.0000	1.0000	1.0000
.750	.8436	1.0000	1.0000	1.0000	1.0000	1.0000
1.000 (EXIT)	.8477	1.0000	1.0000	1.0000	1.0000	1.0000

FIGURE 17(A) CONTINUED

FLUID PROPERTIES AND SURFACE TEMPERATURE OF METEOROID PROTECTION LAYER
****

REFERENCE TEMPERATURE, T00 = 659.670 R
REFERENCE PRESSURE, P00 = 8640.000 LBF/SQ.FT
REFERENCE VELOCITY, W00 = .871 FT/SEC
COOLANT POWER, INLET AT T=T0 H0 = .276867+05 BTU/HR
EXIT CURRENTLY EI = .276866+05 BTU/HR

INLET CURRENTLY HI = .276867+05 BTU/HR
TOT. REJECTION DH = .498047-01 BTU/HR

AXIAL DIST.	PRESSURE P	VELOCITY W	FLUID TEMPERATURES TF	WALL TEMPERATURES TWI	PROTECT. LAYER TEMPERATURES TMP	ENTHALPY REJECTION PER UNIT TUBE LENGTH BTU/(HR FT)	ENTHALPY REJECTION FRACTION OF TOTAL
.000	1.00000	1.0000	1.0000	1.0000	1.0000	.000000	.00000
.250	.99962	1.0000	1.0000	1.0000	1.0000	.000277	.10085
.500	.99924	1.0000	1.0000	1.0000	1.0000	.000415	.33176
.750	.99886	1.0000	1.0000	1.0000	1.0000	.000519	.63619
1.000 (EXIT)	.99848	1.0000	1.0000	1.0000	1.0000	.000588	1.00000

```
ELAPSED TIME IS          .1000 HR
RELATIVE TIME IS         26.1382          **IN ORBIT**          52 INTEGR. STEPS
```

FIN TEMPERATURE DISTRIBUTION AND RADIANT HEAT REJECTION
****

```
REFERENCE TEMPERATURE,      T00   =  659.670 R              ,
REF. RADIANT HEAT FLUX                                        INCIDENT SOLAR FLUX,       QSOLR  =  .1000+03 BTU/(HR SQ FT)
   PER UNIT AXIAL LENGTH, QREF    =  .3246+04 BTU/(HR FT),    INCIDENT INFRARED FLUX,    QIRED  =  .2000+01 BTU/(HR SQ FT)
TOT. RADIANT REJECTION     QTOT   =  .1977+05 BTU/HR      ,   AERODYN. HEATING POWER,    QCONV  =  .0000    BTU/HR
COND. FROM MANIFOLDS,     CONDMF  =  .1545+03 BTU/HR      ,   ENERGY STORAGE RATE,       STORG  = -.7621+04 BTU/HR
```

AXIAL DIST. Z	RELATIVE RAD. HEAT REJECTION Q	RELATIVE TEMPERATURE OF FIN, T — DISTANCE NORMAL TO FLOW DIRECTION X: .00000	.25000	.50000	.75000	1.00000
.000	.7309	.9669	.9669	.9669	.9669	.9669
.250	.5016	.9203	.8992	.8851	.8770	.8744
.500	.4808	.9091	.8903	.8777	.8704	.8681
.750	.4615	.8974	.8815	.8709	.8647	.8628
1.000 (EXIT)	.5476	.9070	.9070	.9070	.9070	.9070

FIGURE 17(A) CONTINUED

FLUID PROPERTIES AND SURFACE TEMPERATURE OF METEOROID PROTECTION LAYER
****

```
REFERENCE TEMPERATURE, T00      =       659.670 R
REFERENCE PRESSURE,    P00      =      8640.000 LBF/SQ.FT
REFERENCE VELOCITY,    W00      =          .871 FT/SEC
COOLANT POWER, INLET  AT T=T0  H0 = .276867+05 BTU/HR        INLET CURRENTLY  HI = .276867+05 BTU/HR
               EXIT  CURRENTLY EI = .156871+05 BTU/HR        TOT. REJECTION   DH = .119996+05 BTU/HR
```

AXIAL DIST.	PRESSURE P	VELOCITY W	FLUID TEMPERATURES TF	WALL TEMPERATURES TWI	PROTECT. LAYER TEMPERATURES TMP	ENTHALPY REJECTION PER UNIT TUBE LENGTH BTU/(HR FT)	ENTHALPY REJECTION FRACTION OF TOTAL
.000	1.00000	1.0000	1.0000	.9669	.9669	69.442389	.00000
.250	.99962	.9884	.9740	.9203	.9203	112.865777	.27736
.500	.99923	.9788	.9559	.9091	.9091	98.273507	.58267
.750	.99886	.9709	.9354	.8974	.8974	79.855536	.82863
1.000 (EXIT)	.99848	.9668	.9238	.9070	.9070	35.347144	1.00000

ELAPSED TIME IS .2000 HR
RELATIVE TIME IS 52.2765 **IN ORBIT** 79 INTEGR. STEPS

FIN TEMPERATURE DISTRIBUTION AND RADIANT HEAT REJECTION
****

REFERENCE TEMPERATURE, T00 = 659.670 R
REF. RADIANT HEAT FLUX PER UNIT AXIAL LENGTH, QREF = .3246+04 BTU/(HR FT),
TOT. RADIANT REJECTION QTOT = .1740+05 BTU/HR
COND. FROM MANIFOLDS, CONDMF = .1896+03 BTU/HR

INCIDENT SOLAR FLUX, QSOLR = .1000+03 BTU/(HR SQ FT)
INCIDENT INFRARED FLUX, QIRED = .2000+01 BTU/(HR SQ FT)
AERODYN. HEATING POWER, QCONV = .0000 BTU/HR
ENERGY STORAGE RATE, STORG = -.2265+04 BTU/HR

AXIAL DIST. Z	RELATIVE RAD. HEAT REJECTION Q	RELATIVE TEMPERATURE OF FIN, T — DISTANCE NORMAL TO FLOW DIRECTION X: .00000	.25000	.50000	.75000	1.00000
.000	.7183	.9632	.9632	.9632	.9632	.9632
.250	.4485	.9041	.8798	.8630	.8533	.8501
.500	.4166	.8883	.8657	.8502	.8411	.8381
.750	.3838	.8698	.8501	.8366	.8287	.8261
1.000 (EXIT)	.4785	.8810	.8810	.8810	.8810	.8810

FIGURE 17(A) CONTINUED

FLUID PROPERTIES AND SURFACE TEMPERATURE OF METEOROID PROTECTION LAYER
****

REFERENCE TEMPERATURE, T00 = 659.670 R
REFERENCE PRESSURE, P00 = 8640.000 LBF/SQ.FT
REFERENCE VELOCITY, W00 = .871 FT/SEC
COOLANT POWER, INLET AT T=T0 H0 = .276867+05 BTU/HR
EXIT CURRENTLY EI = .127453+05 BTU/HR
INLET CURRENTLY HI = .276867+05 BTU/HR
TOT. REJECTION DH = .149414+05 BTU/HR

AXIAL DIST.	PRESSURE P	VELOCITY W	TEMPERATURES: FLUID TF	WALL TWI	PROTECT. LAYER TMP	ENTHALPY REJECTION PER UNIT TUBE LENGTH BTU/(HR FT)	FRACTION OF TOTAL
.000	1.00000	1.0000	1.0000	.9632	.9632	75.726097	.00000
.250	.99961	.9863	.9690	.9041	.9041	133.561531	.25844
.500	.99923	.9745	.9478	.8883	.8883	122.299504	.55811
.750	.99886	.9641	.9208	.8698	.8698	104.992007	.81310
1.000 (EXIT)	.99848	.9585	.9050	.8810	.8810	49.425550	1.00000

ELAPSED TIME IS .3000 HR
RELATIVE TIME IS 78.4147 **IN ORBIT** 104 INTEGR. STEPS

FIN TEMPERATURE DISTRIBUTION AND RADIANT HEAT REJECTION
****

REFERENCE TEMPERATURE, T00 = 659.670 R ,
REF. RADIANT HEAT FLUX
PER UNIT AXIAL LENGTH, QREF = .3246+04 BTU/(HR FT),
TOT. RADIANT REJECTION QTOT = .1685+05 BTU/HR ,
COND. FROM MANIFOLDS, CONDMF = .1986+03 BTU/HR ,

INCIDENT SOLAR FLUX, QSOLR = .1000+03 BTU/(HR SQ FT)
INCIDENT INFRARED FLUX, QIRED = .2000+01 BTU/(HR SQ FT)
AERODYN. HEATING POWER, QCONV = .0000 BTU/HR
ENERGY STORAGE RATE, STORG = -.9773+03 BTU/HR

AXIAL DIST. Z	RELATIVE RAD. HEAT REJECTION Q	RELATIVE TEMPERATURE OF FIN, T — DISTANCE NORMAL TO FLOW DIRECTION X: .00000	.25000	.50000	.75000	1.00000
.000	.7158	.9624	.9624	.9624	.9624	.9624
.250	.4374	.9005	.8755	.8582	.8481	.8448
.500	.4025	.8836	.8600	.8437	.8342	.8311
.750	.3645	.8625	.8417	.8273	.8189	.8162
1.000 (EXIT)	.4617	.8743	.8743	.8743	.8743	.8743

FIGURE 17(A) CONTINUED

FLUID PROPERTIES AND SURFACE TEMPERATURE OF METEOROID PROTECTION LAYER
****

REFERENCE TEMPERATURE, T00 = 659.670 R
REFERENCE PRESSURE, P00 = 8640.000 LBF/SQ.FT
REFERENCE VELOCITY, W00 = .871 FT/SEC
COOLANT POWER, INLET AT T=T0 H0 = .276867+05 BTU/HR
EXIT CURRENTLY EI = .120168+05 BTU/HR

INLET CURRENTLY HI = .276867+05 BTU/HR
TOT. REJECTION DH = .156699+05 BTU/HR

AXIAL DIST.	PRESSURE P	VELOCITY W	FLUID TEMPERATURES TF	WALL TEMPERATURES TWI	PROTECT. LAYER TEMPERATURES TMP	ENTHALPY REJECTION PER UNIT TUBE LENGTH BTU/(HR FT)	ENTHALPY REJECTION FRACTION OF TOTAL
.000	1.00000	1.0000	1.0000	.9624	.9624	76.930037	.00000
.250	.99961	.9858	.9678	.9005	.9005	137.760096	.25316
.500	.99923	.9735	.9462	.8836	.8836	128.067226	.55047
.750	.99886	.9625	.9173	.8625	.8625	112.156114	.80811
1.000 (EXIT)	.99848	.9565	.9003	.8743	.8743	53.326069	1.00000

ELAPSED TIME IS .4000 HR
RELATIVE TIME IS 104.5529 **IN ORBIT** 130 INTEGR. STEPS

FIN TEMPERATURE DISTRIBUTION AND RADIANT HEAT REJECTION

REFERENCE TEMPERATURE, T00 = 659.670 R
REF. RADIANT HEAT FLUX PER UNIT AXIAL LENGTH, QREF = .3246+04 BTU/(HR FT),
TOT. RADIANT REJECTION QTOT = .1671+05 BTU/HR ,
COND. FROM MANIFOLDS, CONDMF = .2010+03 BTU/HR ,

INCIDENT SOLAR FLUX, QSOLR = .1000+03 BTU/(HR SQ FT)
INCIDENT INFRARED FLUX, QIRED = .2000+01 BTU/(HR SQ FT)
AERODYN. HEATING POWER, QCONV = .0000 BTU/HR
ENERGY STORAGE RATE, STORG = -.6569+03 BTU/HR

AXIAL DIST. Z	RELATIVE RAD. HEAT REJECTION Q	RELATIVE TEMPERATURE OF FIN, T — DISTANCE NORMAL TO FLOW DIRECTION X: .00000	.25000	.50000	.75000	1.00000
.000	.7152	.9622	.9622	.9622	.9622	.9622
.250	.4348	.8997	.8745	.8571	.8469	.8436
.500	.3993	.8825	.8587	.8422	.8326	.8294
.750	.3595	.8607	.8395	.8249	.8163	.8135
1.000 (EXIT)	.4574	.8725	.8725	.8725	.8725	.8725

FIGURE 17(A) CONTINUED

FLUID PROPERTIES AND SURFACE TEMPERATURE OF METEOROID PROTECTION LAYER

REFERENCE TEMPERATURE, T00 = 659.670 R
REFERENCE PRESSURE, P00 = 8640.000 LBF/SQ.FT
REFERENCE VELOCITY, W00 = .871 FT/SEC
COOLANT POWER, INLET AT T=T0 H0 = .276867+05 BTU/HR
EXIT CURRENTLY EI = .118339+05 BTU/HR

INLET CURRENTLY HI = .276867+05 BTU/HR
TOT. REJECTION DH = .158528+05 BTU/HR

AXIAL DIST.	PRESSURE P	VELOCITY W	FLUID TEMPERATURES TF	WALL TWI	PROTECT. LAYER TMP	ENTHALPY REJECTION PER UNIT TUBE LENGTH BTU/(HR FT)	FRACTION OF TOTAL
.000	1.00000	1.0000	1.0000	.9622	.9622	77.176887	.00000
.250	.99961	.9857	.9675	.8997	.8997	138.666939	.25172
.500	.99923	.9733	.9458	.8825	.8825	129.416553	.54823
.750	.99886	.9621	.9165	.8607	.8607	114.102509	.80655
1.000 (EXIT)	.99848	.9560	.8992	.8725	.8725	54.379859	1.00000

```
ELAPSED TIME IS             .5000 HR
RELATIVE TIME IS         130.6912               **IN ORBIT**                    157 INTEGR. STEPS

        FIN TEMPERATURE DISTRIBUTION AND RADIANT HEAT REJECTION
        *******************************************************

REFERENCE TEMPERATURE,     T00  =   659.670 R        ,
REF. RADIANT HEAT FLUX                                      INCIDENT SOLAR FLUX,     QSOLR  =  .1000+03 BTU/(HR SQ FT)
   PER UNIT AXIAL LENGTH, QREF  =  .3246+04 BTU/(HR FT),    INCIDENT INFRARED FLUX,  QIRED  =  .2000+01 BTU/(HR SQ FT)
TOT. RADIANT REJECTION    QTOT  =  .1668+05 BTU/HR     ,    AERODYN. HEATING POWER,  QCONV  =  .0000    BTU/HR
COND. FROM MANIFOLDS,   CONDMF  =  .2017+03 BTU/HR     ,    ENERGY STORAGE RATE,     STORG  = -.5757+03 BTU/HR
```

AXIAL DIST. Z	RELATIVE RAD. HEAT REJECTION Q	RELATIVE TEMPERATURE OF FIN, T — DISTANCE NORMAL TO FLOW DIRECTION X: .00000	.25000	.50000	.75000	1.00000
.000	.7150	.9622	.9622	.9622	.9622	.9622
.250	.4342	.8994	.8742	.8568	.8466	.8433
.500	.3985	.8822	.8584	.8419	.8322	.8290
.750	.3582	.8602	.8390	.8243	.8156	.8128
1.000 (EXIT)	.4564	.8721	.8721	.8721	.8721	.8721

Figure 17(a) Continued

```
        FLUID PROPERTIES AND SURFACE TEMPERATURE OF METEOROID PROTECTION LAYER
        **********************************************************************

      REFERENCE TEMPERATURE, T00     =       659.670 R
      REFERENCE PRESSURE,    P00     =      8640.000 LBF/SQ.FT
      REFERENCE VELOCITY,    W00     =          .871 FT/SEC
   COOLANT POWER, INLET  AT T=T0  H0 =  .276867+05 BTU/HR          INLET CURRENTLY  HI =  .276867+05 BTU/HR
                  EXIT   CURRENTLY EI =  .117874+05 BTU/HR          TOT. REJECTION   DH =  .158993+05 BTU/HR
```

AXIAL DIST.	PRESSURE P	VELOCITY W	FLUID TEMPERATURES TF	WALL TEMPERATURES TWI	PROTECT. LAYER TEMPERATURES TMP	ENTHALPY REJECTION PER UNIT TUBE LENGTH BTU/(HR FT)	ENTHALPY REJECTION FRACTION OF TOTAL
.000	1.00000	1.0000	1.0000	.9622	.9622	77.232511	.00000
.250	.99961	.9857	.9674	.8994	.8994	138.877901	.25135
.500	.99923	.9732	.9457	.8822	.8822	129.726835	.54762
.750	.99886	.9620	.9163	.8602	.8602	114.610315	.80610
1.000 (EXIT)	.99848	.9558	.8989	.8721	.8721	54.654328	1.00000

ELAPSED TIME IS .6000 HR
RELATIVE TIME IS 156.8294 **IN ORBIT** 184 INTEGR. STEPS

FIN TEMPERATURE DISTRIBUTION AND RADIANT HEAT REJECTION

REFERENCE TEMPERATURE, T00 = 659.670 R ,
REF. RADIANT HEAT FLUX PER UNIT AXIAL LENGTH, QREF = .3246+04 BTU/(HR FT),
TOT. RADIANT REJECTION QTOT = .1667+05 BTU/HR ,
COND. FROM MANIFOLDS, CONDMF = .2018+03 BTU/HR ,

INCIDENT SOLAR FLUX, QSOLR = .1000+03 BTU/(HR SQ FT)
INCIDENT INFRARED FLUX, QIRED = .2000+01 BTU/(HR SQ FT)
AERODYN. HEATING POWER, QCONV = .0000 BTU/HR
ENERGY STORAGE RATE, STORG = -.5547+03 BTU/HR

AXIAL DIST. Z	RELATIVE RAD. HEAT REJECTION Q	RELATIVE TEMPERATURE OF FIN, T — DISTANCE NORMAL TO FLOW DIRECTION X: .00000	.25000	.50000	.75000	1.00000
.000	.7150	.9622	.9622	.9622	.9622	.9622
.250	.4340	.8994	.8741	.8567	.8465	.8432
.500	.3983	.8822	.8583	.8418	.8321	.8289
.750	.3579	.8601	.8388	.8241	.8155	.8127
1.000 (EXIT)	.4561	.8720	.8720	.8720	.8720	.8720

FIGURE 17(A) CONTINUED

FLUID PROPERTIES AND SURFACE TEMPERATURE OF METEOROID PROTECTION LAYER

REFERENCE TEMPERATURE, T00 = 659.670 R
REFERENCE PRESSURE, P00 = 8640.000 LBF/SQ.FT
REFERENCE VELOCITY, W00 = .871 FT/SEC
COOLANT POWER, INLET AT T=T0 H0 = .276867+05 BTU/HR
EXIT CURRENTLY EI = .117753+05 BTU/HR

INLET CURRENTLY HI = .276867+05 BTU/HR
TOT. REJECTION DH = .159114+05 BTU/HR

AXIAL DIST.	PRESSURE P	VELOCITY W	FLUID TEMPERATURE TF	WALL TEMPERATURE TWI	PROTECT. LAYER TEMPERATURE TMP	ENTHALPY REJECTION PER UNIT TUBE LENGTH BTU/(HR FT)	ENTHALPY REJECTION FRACTION OF TOTAL
.000	1.00000	1.0000	1.0000	.9622	.9622	77.246378	.00000
.250	.99961	.9857	.9674	.8994	.8994	138.930130	.25127
.500	.99923	.9732	.9457	.8822	.8822	129.798357	.54747
.750	.99886	.9620	.9162	.8601	.8601	114.739276	.80599
1.000 (EXIT)	.99848	.9558	.8988	.8720	.8720	54.722584	1.00000

ELAPSED TIME IS .6183 HR
RELATIVE TIME IS 161.6107 **IN ORBIT** 188 INTEGR. STEPS

FIN TEMPERATURE DISTRIBUTION AND RADIANT HEAT REJECTION
****

REFERENCE TEMPERATURE, T00 = 659.670 R ,
REF. RADIANT HEAT FLUX
PER UNIT AXIAL LENGTH, QREF = .3246+04 BTU/(HR FT),
TOT. RADIANT REJECTION QTOT = .1667+05 BTU/HR ,
COND. FROM MANIFOLDS, CONDMF = .2019+03 BTU/HR ,

INCIDENT SOLAR FLUX, QSOLR = .1000+03 BTU/(HR SQ FT)
INCIDENT INFRARED FLUX, QIRED = .2000+01 BTU/(HR SQ FT)
AERODYN. HEATING POWER, QCONV = .0000 BTU/HR
ENERGY STORAGE RATE, STORG = -.5533+03 BTU/HR

FIGURE 17(A) CONCLUDED

AXIAL DIST. Z	RELATIVE RAD. HEAT REJECTION Q	RELATIVE TEMPERATURE OF FIN, T — DISTANCE NORMAL TO FLOW DIRECTION X: .00000	.25000	.50000	.75000	1.00000
.000	.7150	.9622	.9622	.9622	.9622	.9622
.250	.4340	.8994	.8741	.8567	.8465	.8432
.500	.3983	.8822	.8583	.8418	.8321	.8289
.750	.3579	.8600	.8388	.8241	.8155	.8126
1.000 (EXIT)	.4561	.8720	.8720	.8720	.8720	.8720

FLUID PROPERTIES AND SURFACE TEMPERATURE OF METEOROID PROTECTION LAYER
****

REFERENCE TEMPERATURE, T00 = 659.670 R
REFERENCE PRESSURE, P00 = 8640.000 LBF/SQ.FT
REFERENCE VELOCITY, W00 = .871 FT/SEC
COOLANT POWER, INLET AT T=T0 H0 = .276867+05 BTU/HR
EXIT CURRENTLY EI = .117746+05 BTU/HR

INLET CURRENTLY HI = .276867+05 BTU/HR
TOT. REJECTION DH = .159121+05 BTU/HR

AXIAL DIST.	PRESSURE P	VELOCITY W	FLUID TEMPERATURES TF	WALL TEMPERATURES TWI	PROTECT. LAYER TEMPERATURES TMP	ENTHALPY REJECTION PER UNIT TUBE LENGTH BTU/(HR FT)	ENTHALPY REJECTION FRACTION OF TOTAL
.000	1.00000	1.0000	1.0000	.9622	.9622	77.247403	.00000
.250	.99961	.9857	.9674	.8994	.8994	138.934032	.25126
.500	.99923	.9732	.9457	.8822	.8822	129.805758	.54745
.750	.99886	.9620	.9162	.8600	.8600	114.752011	.80597
1.000 (EXIT)	.99848	.9558	.8988	.8720	.8720	54.731251	1.00000

STEADY STATE IS REACHED

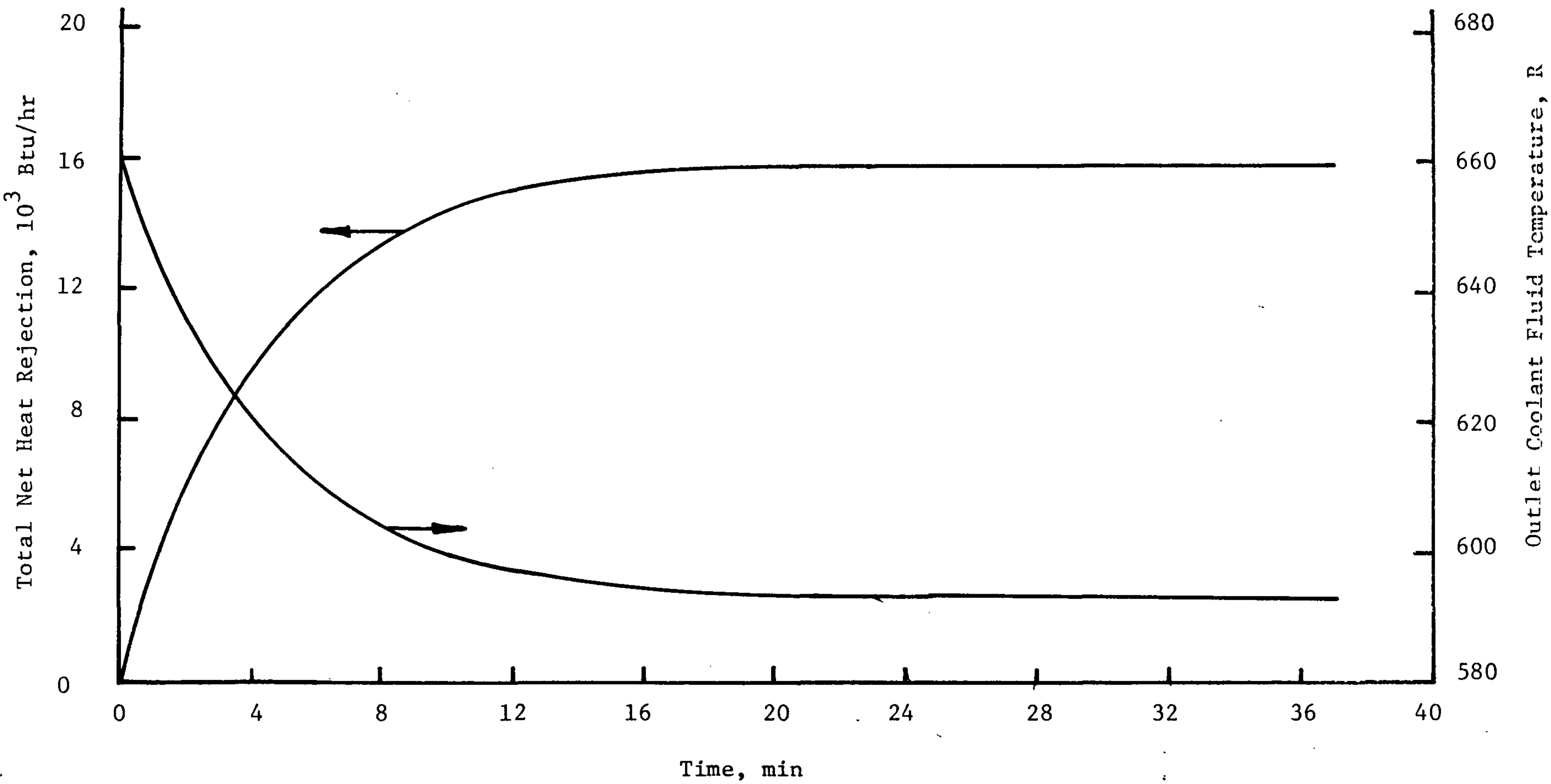

Fig. 17(b) System Response for Steady State Environment-System Heat Rejection And Outlet Fluid Temperature

B. Program Description

1. Structure

The program structure is dictated by the calling sequence of the Runge-Kutta-Simpson integration procedure (see Section III-2 of the System Analysis Manual). The Source Deck consists of two parts. The first part is referred to as the Permanent Part and the second part is called the Selective Part. The Input Data Set follows the Selective Part.

a. The Permanent Part

The Permanent Part requires no attention from the user unless he plans major program modifications such as consideration of geometrical configurations other than the one considered on the present analysis. The Permanent Part contains the first 42 program units.

b. The Selective Part

The Selective part contains the options for selection of system materials. It is assembled from case to case by the user in accordance with his choice of the coolant fluid material, flow channel material, meteoroid protection layer material, fin panel material and thermal control coating material. There are always 20 program units in the Selective Part.

c. The Input Data Set

The Input Data Set follows immediately after the Source Deck. As discussed in Section A-3 the Data Set consists of six groups that specify the non-symmetrical panel conditions, ascent and reentry profiles, the irradiation on the panel, inlet coolant fluid conditions, system specifications and finally the program options. These separate data units are arranged in an order of increasing possibility of input changes so that data units most likely to be changed are at the end of the Data Set.

2. Fastrand Execution

A run procedure was written for the purpose of entering the entire program, including property subprograms, on FASTRAND drums and collecting, or mapping, the program into convenient elements. The elements are chosen so that they form commonly used groups of subprograms which then may be selectively collected into a complete program. The advantages of this technique are the significant reduction in the compilation and collection time and the elimination of submitting the program in card form.

The entire program is mapped into two basic elements: the permanent element and the property elements. The permanent element (called PERM) consists of all subroutines listed in the permanent part of the program; the property elements consist of the material properties of the surface coating, fin material, tube material, meteoroid protection material, and coolant fluid.

Each property element has a unique name. The first two letters of the name are a prefix which indicates the function of the particular material. For example, a property element starting with the prefix CF indicates that those properties to be used for the coolant fluid. The remaining letters of the element name are a suffix which describes the particular material to be used. For example, the suffix HE indicates the material helium. The prefix-suffix combination CFHE, therefore, denotes the coolant fluid of helium.

The sixteen names designating the permanent part of the program and the property elements are as follows:

i) Permanent Elements

1. Element PERM contains all subroutines in the permanent part of the program. (See Part B.3 a through g)

ii) Property Elements

A. Coolant Fluid Properties (Prefix CF)

2. Element CFHE contains all helium properties
3. Element CFSIL contains all silicon oil properties
4. Element CFNAK contains all NaK properties

5. Element CFFC43 contains all properties of the 3-M fluorochemical liquid FC43
6. Element CFFC75 contains all properties of the 3-M fluorochemical liquid FC75

B. Fin Properties (Prefix FN)

7. Element FNAL contains all aluminum properties
8. Element FNCU contains all copper properties
9. Element FNBR contains all beryllium properties

C. Tube Properties (Prefix TB)

10. Element TBAL contains all aluminum properties
11. Element TBCU contains all copper properties
12. Element TBBR contains all beryllium properties

D. Meteoroid Protection Properties (Prefix MP)

13. Element MPAL contains all aluminum properties
14. Element MPCU contains all copper properties
15. Element MPBR contains all beryllium properties

E. Surface Coating Properties (Prefix SC)

16. Element SCZ93 contains all zinc oxide coating (Z93) properties

a. Control Statements

The run deck consists of the following control statements:

The catalogue card

@ CAT,P NASA.,F2

is used to create a file, called here NASA. This card is to be used only the first time the FASTRAND program is run. It must be omitted when subsequent runs are made because the file NASA should be created only once.

The assign card

@ ASG,AX NASA.

is used to name an external file which has been previously catalogued and to cause its assignment to the run. The option A specifies that the file is currently catalogued and the option X specifies that the run is to have exclusive use of the file until the run terminates so that no other run may interfere with the program operation.

The use card

@ USE N.,NASA.

allows the user to refer to the previously catalogued file called NASA by the single letter N. The abbreviated file name will save a great deal of card punching for the subsequent portions of the run.

The Fortran compiler cards, one of which would be

@ FØR,IS N.MAIN

creates Fortran symbolic and relocatable elements both called MAIN which are to be entered into the file NASA. The I option causes the insertion of the element MAIN and the S option produces a listing of the element. There must be a FØR card for each subprogram that is to be entered into the file NASA.

After all of the subprograms have been filed, they are mapped into separate elements. This is achieved by the MAP and IN card.

The MAP cards, one of which would be

@ MAP,ISR ,N.PERM

specifies that the collector should combine a set of relocatable elements from the file NASA into a single relocatable element called PERM. There must be a MAP card for each program element that the user expects to utilize during program operation. A listing of these seventeen elements is given at the beginning of this section.

Following each MAP card is a list of the separate subprograms that are to be placed in the element declared by the MAP card. The placing of each subprogram into the element is achieved by an IN card.

The IN card, one of which would be

IN N.MAIN

places the element MAIN from the file NASA in the element name declared by the previous MAP statement. There must be an IN card for each program element that is to be entered into the element declared by the previous MAP statement.

As an example, if the user wishes to collect the subprograms called AA, BB and CC which are located in the file NASA and place them in an element called ELEM, the proper cards would be:

```
@ MAP,ISR ,NASA.ELEM
IN NASA.AA
IN NASA.BB
IN NASA.CC
```

It is necessary to place a define card at the end of each mapped element.

A define card, one of which could be

DEF THCFN, DTHCFN, CPFN

is used to list those external definitions to be retained by the resulting relocatable element. The DEF statement causes the collector to construct a table defining the entry points to the element. There should be a DEF statement following each MAP card which declares the entry point to each element collected by the MAP card.

b. Input Data

The runstream described above enters all subprograms into the file called NASA and then subdivides the program into convenient groupings of elements. Once this run has been made, it becomes a relatively simple task to collect and run a typical system simulation. As an example, assume the user wishes output for a radiator system consisting of an aluminum fin, copper tube, beryllium meteoroid protection layer, silicon oil coolant fluid and Z93 surface coating. Assuming the user has previously declared the file NASA and he has mapped the sixteen elements discussed above, then this combination of materials could be mapped into an absolute element called VER1 by the runstream consisting of

(Run cards appropriate to the users system)

```
@ ASG,AX NASA.
@ USE N.,NASA.
@ MAP,IS ,N.VER1
IN N.PERM
```

```
IN N.FNAL
IN N.TBCU
IN N.MPBR
IN N.CFSIL
IN N.SCZ93
END
@ XQT N.VER1
```

This deck must be followed by the data set described in Section A-3.

As a second example, if the user wishes to run the program for a system consisting of an aluminum tube, fin and protection layer with helium coolant fluid and Z93 surface coating the deck would consist of

(Run cards appropriate to the users system)

```
@ ASG,AX NASA.
@ USE N.,NASA.
@ MAP,IS ,N.VER2
IN N.PERM
IN N.FNAL
IN N.TBAL
IN N.MPAL
IN N.CFHE
IN N.SCZ93
END
@ XQT N.VER2
```

This deck must be followed by the data deck described in Section A-3. In this example the element PERM plus the property elements are mapped into an absolute element called VER2. It should be pointed out that once these absolute elements have been mapped they are available for subsequent runs without being re-mapped. In future runs, if VER2 is called upon to be executed, the element consisting of PERM plus is the property elements listed above are automatically used.

3. Description of Program Units

This section describes each subprogram which makes up the Permanent and Selective Part of the program.

The description of each subprogram follows the same format. The name of the subprogram is given and it is categorized as either a FUNCTIØN or SUBRØUTINE subprogram. The argument list is also stated.

The objective of each of the subprograms is stated. All input and output variables in the argument list are defined and units are given for all dimensional input and output quantities.

The calling subprograms and those subprograms called are listed for each program unit.

The program units are subdivided into groups of subprograms each of which has a common overall function. For example, all subprograms that are used for the calculation of the aerodynamic heating of the radiator panel are grouped into a common block of programs. In all, there are 62 program units with 42 units on the permanent part and 20 units in the Selective Part. The Permanent Part contains 42 program units grouped in seven sets from (a) through (g) as follows:

a) the principal integration program set with

1. MAIN, the main program unit which

provides	α)	input and output
	β)	unit conversion
	γ)	computation of design parameters
	δ)	preparations for principal integration,
calls	α)	RKS, DERIVM, CNTLM, for principal integration
	β)	FLSTRT to establish the initial flow field
	γ)	FUNCTIØN subprograms for fluid and structural material properties
	δ)	QINCID, SHAPEF (see group c)
	ε)	mathematical procedure subprograms,

2. SUBRØUTINE DERIVM (Y,DY,TIME) which is called from RKS,

receives	α)	the current system state variables Y
	β)	the current time TIME,
provides	α)	all derivatives of the variables Y with respect to time,
calls	α)	CØNVEC, QRAD
	β)	FLSTRT to establish the flow field
	γ)	FUNCTIØN subprograms for fluid and structural material properties
	δ)	mathematical procedure subprograms,

3. SUBRØUTINE CNTLM (Y,DY,DX,X,NTRY,IFVD) which

is called from		RKS,
receives	α)	all system state variables Y
	β)	their derivatives DY
	γ)	current time X, step size DX,
provides	α)	output during integration
	β)	integration step size control
	γ)	integration termination criteria,
calls	α)	HFL, fluid enthalpy subprogram
	β)	mathematical procedure subprograms,

b) the secondary integration program set, necessary to establish the dynamic fluid flow field, with

4. SUBRØUTINE FLSTRT (RE,PR,DELTA) which

is called from		MAIN,DERIVM,
receives	α)	RE, the mean Reynolds number
	β)	PR, the mean Prandtl number
	γ)	DELTA, the diameter-to-length ratio for the tube,
provides	α)	fluid flow (initial and current) conditions
	β)	table heading for initial conditions,
calls	α)	TRNSPT to compute friction factor and convective film coefficient (in non-dimensional form)
	β)	RKSF, DERIVL, CNTLN
	γ)	fluid flow property subprograms
	δ)	mathematical procedure subprograms,

5. SUBRØUTINE DERIVL (Y,DY,X) which

is called from		RKSF,
receives	α)	local fluid flow variables Y
	β)	position along flow channel axis, X,
provides	α)	spatial derivatives DY of Y,

6. SUBRØUTINE CNTLN (Y,DY,DX,X,NTRY,IFVD) which

is called from		RKSF,
receives	α)	the flow variables Y
	β)	their spatial derivatives DY
	γ)	position X, interval DX along channel axis,
provides	α)	output when initial conditions are established
	β)	termination criteria for RKSF integration,

7. SUBRØUTINE TRNSPT (RE,PRL,DELTA,FR,FNU) which computes non-dimensional friction factor and convective film ooefficient, Eqs. 3.7 through 9 and Eqs. 3.16 through 18, and

is called from		FLSTRT,
receives	α)	Reynolds number RE

β) Prandtl number PRL

γ) diameter-to-length ratio DELTA,

provides α) FR = $4f/\delta$, Eq. 3.32

β) FNU = $4\ N_{Nu}/(\delta\ N_{Re}N_{Pr})$, Eq. 3.37,

c) The program set used to calculate the incident net radiant flux, with,

8. SUBRØUTINE QINCID which

is called from MAIN,

receives α) MSTØTR control option for simulation of steady state (= 1) or transient (= 2) conditions

β) NSRD the number of radiator sides that are exposed to the environment

γ) PHN the angle between the reference used in the MRI file data and the normal to the fin panel,

provides α) data transfer from the MRI Incident Radiation Computer program or card input

β) averaging of radiant flux over circumference of tube cross-section,

9. SUBRØUTINE SHAPEF which

is called from MAIN,

provides exchange function SS as defined by Eq. 6.15, see Appendix D,

10. SUBRØUTINE TRMATX which

is called from QRAD,

provides the evaluation of the transfer matrix M_{ij}, defined by Eq. 6.7,

11. SUBRØUTINE EXITAV which

is called from QRAD,

provides the evaluation of the excitation vector P_j in Eq. 6.18,

12. SUBRØUTINE ABSØRB which

is called from QRAD,

receives α) total hemispherical emittance ε, see Eq. 6.5

β) temperature distributions on the fin and tube surfaces

γ) exchange function SS

δ) functions x_{ij} and x_{ijk} defined by Eqs. 6.10 and 6.11,

provides adsorptance matrix α_{ij} as defined by Eq. 6.9,

calls
α) SHAPEF for SS
β) EMIT for (T)
γ) AVGEMT for x_{ij} and x_{ijk}
δ) DEFINT for integration,

13. SUBRØUTINE QRAD which

is called from DERIVM,

receives α) transfer matrix and excitation vector M_{ij} and P_j, respectively,

provides
α) inversion of transfer matrix
β) solution of radiosity equations
γ) grid mapping,

calls
α) TRMATX
β) EXITAV
γ) YINT, INTERP,

d) the program set used to calculate the aerodynamic heating during ascent and reentry, consisting of

14. FUNCTIØN ALTVEL (TIME, IØPTN, AVA, AVR, TA, TR, NA, NR) which interpolates user-supplied altitude and velocity profiles for a given instant, and

is called from CØNVEC,

receives
α) current real time, TIME, in seconds, measured from start of transition phase, i.e., ascent: TIME = 0, ALTVEL = AVA (1)
reentry: TIME = 0, ALTVEL = AVR (1)
β) ordered pairs of time and altitude (TA,AVA) and (TR,AVR) for ascent and reentry, respectively
γ) NA and NR, the number of ordered pairs and elements in TA,AVA and TR,AVR, respectively

δ) IØPTN = 0 for ascent
= 1 for reentry,

provides — data interpolation,

calls — YINT for interpolation,

15. SUBRØUTINE ATMØS (ELEV, TATM, CATM) which computes the atmospheric temperature and the speed of sound as functions of altitude and

is called from — CØNVEC,

receives — α) current shuttle elevation, ELEV, in feet

provides — atmospheric temperature, TATM in degrees R and speed of sound, CATM, in ft/sec,

calls — YINT for interpolation, PØLY for evaluation of polynomials,

16. SUBRØUTINE REFP (ELEV, REFTP, REFPR, REFVIS, REFRHØ, REFK, REFCP, REFGAM) which computes the atmospheric air properties as a function of elevation and of high speed reference temperature and

is called from — CØNVEC,

receives — α) current orbiter elevation, ELEV, in feet

β) current high speed reference temperature REFTP, in degrees R,

provides — atmospheric Prandtl number REFPR (dimensionless), dynamic viscosity REFVIS in lbm/(ft sec), density REFRHØ in lbm/ft^3, thermal conductivity REFK in Btu/(sec ft R), specific heat at constant pressure REFCP in Btu/(lbm/R) and the ratio of specific heats REFGAM (dimensionless),

calls — α) YINT for interpolation

β) PØLY for polynomial expansion,

17. SUBRØUTINE NUS (MACHNØ, TATM, CATM, TIN, PRATM, VISATM, RHØATM, STAGX, VERTX, NSRAD, NUS1) which provides a single Nusselt number for the calculation of the aerodynamic heating of the orbiter radiator system at the current time and

is called from — CØNVEC,

receives — α) current orbiter Mach number MACHNØ (dimensionless)

β) current atmospheric temperature TATM, in degrees R γ) current atmospheric velocity of sound, CATM, in ft/sec

ε) temperature of the coolant fluid at the inlet plane TIN, in degrees R

ζ) atmospheric Prandtl number PRATM, evaluated at the high speed reference temperature (dimensionless)

η) atmospheric density RHØATM, evaluated at the high speed reference temperature in lbm/ft^3

θ) distance from the stagnation point on the shuttle vehicle to the midpoint of the radiator panel measured along a streamline, STAGX, in feet

ι) overall dimension of the radiator panel measure in a direction parallel to the acceleration of gravity, VERTX, in feet

κ) integer value indicating number of non-adiabatic sides of the radiator panel, NSRAD, i.e., NSRAD = 1 for single non-adiabatic surface or NSRAD = 2 for both sides of radiator being non-adiabatic,

provides — mean Nusselt number NUS1, for meteoroid layer and fin at current orbiter elevation during either ascent or reentry (dimensionless),

calls — YINT for interpolation,

18. SUBROUTINE CØNVEC (TIME) which computes normalized aerodynamic heating of fin and meteoroid protection layer for both ascent and reentry phases of orbiter operation and

is called from — DERIVM,

receives

α) current real time TIME, in seconds, measured from start of transition phase; i.e., TIME must be measured with respect to same reference point as user supplied time arrays in FUNCTIØN ALTSH and VELSH,

provides — normalized convective flux from fin surface CØNFN (I,J), and from meteoroid protection surface CØNMP (I),

calls

α) ALTVEL for altitude and velocity of orbiter

β) ATMØS for atmospheric properties

γ) REFP for atmospheric properties evaluated at high speed reference temperature δ) YINT for interpolation

ε) NUS for Nusselt number,

19. FUNCTIØN CPAIR (T) which computes the specific heat at constant pressure for atmospheric air and

is called from		ATMØS, REFTP and CØNVEC,
receives		absolute temperature T in R,
provides		specific heat at constant pressure in Btu/lbmR,
calls		PØLY for polynomial expansion,

20. FUNCTIØN ENTAIR (T) which computes the enthalpy of atmospheric air and

is called from		CØNVEC,
receives		absolute temperature T in R,
provides		enthalpy in Btu/lbm,

21. FUNCTIØN TNH (ENT) which computes the temperature of atmospheric air for a given enthalpy and

is called from		CØNVEC,
receives		enthalpy ENT in Btu/lbm,
provides		absolute temperature in R,
calls	α)	CPAIR for the specific heat at constant pressure of atmospheric air
	β)	ENTAIR for the enthalpy of air,

e) the program to compute the thickness of the meteoroid protection layer

22. FUNCTION TK (GAMMA, A, BETA, DENSM, THETA, PHI, AN ALPHA, VELM, PØ, TAU, DENST, W, TNN, AMAN, TIN, RØUT) which computes the thickness of the meteoroid protection layer for given environmental conditions, tube and manifold areas, experimental constants and protection layer properties and

is called from		MAIN,
receives	α)	nondimensional experimental constant, GAMMA, see Eq. 8.9

β) nondimensional experimental constant A, see Eq. 8.9

γ) nondimensional constant which relates meteoroid flux to mass, BETA

δ) density of the meteoroid particle, DENSM, in gm/cm^3

ε) nondimensional experimental constant THETA, see Eq. 8.9

ζ) nondimensional experimental constant PHI, see Eq. 8.9

η) nondimensional constant AN, used to describe penetration depth as a function of angle of incidence of meteoroid particle

θ) velocity of meteoroid particle relative to radiator panel, VELM, in ft/sec

ι) probability of no damage caused by impact of meteoroid, PØ

κ) time TAU, the radiator panel is exposed to meteoroid environment, in days

λ) density of protection material DENST, in lbm/ft^3

μ) axial length of single flow channel exposed to meteoroid environment, W, in inches

ν) integer number of flow channels, TNN,

ξ) area of the manifold that is exposed, AMAN, in ft^2

ϕ) temperature of coolant fluid at inlet plane of flow channel, TIN, in degrees R

π) outside radius RØUT of the unprotected flow channel, in inches,

provides meteoroid protection thickness TK, in inches,

calls ELAS for modulus of elasticity of protection material,

f) the program set which calculates the location of the adiabatic plane between two flow channels under conditions of non-symmetrical loading of the tubes and for curved radiator panels, consisting of

23. <u>SUBRØUTINE SHADE</u> which zeros those elements in the array Q which correspond to portions of the radiator panel that do not receive solar, albedo and planetary irradiation and

is called from		TCALC and QINCID,
receives	α)	NS, number of flat sides to the polygon used as a reference body by MRI program for calculating incident radiant flux
	β)	radiant flux array Q in Btu/hr ft^2. Array must have NS or greater values,
provides		zeros in part of the Q array which correspond to fin elements in the shade,

24. SUBRØUTINE TCALC which calculates the equivalent sink temperatures from incident flux data and,

is called from		MAIN,
receives		NTF the number of flat fin segments.
provides		TSTAR the equivalent sink temperature in R,
calls		SHADE for incident flux data,

25. SUBRØUTINE EFFICY which evaluates the one-dimensional fin efficiency and its derivative as a function of the fin base temperature and

is called from		TTIPS,
receives	α)	the dimensionless conductance parameter NC
	β)	the derivative of the conductance parameter with respect to the base temperature NCPR in R^{-1}
	γ)	the ratio of the sink to base temperature TSØTB
	δ)	the fin base temperature TB in R,
provides	α)	the fin efficiency ETA
	β)	the derivative of the fin efficiency with respect to the base temperature ETAPR in R^{-1},
calls		PØLY for polynomial expansion,

26. SUBRØUTINE TTIP which computes the tip temperature of a one-dimensional fin and

is called from		ADIABH,
receives	α)	the dimensionless conductance parameter NC

β) the ratio of the sink to base temperature TSØTB,

provides — the ratio of the difference between the fin tip temperature and sink temperature to the difference between the base and sink temperature,

calls — PØLY for polynomial expansion,

27. <u>FUNCTIØN NUSA</u> which evaluates the Nusselt number for the coolant fluid flow for both laminar and turbulent flow and

is called from — ADIABH and TTIPS,

receives
α) the Reynold number for the fluid REY
β) the Prandtl number for the fluid PR
γ) the ratio of the internal tube diameter to tube length DØL,

provides — the fluid Nusselt number,

28. <u>SUBRØUTINE TTIPS</u> which uses the Newton-Raphson method to numerically solve for the base temperature of the one-dimensional fin and

is called from — ADIABH,

receives
α) the integer IT used to specify the tube number for which the fin tip temperatures are calculated. Numbering system is consistent with the input parameters TIN (inlet temperature), PIN (inlet pressure), T (fin thickness), AL (tube length) and M (mass flow rate)
β) the integer ITST which designates the sink temperature data stored in the array TSTAR
γ) the distance H1 to the adiabatic plane for the fin attached to the left of the tube number IT, in inches
δ) the distance H2 to the adiabatic plane for the fin attached to the right of the tube number IT, in inches,

provides
α) the adiabatic plane temperature for the fin attached to the right of tube IT in R
β) the adiabatic plane temperature for the fin attached to the left of tube IT in R,

calls
α) NUS for the coolant fluid Nusselt number
β) EFFICY for fin efficiency
γ) TTIP for the fin tip temperature,

29. SUBRØUTINE ADIABH which determines the position of the adiabatic planes so that there is a continuity in adiabatic plane temperature of the one-dimensional fin and so that the heat convected from the fluid equals the heat radiated from the fin and

is called from		MAIN,
receives		the integer ITST which designates sink temperature data stored in the array TSTAR,
provides		printout of table headings and system parameters when radiator is non-symmetrically loaded and diagnostic printout if distance to adiabatic plane exceeds the spacing between the tubes. For this case one tube is transferring heat to the fin while the adjacent tube is gaining heat. TTIPS also provides the distances to all the adiabatic planes within the non-symmetrical radiator section,
calls	α)	property subroutines for fin and fluid properties
	β)	NUS for the coolant fluid Nusselt number
	γ)	TTIPS for the tip temperature of the fin
	δ)	PDERIV for determination of the elements of the matrix P_{ij}
	ε)	FMINV for matrix inversion,

30. FUNCTIØN PDERIV which calculates the partial derivative $\partial\delta_i/\partial h_j$ (see Section II-14 of the System Analysis Manual) and

is called from		ADIABH,
receives	α)	the integer J denotes the tube under consideration, J = -1 denotes tube IT - 1; J = 0 denotes tube IT and J = +1 denotes tube IT + 1
	β)	the integer IT which specifies the tube number to be considered
	γ)	the integer ITST which designates sink temperature data stored in the array TSTAR,
provides		the partial derivative $\partial h_i/\partial h_j$
calls		TTIPS for evaluation of the temperature at the adiabatic plane,

g) the program set consisting of all the mathematical procedures discussed in detail in Part III of the System Analysis Manual

31. SUBRØUTINE RKSF (see Section III.15) which

is called from	FLSTRT, for dynamic fluid flow field,
calls	DERIVL, CNTLN,

32. SUBRØUTINE RKS (see Section III.15) which

is called from	MAIN, for principal integration,
calls	DERIVM, CNTLM,

33. FUNCTIØN PØLY (X,A,M) (see Section III.16),

34. FUNCTIØN YINT (X,Y,M,N,P) (see Section III.17),

35. SUBRØUTINE DDX (Y,DY,DX,N),

36. SUBRØUTINE D2DX2 (Y,D2Y,DX,N), (see Section III.18)

37. FUNCTIØN DEFINT (Y,DX,N),

38. SUBRØUTINE FINT (Y,YO,DX,N,F), (see Section III.19)

39. SUBRØUTINE INTERP (NX1,MZ1,XX1,ZZ1,YY1,NX2,MZ2,XX2,ZZ2,YY2) maps a two-dimensional function YY1 from one grid (XX1,ZZ1) onto another grid (XX2,ZZ2) and

is called from		QRAD,
receives	α)	the number of nodal points (NX1,MZ1) of the original grid
	β)	the function YY1
	γ)	the number of nodal points (NX2,MZ2) of new grid,
provides		the function YY2 at the new grid,
calls		YINT,
is restricted to		NX1,MZ1,NX2,MZ2 $\leq$ 10,

40. FUNCTIØN DEFNT serves to integrate by the trapezoidal rule and is used where random error accumulation is more critical than truncation errors, and V accepts through its argument list (Y, DX, N)

α) the array Y of N equally spaced ordinates

β) the interval DX

γ) the integer constant N, representing the number of nodal points.

returns the integral of YCS) as DEFNT.

41. SUBROUTINE MTXINV (N,M) performs two related tasks:

(i) to solve a system of N linear algebraic equations, when M = N + 1,

(ii) to invert an N x N invertible matrix, when M = 2N.

For task (i) it

accepts through CØMMØN TRMTX (k,1) the augmented coefficient matrix (see Chapter III.7). Here k and 1 represent integer constants, k = N, 1 = N + 1.

through the argument list (N,M) the rank N of the coefficient matrix and M = N + 1, two integer constants.

returns the solution in TRMTX (I,J), I = 1, ..., k, J = k.

For task (i) it

accepts through CØMMØN TRMTX (k,1)

the k x k matrix in the first k columns of TRMTX (I,J), I = 1, ..., k; J = 1, ..., k and the k x k identity matrix in the second k columns of TRMTX (I,J) I = 1, ..., k; J = k + 1, ..., 2k. Hence 1 = 2k.

through the argument list (N,M) the rank N of the coefficient matrix and M = 2N, both integer constants.

returns the inverted matrix in the second k columns of TRMTX (I,J), I = 1, ..., k; J = k + 1, ..., 2k.

42. SUBRØUTINE FMINV serves to solve N linear algebraic equations by the method used for SUBRØUTINE MTXINV. It's calling provisions are designed to accommodate the requirements of ADIABH. It

receives, through its argument list (A,X,N,M)

α) the (N x N), invertible coefficient matrix A

β) the know, N-dimensional vector X

γ) the rank (N) of A, an integer constant

δ) $M = N + 1$

where $N \le 25$

returns the solution $Y = A^{-1}X$ placed in the array X

is called from ADIABH.

The Selective Part contains five groups of thermophysical properties, with the total of 20 program units. Each group constitutes a property package, one each for

(i) the coolant fluid (8 program units)
(ii) the flow channel material (3 program units)
(iii) the meteoroid protection layer (4 program units)
(iv) the fin material (3 program units)
(v) the thermal control coating (2 program units).

The choice of a particular material combination must be reflected in the corresponding data specification of the Input Data Set, (see Section 3f of Chapter A).

a) The coolant property subprogram set consists of eight elements, 43 through 50

43. FUNCTIØN RHØF (P,T) which computes the fluid density RHØF in slug/ft^3 as a function of pressure P in lbf/ft^2, and absolute temperature T in R,

44. FUNCTIØN BETA (RHØ,T) which computes the isobaric expansion coefficient β, Section II.C.11, in 1/R as a function of density RHØ in slug/ft^3, and temperature T in R,

45. FUNCTIØN CAPPA (P,T) which computes the isothermal compressibility, Eq. 11.3, in ft^2/lbf, as a function of pressure P in lbf/ft^2, and temperature T in R,

46. FUNCTIØN CPF (RHØ,T) which computes the specific heat at constant pressure CPF, in Btu/(slug R), as a function of density RHØ in slug/ft^3, and temperature T, in R,

47. FUNCTIØN HFL (RHØ,T) which computes the fluid enthalpy HFL, in Btu/slug, as a function of density RHØ in slug/ft^3, and temperature T, in R,

48. FUNCTIØN VISC (RHØ,T) which computes the fluid dynamic viscosity VISC, in slug/(ft sec) as a function of density RHØ in slug/ft^3, and temperature T, in R,

49. FUNCTIØN THCF (RHØ,T) which computes the fluid thermal conductivity THCF in Btu/(hr ft R) as a function of density RHØ in slug/ft^3, and temperature T, in R,

50. FUNCTIØN PF (RHØ,T) which computes the fluid pressure PF in lbf/ft^2 as a function of density RHØ in slugs/ft^3, and absolute temperature T, in R. For specific details of the coolant fluid properties, see Section II.11 and 12 and Appendix B of the System Analysis Manual.

b) The coolant channel material property subprogram set consists of three elements, 51 through 53.

51. FUNCTIØN THCTB (T) computes the thermal conductivity THCTB in Btu/(hr ft R), of the tube wall material as a function of the absolute temperature T, in R,

52. FUNCTIØN DTHCTB (T) computes the relative change of thermal conductivity k with temperature T, namely $(dk_w/dT)/k_w$ in 1/R, as a function of temperature T, in R,

53. FUNCTIØN CPTB (T) computes the specific heat at constant pressure CPTB, in Btu/(slug R) as a function of T, in R.

For specific details of the coolant channel properties, see Appendix A of the System Analysis Manual.

c) the meteoroid protection layer material properties are coded in a set of four elements, 54 through 57

54. FUNCTIØN THCMP (T),
55. FUNCTIØN DTHCMP (T),
56. FUNCTIØN CPMP (T),
57. FUNCTIØN ELAS (T) computes the modulus of elasticity ELAS in lbf/in^2 as a function of temperature T, in R.

For specific details of the meteoroid protection properties, see Appendix A of the System Analysis Manual.

d) The fin material properties required are coded in three FUNCTIØN subprograms, numbered 58 through 60

58. FUNCTIØN THCFN (T) computes the thermal conductivity THCFN, in Btu/(hr ft R) for the fin material as a function of absolute temperature T, in R,

59. FUNCTIØN DTHCFN (T) computes the relative change of thermal conductivity, namely $(dk_f/dT)/k_f$ in 1/R, as a function of temperature T, in R,

60. FUNCTIØN CPFN (T) computes the specific heat at constant pressure CPFN, in Btu/(slug R) as a function of temperature T, in R.

For specific details of the fin material properties, see Appendix A of the System Analysis Manual.

e) Optical properties of the thermal control coating are coded in two subprograms, numbered 61 and 62

61. FUNCTIØN EMIT (T) computes the total hemispherical emittance in accordance with Eq. 6.5 of the System Analysis Manual as a function of the surface temperature T in R, and is called by ABSØRB and EXITAV,

62. SUBRØUTINE AVGEMT (T,XX,XXX,N) evaluates the expressions for x_{ij} and x_{ijk} given as Eqs. 6.10 and 11 in the System Analysis Manual for N interacting surface elements. It is called by ABSØRB (see program No. 12).

For specific details of surface coating properties, see Appendix C of the System Analysis Manual.

This completes the Source Deck discussion. Recall that the Source Deck composition implies a particular selection of coolant fluid and structural materials.

4. Program Listing

This section contains the entire program listing in alphabetical order of subprogram name.

Labelled common blocks and external program references and printed out prior to the listing of each program unit.

All program units have been documented with comment cards for the convenience of the user.

All program units are summarized in a table of contents which follows the final unit listing. The table of contents lists all program elements as either symbolic or relocatable and it also prints the time and date when the program element was most recently stored on FASTRAND drum.

```
@FOR,S ME*NASA5.ABSORB,ME*NASA5.ABSORB
FOR S9A-07/13/72-20:52:53 (0,)

   SUBROUTINE ABSORB    ENTRY POINT 000552

   STORAGE USED: CODE(1) 000600; DATA(0) 000115; BLANK COMMON(2) 000000

    COMMON BLOCKS:

    0003   QRD    003721
    0004   ABSRST 000601
    0005   AVGABS 000251

   EXTERNAL REFERENCES (BLOCK, NAME)

    0006   EMIT
    0007   DEFNT
    0010   NERR3$

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

    0001     000032 116G     0001     000042 123G     0001     000062 132G     0001     000065 135G     0001     000067 140G
    0001     000137 152G     0001     000155 161G     0001     000156 164G     0001     000244 174G     0001     000251 177G
    0001     000260 202G     0001     000271 206G     0001     000352 220G     0001     000355 223G     0001     000357 226G
    0001     000430 240G     0004 R 000000 ALPHFN  0004 R 000226 ALPHMP  0000 R 000000 AUX1    0000 R 000005 AUX2
    0000 R 000012 AUX3    0000 R 000017 AUX4    0003 R 003465 CSF     0007 R 000000 DEFNT   0003 R 003464 DXX2
    0003     003472 DXX21   0003     003463 DZMFN   0003 R 003410 EBFN    0003 R 003441 EBMP    0006 R 000000 EMIT
    0004 R 000461 EMITFN  0004 R 000512 EMITMP  0003 R 003467 EXTIFN  0003 R 003471 EXTIMP  0003 R 003466 EXTSFN
    0003 R 003470 EXTSMP  0004     000517 EXTVCT  0000 I 000032 I       0000 I 000037 IL      0000     000057 INJP$
    0000 I 000034 J       0000 I 000040 JL      0000 I 000036 K       0000 I 000043 L       0003     003461 LCT
    0003     003462 LTT     0003     003460 MCVRD   0003 R 003473 SS      0003 R 003670 SSTT    0005 R 000100 TFIN
    0000 R 000035 TFINN   0000 R 000033 TM      0005 R 000244 TPR     0003     000000 TRMTX   0000 R 000041 X
    0005 R 000062 XXFN    0005 R 000000 XXMP    0005 R 000071 XXXFN   0005 R 000031 XXXMP   0003     003446 XX2
    0000 R 000042 Y       0000 R 000026 ZCF     0000 R 000031 ZCM     0000 R 000024 ZF      0000 R 000025 ZFM
    0000 R 000027 ZM      0000 R 000030 ZMM     0003     003453 ZZ2


 00101      1*           SUBROUTINE ABSORB (T0,XCFN,XCMP,XXCFN,XXCMP)
 00101      2*     C
 00101      3*     C   THIS SUBROUTINE COMPUTES :
 00101      4*     C     THE ABSORBTANCE MATRIX REPRESENTING THE MAIN ABSORBTANCE AFTER
 00101      5*     C     INTERNAL INTEGRATIONS
 00101      6*     C
 00103      7*           COMMON /QRD/ TRMTX(30,60),EBFN(5,5),EBMP(5),XX2(5),ZZ2(5),
 00103      8*          1             MCVRD,LCT,LTT,DZMFN,
 00103      9*          2             DXX2,CSF,EXTSFN,EXTIFN,EXTSMP,EXTIMP,DXX21,SS(5,5,5)
 00103     10*          3             ,SSTT(5,5)
 00104     11*           COMMON /ABSRST/ALPHFN(5,5,6),ALPHMP(5,31),EMITFN(5,5),EMITMP(5),
 00104     12*          1                EXTVCT(50)
 00105     13*           COMMON/AVGABS/XXMP(5,5),XXXMP(5,5),XXFN(7),XXXFN(7),
 00105     14*          1               TFIN(10,10),TPR(5)
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```
00106          DIMENSION AUX1(5),AUX2(5),AUX3(5),AUX4(5)
00106     C
00107          ZF     = EXTSFN+EXTIFN
00110          ZFM    = ZF*(1-XCFN)
00111          ZCF    = ZF*(XCFN-XXCFN)
00112          ZM     = EXTSMP+EXTIMP
00113          ZMM    = ZM*(1-XCMP)
00114          ZCM    = ZM*(XCMP-XXCMP)
00114     C
00114     C    FIN
00114     C
00115          DO 10 I=1,5
00120          TM     = T0*TPR(I)
00121          EMITMP(I)    = EMIT(TM)
00122          DO 10 J=1,5
00125          TFINN  = T0*TFIN(J,I)
00126       10 EMITFN(J,I)  = EMIT(TFINN)
00131          DO  60 K=1,5
00134          DO 30 IL=1,5
00137          DO 20 JL=1,5
00142          X       = CSF*SS(JL,IL,K)*EBFN(IL,JL)
00143          AUX1(JL) = X*(XXMP(IL,JL)-XXXMP(IL,JL))
00144       20 AUX3(JL) = X*(EMITFN(IL,JL)-XXMP(IL,JL))
00146          AUX2(IL) = DEFNT (AUX1,DXX2,5)+AUX1(1)*DXX2/2.0
00147       30 AUX4(IL) = DEFNT (AUX3,DXX2,5)+AUX3(1)*DXX2/2.0
00151          DO 35 IL=1,5
00154          Y        = SSTT(IL,K)*EBMP(IL)
00155          AUX1(IL) = Y*(XXFN(IL)-XXXFN(IL))
00156       35 AUX3(IL) = Y*(EMITMP(IL)-XXFN(IL))
00160          DO  60 I=1,5
00163          DO  60 J=1,5
00166          ALPHFN(I,J,K) = (XXFN(K)*EBMP(K)+DEFNT(AUX1,0.25,5)+DEFNT(AUX2,
00166         1               0.25,5)+ZCM)/(EMITMP(K)*EBMP(K)+DEFNT(AUX3,0.25,
00166         2               5)+DEFNT(AUX4,0.25,5)+ZMM)
00166     C
00166     C
00167       60 ALPHFN(I,J,6) = XCFN
00167     C
00167     C    CHANNEL
00167     C
00173          DO 120 K=1,5
00176          DO 90  I=1,5
00201          DO 90  J=1,5
00204          L       = J+5*(I-1)
00205          DO 80 JL=1,5
00210          X       = SS(I,J,JL)*EBMP(JL)
00211          AUX1(JL) = X*(XXFN(JL)-XXXFN(JL))
00212       80 AUX3(JL) = X*(EMITMP(JL)-XXFN(JL))
00212     C
00214       90 ALPHMP(K,L) = (XXMP(J,I)*EBFN(J,I)+DEFNT(AUX1,0.25,5)+ZCF)/
00214         1             (EMITFN(J,I)*EBFN(J,I)+DEFNT(AUX3,0.25,5)+ZFM)
00214     C
00217          DO 95  I=1,5
00222          DO 93 IL=1,5
00225          DO 92 JL=1,5
00230          X       = CSF*SS(JL,IL,K)*EBFN(IL,JL)
00231          AUX1(JL) = X*(XXMP(IL,JL)-XXXMP(IL,JL))
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00232     72*        92 AUX3(JL) = X*(EMITFN(IL,JL)-XXMP(IL,JL))
00234     73*           AUX2(IL) = DEFNT (AUX1,DXX2,5)+AUX1(1)*DXX2/2.0
00235     74*        93 AUX4(IL) = DEFNT (AUX3,DXX2,5)+AUX3(1)*DXX2/2.0
00237     75*           DO 94 IL=1,5
00242     76*           Y        = SSTT(IL,I)*EBMP(IL)
00243     77*           AUX1(IL) = Y*(XXFN(IL)-XXXFN(IL))
00244     78*        94 AUX3(IL) = Y*(EMITMP(IL)-XXFN(IL))
00246     79*        95 ALPHMP(K,25+I)= (XXFN(I)*EBMP(I)+DEFNT(AUX1,0.25,5)+DEFNT(AUX2,
00246     80*         1                0.25,5)+ZCM)/(EMITMP(I)*EBMP(I)+DEFNT(AUX3,0.25,
00246     81*         2                5)+DEFNT(AUX4,0.25,5)+ZMM)
00246     82*      C
00250     83*       120 ALPHMP(K,31) = XCMP
00252     84*           RETURN
00253     85*           END

      END OF COMPILATION:        NO  DIAGNOSTICS.


@HDG,P  ******  ADIABH  ******
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****** ADIABH ******                                                                                  DATE 071372        PAGE     1

@FOR,S ME*NASA5.ADIABH,ME*NASA5.ADIABH
FOR S9A-07/13/72-20:52:57 (0,)

   SUBROUTINE ADIABH    ENTRY POINT 000506

   STORAGE USED: CODE(1) 000522; DATA(0) 000451; BLANK COMMON(2) 000000

    COMMON BLOCKS:

    0003   ADBH   000352

   EXTERNAL REFERENCES (BLOCK, NAME)

    0004   NUSA
    0005   RHOF
    0006   VISC
    0007   CPF
    0010   THCF
    0011   THCFN
    0012   EMIT
    0013   TTIPS
    0014   PDERIV
    0015   FMINV
    0016   NPRT$
    0017   NIO2$
    0020   NSTOP$
    0021   EXP
    0022   NWDU$
    0023   NERR3$

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

    0000   000174 1005F     0001   000004 113G      0001   000074 131G      0000   000373 15F       0001   000124 150G
    0001   000161 157G      0001   000167 165G      0001   000201 173G      0001   000271 205G      0001   000326 231G
    0001   000401 255G      0001   000420 263G      0001   000445 276G      0000   000316 5F        0001   000077 55L
    0001   000115 60L       0001   000322 76L       0001   000346 81L       0001   000336 815L      0001   000356 82L
    0001   000362 86L       0001   000433 89L       0001   000441 895L      0000 R 000000 A         0003 R 000001 AL
    0003 R 000161 CONFL     0003 R 000173 CONFNA    0003 R 000147 CP        0007 R 000000 CPF       0003 R 000000 D
    0000 R 000144 DHAB      0003 R 000326 DTL       0003 R 000244 EFF       0003 R 000205 EMIS      0012 R 000000 EMIT
    0003 R 000013 H         0003 R 000231 HAB       0000 R 000170 HABR      0000 I 000156 I         0000 I 000163 ICNT
    0000   000425 INJP$     0000 I 000164 IT        0000 I 000173 J         0000 I 000171 J1        0000 I 000172 J2
    0003 R 000064 M         0000 I 000160 NSTOP     0003 I 000076 NT        0000 I 000162 NTM1      0000 I 000161 NT1
    0004 I 000000 NUSA      0014 R 000000 PDERIV    0003 R 000052 PIN       0003 R 000314 QOUT      0000 R 000157 RHO
    0005 R 000000 RHOF      0003 R 000217 TB        0000 R 000167 TF        0003   000026 TH        0010 R 000000 THCF
    0011 R 000000 THCFN     0003 R 000040 TIN       0003 R 000270 TL        0000 R 000165 TL1       0000 R 000166 TL2
    0003 R 000340 TOUT      0003   000077 TSTAR     0006 R 000000 VISC      0003 R 000135 VSC


00101      1*          SUBROUTINE ADIABH(ITST)
00103      2*             PARAMETER NTP = 10
00104      3*             PARAMETER NTP1 = NTP+1
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00105                PARAMETER NTPSQ = NTP*NTP
00106                REAL M
00107                COMMON /ADBH/ D,AL(NTP),H(NTP1),TH(NTP),TIN(NTP),PIN(NTP),
00107          1     M(NTP),NT,TSTAR(NTP,3),VSC(NTP),CP(NTP),CONFL(NTP),
00107          2     CONFNA(NTP),EMIS(NTP),TB(NTP),HAB(NTP1),EFF(NTP,2),TL(NTP,2),
00107          3     QOUT(NTP),DTL(NTP),TOUT(NTP)
00110             DIMENSION A(NTPSQ),DHAB(NTP)
00111             DEFINE U(I) = 3.1415927*CONFL(I)*AL(I)*NUSA(48.0*M(I)/(3.1415927*
00111            1D*VSC(I)),VSC(I)*CP(I)/CONFL(I),D/(12*AL(I)))/(M(I)*CP(I))
00112                DO 10 I = 1,NT
00115                RHO = RHOF(PIN(I),TIN(I))
00116                VSC(I) = VISC(RHO,TIN(I))
00117                CP(I) = CPF(RHO,TIN(I))
00120                CONFL(I) = THCF(RHO,TIN(I))
00121                CONFNA(I) = THCFN(TIN(I))
00122     10         EMIS(I) = EMIT(TIN(I))
00124             NSTOP=20
00125             NT1=NT+1
00126             NTM1=NT-1
00127             ICNT=1
00130             DO 2 IT=1,NT1
00133     2       HAB(IT)=H(IT)
00135     55      CONTINUE
00136             ICNT=ICNT+1
00137             IF(ICNT.LE.NSTOP)GO TO 60
00141             PRINT 1005,NSTOP
00144     1005    FORMAT('0PROGRAM STOPPED IN SUBROUTINE ADIABH BECAUSE THE DISTANCE
00144            > TO AN',/,' ADIABATIC PLANE FAILED TO CONVERGE WITHIN THE ALLOWABL
00144            >E RANGE OF
00144            >',/,' VALUES(2.5% AND 97.5% OF TOTAL FIN WIDTH) AFTER',I3,' ITERAT
00144            >IONS.',/,' THIS IS PROBABLY BECAUSE THE INPUT CONDITIONS DO NOT AL
00144            >LOW A SOLUTION',/,' IN THIS RANGE. HOWEVER THE NUMBER OF ITERATION
00144            >S CAN BE INCREASED ',/,' BY ASSIGNING A LARGER VALUE TO NSTOP IN S
00144            >UBROUTINE ADIABH.')
00145                STOP
00146     60      CONTINUE
00147             DO 6 IT=1,NT
00152                CALL TTIPS(IT,ITST,HAB(IT),H(IT+1)*2.0-HAB(IT+1),TL1,TL2)
00153                TL(IT,1) = TL1
00154     6          TL(IT,2) = TL2
00156             DO 7 IT=1,NTM1
00161             DTL(IT)=TL(IT,2)-TL(IT+1,1)
00162     7       CONTINUE
00164             DO 75 IT=1,NTM1
00167     75      IF(ABS(DTL(IT)).GT.0.05)GO TO 76
00172                DO 752 IT = 1,NT
00175                TF = (TIN(IT)-TB(IT))*(1.0-EXP(-U(IT)))
00176                QOUT(IT) = M(IT)*CP(IT)*TF
00177     752        TOUT(IT) = TIN(IT)-TF
00201                WRITE(6,5)
00203     5          FORMAT(////,7X,'BULK TEMP',5X,'INCHES TO ADIABATIC PLANE',
00203          1     5X,'PER CENT FIN EFFICIENCY',5X,'FIN TIP TEMP  DEG R',
00203          2     5X,'OUTLET TEMP',5X,'HEAT REJECTED',/,1X,'TUBE',4X,
00203          3     'DEG R',11X,'LEFT',8X,'RIGHT',12X,2('LEFT',8X,'RIGHT',9X),
00203          4     'DEG R',11X,'BTU/HR',/)
00204                DO 100 I = 1,NT
00207                HABR = H(I+1)*2.0-HAB(I+1)
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```
00210    61*   100       WRITE(6,15) I,TB(I),HAB(I),HABR,EFF(I,1),EFF(I,2),TL(I,1),
00210    62*          1   TL(I,2),TOUT(I),QOUT(I)
00225    63*    15       FORMAT(1X,I2,3X,1PE10.4,6X,1PE10.4,2X,1PE10.4,7X,
00225    64*          1   2(1PE10.4,2X,1PE10.4,4X),1PE10.4,7X,1PE10.4)
00226    65*           RETURN
00227    66*    76     CONTINUE
00230    67*           DO 88 IT=1,NTM1
00233    68*           IF(NT.NE.2)GO TO 815
00235    69*           J1=0
00236    70*           J2=0
00237    71*           GO TO 86
00240    72*   815     IF(IT.NE.1)GO TO 81
00242    73*           J1=0
00243    74*           J2=1
00244    75*           GO TO 86
00245    76*    81      IF(IT.NE.NTM1)GO TO 82
00247    77*           J1=-1
00250    78*           J2=0
00251    79*           GO TO 86
00252    80*    82     J1=-1
00253    81*           J2=1
00254    82*    86      DO 88 J=J1,J2
00257    83*    88     A(IT*NTM1-1*NTM1+J*NTM1+IT)=PDERIV(J,IT,ITST)
00262    84*           DO 8 IT=1,NTM1
00265    85*     8     DHAB(IT)=-DTL(IT)
00267    86*           IF(NT.NE.2)GO TO 89
00271    87*           DHAB(1)=-DTL(1)/A(1)
00272    88*           GO TO 895
00273    89*    89     CALL FMINV(A,DHAB,NTM1,NT)
00274    90*   895     CONTINUE
00275    91*           DO 9 IT=2,NT
00300    92*           HAB(IT)=HAB(IT)+DHAB(IT-1)
00301    93*           HAB(IT)=MIN(HAB(IT),1.95*H(IT))
00302    94*           HAB(IT)=MAX(.05*H(IT),HAB(IT))
00303    95*     9     CONTINUE
00305    96*           GO TO 55
00306    97*           END

      END OF COMPILATION:       NO  DIAGNOSTICS.


@HDG,P  ******  ALTVEL  ******
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****** ALTVEL ******                                                                              DATE 071372      PAGE    1

@FOR,S ME*NASA5.ALTVEL,ME*NASA5.ALTVEL
FOR S9A-07/13/72-20:53:00 (0,)

  FUNCTION ALTVEL      ENTRY POINT 000151

  STORAGE USED: CODE(1) 000207; DATA(0) 000016; BLANK COMMON(2) 000000

  EXTERNAL REFERENCES (BLOCK, NAME)

   0003   YINT
   0004   NERR3$

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

   0001   000052 1L       0001   000120 2L        0001   000124 3L        0001   000133 4L        0000 R 000000 ALTVEL
   0000   000002 INJP$    0000 I 000001 M         0003 R 000000 YINT


00101      1*          FUNCTION ALTVEL (TIME,IOPTN,AVA,AVR,TA,TR,NA,NR)
00101      2*     C
00101      3*     C   THIS SUBROUTINE COMPUTES :
00101      4*     C       ALTITUDE AND VELOCITY OF ORBITER AS A FUNCTION OF TIME FROM
00101      5*     C       LAUNCH  (IOPTN = 0 ) OR TIME FROM PASSING THROUGH 400,000 FEET
00101      6*     C       FOR REENTRY ( IOPTN = 0 )
00101      7*     C                                    TIME IN SECS, ALTITUDE IN FEET
00101      8*     C                                    AND VELOCITY IN FEET/SEC
00101      9*     C
00103     10*          DIMENSION TA(NA),TR(NR),AVA(NA),AVR(NR)
00104     11*          IF (TIME .GT. TA(NA) .AND. IOPTN .EQ. 0)  GO TO 3
00106     12*          IF (TIME .GT. TR(NR) .AND. IOPTN .EQ. 1)  GO TO 4
00110     13*          M      =  2
00111     14*        1 IF (IOPTN .EQ. 0) ALTVEL =  YINT(TA,AVA,NA,M,TIME)
00113     15*          IF (IOPTN .EQ. 1) ALTVEL =  YINT(TR,AVR,NR,M,TIME)
00115     16*          IF (ALTVEL .LT. 0.0 .AND. M .GT. 2) GO TO 2
00117     17*          RETURN
00120     18*        2 M      =  M-1
00121     19*          GO TO 1
00122     20*        3 ALTVEL  =  AVA(NA)
00123     21*          RETURN
00124     22*        4 ALTVEL  =  AVR(NR)
00125     23*          RETURN
00126     24*          END

     END OF COMPILATION:       NO  DIAGNOSTICS.


@HDG,P ****** ATMOS ******
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@FOR,S ME*NASA5.ATMOS,ME*NASA5.ATMOS
FOR S9A-07/13/72-20:53:03 (0,)

   SUBROUTINE ATMOS      ENTRY POINT 000237

   STORAGE USED: CODE(1) 000261; DATA(0) 000211; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003    POLY
    0004    CPAIR
    0005    NWDU$
    0006    NI02$
    0007    SQRT
    0010    NERR3$

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

    0001    000105 10L     0001    000137 15L     0001    000070 2L      0001    000161 20L     0001    000057 231G
    0001    000012 30L     0000    000116 35F     0001    000022 40L     0000    000136 45F     0001    000032 60L
    0000 R 000041 A        0000 R 000055 B        0000 R 000074 CF1      0004 R 000000 CPAIR    0000 R 000107 CPATM
    0000 R 000104 DH       0000 R 000100 ELEVM    0000 R 000110 GAMATM   0000 R 000102 GEOH     0000 R 000101 GEOHM
    0000 R 000007 GH       0000 R 000031 GT       0000 R 000000 H        0000 I 000103 I        0000    000201 INJP$
    0000 I 000105 J        0000 R 000077 MWT      0000 R 000113 PATM     0003 R 000000 POLY     0000 R 000075 PSL
    0000 R 000112 PZ       0000 R 000115 RHOATM   0000 R 000076 RSL      0000 R 000072 RU       0000 R 000073 RU1
    0000 R 000114 RZ       0000 R 000020 T        0000 R 000106 TMK      0000 R 000071 WMO      0000 R 000111 Z


00101           SUBROUTINE ATMOS (ELEV,TATM,CATM)
00101       C
00101       C  THIS SUBROUTINE COMPUTES :
00101       C       PROPERTIES FOR ATMOSPHERIC AIR UP TO 528,000 FEET (100 MILES OR 161 KM)
00101       C       PROPERTIES FOR AN ALTITUDE LESS THAN 301,000 FEET TAKEN FROM
00101       C       U. S. STANDARD ATMOSPHERE FOR  1966. PROPERTIES FOR ALTITUDES BETWEEN
00101       C       301,000 FEET AND 528,000 FEET ARE TAKEN FROM APPROXIMATE ANALYSIS GIVEN
00101       C       IN THE SAME REFERENCE. ERRORS IN PRESSURE AND DENSITY ARE NO LARGER
00101       C       THAN 5 PERCENT FOR ALTITUDES GREATER THAN 301,000 FEET AND LESS
00101       C       THAN 528,000 FEET.
00101       C                                     ELEVATION IN FEET
00101       C                                     TEMPERATURE IN DEG R.
00101       C                                     SPECIFIC HEAT IN BTU/LBM R
00101       C                                     VEL OF SOUND IN FT/SEC
00101       C
00103           DIMENSION H(7),GH(9),T(9),GT(8),A(12),B(12)
00104           DATA H(1),H(2),H(3),H(4),H(5),H(6),H(7) /0.0,1.0,-1.5731262E-07,2.
00104          14656553E-14,-3.8667054E-21,6.0621354E-28,-9.5013649E-35/,GH(1),GH(
00104          22),GH(3),GH(4),GH(5),GH(6),GH(7),GH(8),GH(9) /0.0,11.0,20.0,32.0,4
00104          37.0,52.0,61.0,79.0,90.0/,T(1),T(2),T(3),T(4),T(5),T(6),T(7),T(8),T
00104          4(9) /288.15,216.65,216.65,228.65,270.65,270.65,252.65,180.65,180.6
00104          55/,GT(1),GT(2),GT(3),GT(4),GT(5),GT(6),GT(7),GT(8) /-6.5,0.0,1.0,2
00104          6.8,0.0,-2.0,-4.0,0.0/,WMO,RU,RU1/ 28.9644,8314.32,1545.31/
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00104        7 CF1/ 1000.0/,PSL,RSL /2116.22657,0.07647438/
00154         DATA A(1),A(2),A(3),A(4),A(5),A(6),A(7),A(8),A(9),A(10),A(11),
00154        1A(12)/
00154        1      0.10E+01,  0.3533367370E-01,  -0.7474788290E-03,
00154        2      0.2121572232E-03,  -0.1325255219E-04,  0.5344159692E-06,
00154        3      -0.1322745646E-07,  0.1965359762E-09,  -0.1723714966E-11,
00154        4      0.8707590786E-14,  -0.2341816445E-16,  0.2597772972E-19/,
00154        5B(1),B(2),B(3),B(4),B(5),B(6),B(7),B(8),B(9),B(10),B(11),B(12)/
00154        6      0.10E+01,  0.3393495800E-01,  -0.3433553057E-02,
00154        7      0.5497466428E-03,  -0.3228358326E-04,  0.1106617734E-05,
00154        8      -0.2291755793E-07,  0.2902146443E-09,  -0.2230070938E-11,
00154        9      0.1010575266E-13,  -0.2482089627E-16,  0.2548769715E-19/
00205         REAL MWT
00206         IF (ELEV .LT. 0.0) GO TO 30
00210         IF (ELEV .GT. 528000.) GO TO 40
00212         GO TO 60
00213      30 WRITE (6,35)
00215      35 FORMAT (1X,'AN ATTEMPT HAS BEEN MADE TO EVALUATE ATMOSPHERIC PROPE
00215        1RTIES FOR NEGITIVE ALTITUDES')
00216         RETURN
00217      40 WRITE (6,45)
00221      45 FORMAT (1X,'AN ATTEMPT HAS BEEN MADE TO EVALUATE ATMOSPHERIC PROPE
00221        1RTIES FOR AN ALTITUDE EXCEEDING 100 MILES')
00222         RETURN
00223      60 IF (ELEV .GT. 301000.)  GO TO 20
00225         ELEVM  = ELEV*0.3048
00226         GEOHM  = POLY(7,H,ELEVM)
00227         GEOH   = GEOHM/0.3048
00230         DO 1  I=1,9
00233         DH     = GH(I)-GEOHM/CF1
00234         IF (DH.GT.0.0) GO TO 2
00236       1 CONTINUE
00240       2 J      = I-1
00241         DH     = GH(J)-GEOHM/CF1
00242         TMK    = T(J)-GT(J)*DH
00243         TATM   = TMK*1.8
00244      10 CPATM   =  CPAIR(TATM)
00245         IF (ELEV .GT. 301000.) GO TO 15
00247         GAMATM =  CPATM/(CPATM-0.0686)
00250         CATM   = SQRT(1.4*RU*TMK/WMO)/0.3048
00251         RETURN
00252      15 GAMATM =  CPATM/(CPATM-(1.98585/MWT))
00253         CATM   =  SQRT(GAMATM*RU*TMK/MWT)/0.3048
00254         RETURN
00255      20 Z      =  ELEV/(3280.8399)
00256         MWT    =  28.9644-0.0309491*(Z-90.0)
00257         PZ     = POLY(12,A,Z)
00260         PATM   = PSL/(PZ**4)
00261         RZ     = POLY(12,B,Z)
00262         RHOATM = RSL/(RZ**4)
00263         TATM   =  PATM*MWT/(RHOATM*1545.31)
00264         TMK    = TATM/1.8
00265         GO TO 10
00266         END
```

END OF COMPILATION: NO DIAGNOSTICS.

@HDG•P ****** AVGEMT/SCZ93 ******

```
@FOR,S ME*NASA5.AVGEMT/SCZ93,ME*NASA5.AVGEMT/SCZ93
FOR S9A-07/13/72-20:53:05 (0,)

   SUBROUTINE AVGEMT    ENTRY POINT 000110

   STORAGE USED: CODE(1) 000121; DATA(0) 000040; BLANK COMMON(2) 000000

    COMMON BLOCKS:

    0003   AVGABS 000251

   EXTERNAL REFERENCES (BLOCK, NAME)

    0004   POLY
    0005   NERR3$

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

    0001    000004 124G      0001    000024 132G      0000 R 000000 A         0000 R 000005 B         0000 I 000016 I
    0000    000025 INJP$     0000 I 000014 J          0004 R 000000 POLY      0000 R 000013 TALB      0003 R 000100 TFIN
    0000 R 000017 TFNX       0000 R 000015 TMPX       0003 R 000244 TPR       0000 R 000012 TSOL      0003 R 000062 XXFN
    0003 R 000000 XXMP       0003 R 000071 XXXFN      0003 R 000031 XXXMP


00101      1*            SUBROUTINE AVGEMT(T0)
00101      2*      C
00101      3*      C   THIS SUBROUTINE COMPUTES :
00101      4*      C     THE NECESSARY VARIABLES FOR THE COMPUTATIONS OF THE AVERAGE
00101      5*      C     SURFACE COATING EMITTANCE
00101      6*      C
00103      7*            COMMON/AVGABS/XXMP(5,5),XXXMP(5,5),XXFN(7),XXXFN(7),
00103      8*           1              TFIN(10,10),TPR(5)
00104      9*            DIMENSION A(5), B(5)
00105     10*            DATA  A(1),A(2),A(3),A(4),A(5)/0.7804112E+00, -0.5527205E-04,
00105     11*           1      0.2530228E-06, -0.3229181E-09, 0.8854202E-13/
00105     12*           2      B(1),B(2),B(3),B(4),B(5)/0.6538383E+00, 0.1144374E-03,
00105     13*           3      -0.2432286E-07, -0.1437500E-09, 0.4947915E-13/
00120     14*            DATA TSOL,TALB/10400.0,480.0/
00123     15*            DO  1  J = 1,5
00126     16*            TMPX      = TPR(J)*T0
00127     17*            XXFN(J)   = POLY(5,A,TMPX)
00130     18*            XXXFN(J)  = POLY(5,B,TMPX)
00131     19*            DO  1  I = 1,5
00134     20*            TFNX      = TFIN(J,I)*T0
00135     21*            XXMP(J,I)= POLY(5,A,TFNX)
00136     22*          1 XXXMP(J,I)= POLY(5,B,TFNX)
00141     23*            XXFN(6)   = POLY(5,A,TALB)
00142     24*            XXXFN(6)  = POLY(5,B,TALB)
00143     25*            XXFN(7)   = 0.07156
00144     26*            XXXFN(7)  = 0.030562
00145     27*            RETURN
```

```
00146     28*          END
      END OF COMPILATION:        NO  DIAGNOSTICS.

@HDG,P  ******  BETA/CFFC43  ******
```

```
QFOR,S ME*NASA5.BETA/CFFC43,ME*NASA5.BETA/CFFC43
FOR S9A-07/13/72-20:53:07 (0,)

   FUNCTION BETA        ENTRY POINT 000015

   STORAGE USED: CODE(1) 000017; DATA(0) 000010; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   NERR3$

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

    0000 R 000000 BETA      0000   000003 INJP$     0000 R 000001 X1       0000 R 000002 X2


00101      1*          FUNCTION BETA(RHO,T)
00101      2*     C
00101      3*     C       THIS FUNCTION SUBPROGRAM COMPUTES :
00101      4*     C       COEFFICIENT OF THERMAL EXPANSION AS A FUNCTION OF DENSITY
00101      5*     C       (SLUG/QU.FT) AND TEMPERATURE (R) OF FC-43
00101      6*     C                              UNITS 1/R
00101      7*     C
00103      8*          DATA X1,X2 /157.0883,-0.076167/
00106      9*          BETA = -X2/(X1+X2*T)
00107     10*          RETURN
00110     11*          END

      END OF COMPILATION:        NO  DIAGNOSTICS.


QHDG,P  ******  BETA/CFFC75  ******
```

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****** BETA/CFFC75 ******                                                        DATE 071372     PAGE    1

@FOR,S ME*NASA5.BETA/CFFC75,ME*NASA5.BETA/CFFC75
FOR S9A-07/13/72-20:53:09 (0,)

   FUNCTION BETA        ENTRY POINT 000015

   STORAGE USED: CODE(1) 000017; DATA(0) 000010; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   NERR3$

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

    0000 R 000000 BETA      0000    000003 INJP$     0000 R 000001 X1        0000 R 000002 X2


00101       1*              FUNCTION BETA(RHO,T)
00101       2*      C
00101       3*      C          THIS FUNCTION SUBPROGRAM COMPUTES :
00101       4*      C          COEFFICIENT OF THERMAL EXPANSION AS A FUNCTION OF DENSITY
00101       5*      C          (SLUG/QU.FT) AND TEMPERATURE (R) OF FC-75
00101       6*      C                                     UNITS 1/R
00101       7*      C
00103       8*              DATA X1,X2 /155.522,-0.085/
00106       9*              BETA = -X2/(X1+X2*T)
00107      10*              RETURN
00110      11*              END

      END OF COMPILATION:        NO  DIAGNOSTICS.


@HDG,P  ******  BETA/CFHE  ******
```

```
@FOR,S ME*NASA5.BETA/CFHE,ME*NASA5.BETA/CFHE
FOR S9A-07/13/72-20:53:10 (0,)

 FUNCTION BETA        ENTRY POINT 000106

 STORAGE USED: CODE(1) 000112; DATA(0) 000037; BLANK COMMON(2) 000000

 EXTERNAL REFERENCES (BLOCK, NAME)

  0003   NERR3$

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

  0000 R 000005 A        0000 R 000014 ALPHA     0000 R 000002 A1       0000 R 000000 BETA      0000 R 000003 B1
  0000 R 000004 C        0000 R 000017 DPDRHO    0000 R 000015 DPDT     0000 R 000016 DPDV      0000   000026 INJP$
  0000 R 000001 R        0000 R 000006 RHOX      0000 R 000013 TM2      0000 R 000007 TX        0000 R 000010 V
  0000 R 000011 VM2      0000 R 000012 VM3


00101            FUNCTION BETA(RHO,T)
00101      C
00101      C        THIS FUNCTION SUBPROGRAM COMPUTES :
00101      C        COEFFICIENT OF THERMAL EXPANSION AS A FUNCTION OF DENSITY
00101      C        (SLUG/QU.FT) AND TEMPERATURE (R) OF HELIUM
00101      C                                      UNITS 1/R
00101      C
00103            DATA R,A1,B1,C,A /2077.02,136.9595,3.5002295E-03,10.000658,1.49610
00103           13E-02/
00111            RHOX  = RHO*515.4275
00112            TX    = T/1.8
00113            V     = 1.0/RHOX
00114            VM2   = RHOX*RHOX
00115            VM3   = RHOX*VM2
00116            TM2   = 1.0/(TX*TX)
00117            ALPHA = C*RHOX/(TX**3)
00120            DPDT  = R*(V+B1)*VM2*(1.0+2.0*ALPHA)
00121            DPDV  =-R*TX*VM2*(1.0+2.0*RHOX*B1)+A1*VM3*(2.0-3.0*A*RHOX)+R*C*VM3
00121           1*TM2*(2.0+3.0*B1*RHOX)
00122            DPDRHO=-DPDV/VM2
00123            BETA  = DPDT/(DPDRHO*RHOX*1.8)
00124            RETURN
00125            END

     END OF COMPILATION:        NO  DIAGNOSTICS.


@HDG,P ****** BETA/CFNAK ******
```

```
****** BETA/CFNAK ******                                                    DATE 071372      PAGE    1

@FOR,S ME*NASA5.BETA/CFNAK,ME*NASA5.BETA/CFNAK
FOR S9A-07/13/72-20:53:13 (0,)

   FUNCTION BETA         ENTRY POINT 000015

   STORAGE USED: CODE(1) 000017; DATA(0) 000010; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   NERR3$

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

    0000 R 000000 BETA      0000   000003 INJP$     0000 R 000001 X1        0000 R 000002 X2


00101      1*           FUNCTION BETA(RHO,T)
00101      2*     C
00101      3*     C        THIS FUNCTION SUBPROGRAM COMPUTES :
00101      4*     C        COEFFICIENT OF THERMAL EXPANSION AS A FUNCTION OF DENSITY
00101      5*     C        (SLUG/QU.FT) AND TEMPERATURE (R) OF NAK 78.6
00101      6*     C                                     UNITS 1/R
00101      7*     C
00103      8*           DATA X1,X2 /58.773064,-0.008433/
00106      9*           BETA = -X2/(X1+X2*T)
00107     10*           RETURN
00110     11*           END

      END OF COMPILATION:        NO  DIAGNOSTICS.

@HDG,P  ******  BETA/CFSIL  ******
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```
@FOR,S ME*NASA5.BETA/CFSIL,ME*NASA5.BETA/CFSIL
FOR S9A-07/13/72-20:53:15 (0,)

   FUNCTION BETA        ENTRY POINT 000162

   STORAGE USED: CODE(1) 000177; DATA(0) 000076; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   PF
    0004   NWDU$
    0005   NI02$
    0006   NERR3$

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

    0000   000030 1F        0000 R 000001 A1        0000 R 000022 A11       0000 R 000002 A2        0000 R 000003 A3
    0000 R 000004 A4        0000 R 000005 A5        0000 R 000000 BETA      0000 R 000006 B1        0000 R 000023 B11
    0000 R 000007 B2        0000 R 000010 B3        0000 R 000011 B4        0000 R 000012 B5        0000 R 000024 C
    0000 R 000013 C1        0000 R 000025 C11       0000 R 000014 C2        0000 R 000017 DT        0000   000067 INJP$
    0000 R 000026 P         0003 R 000000 PF        0000 R 000027 P1        0000 R 000020 THETA     0000 R 000021 THETA1
    0000 R 000015 T0        0000 R 000016 T01


00101      1*         FUNCTION BETA(RHO,T)
00101      2*     C
00101      3*     C      THIS FUNCTION SUBPROGRAM COMPUTES :
00101      4*     C      COEFFICIENT OF THERMAL EXPANSION AS A FUNCTION OF DENSITY
00101      5*     C           (SLUG/CU.FT) AND TEMPERATURE (R) OF DOW CORNING 200
00101      6*     C           SILICON OIL (1 CS)
00101      7*     C                                     UNITS 1/R
00101      8*     C           TEMPERATURE .GE. 359.67 AND .LE. 859.67
00101      9*     C
00103     10*         DATA A1,A2,A3,A4,A5 /12.35,2.98333,1.1,-0.48333,0.1/,B1,B2,B3,B4,B
00103     11*        15 /-1.5,-0.01333,-1.18,0.57333,-0.1/,C1,C2 /0.7767,-0.0288/,T0,T01
00103     12*        2,DT /559.67,609.67,50.0/
00123     13*         THETA  = (T-T0)/DT
00124     14*         THETA1 = (T-T01)/DT
00125     15*         A11 = (((4.0*A5*THETA+3.0*A4)*THETA+2.0*A3)*THETA+A2)*(1.0E-06)/DT
00126     16*         B11 = (((4.0*B5*THETA+3.0*B4)*THETA+2.0*B3)*THETA+B2)*(1.0E-09)/DT
00127     17*         C   = C1+C2*THETA1
00130     18*         C11 = C2/DT
00131     19*         P  = PF(RHO,T)
00132     20*         P1 = P/144.0-14.696
00133     21*         BETA= -C11/C-A11*P1-B11*P1*P1/2.0
00134     22*         IF (T.LT.360.67.OR.T.GT.860.67.OR.P.GT.146116.224.OR.P.GT.110116.2
00134     23*        124.AND.T.LT.460.67) WRITE(6,1) T,P
00141     24*       1 FORMAT (1H0,67HCOEFFICIENT OF THERMAL EXPANSION OF SILICON OIL, OU
00141     25*        1T OF RANGE, T = ,F10.5,6H, P = ,F15.5,/)
00142     26*         RETURN
00143     27*         END
```

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****** BETA/CFSIL ******                                                    DATE 071372      PAGE    2
      END OF COMPILATION:       NO  DIAGNOSTICS.

@HDG,P ****** CAPPA/CFFC43 ******
```

```
@FOR,S ME*NASA5.CAPPA/CFFC43,ME*NASA5.CAPPA/CFFC43
FOR S9A-07/13/72-20:53:17 (0,)

   FUNCTION CAPPA       ENTRY POINT 000010

   STORAGE USED: CODE(1) 000012; DATA(0) 000006; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   NERR3$

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

    0000 R 000000 CAPPA     0000   000001 INJP$


00101      1*            FUNCTION CAPPA(RHO,T)
00101      2*     C
00101      3*     C         THIS FUNCTION SUBPROGRAM COMPUTES :
00101      4*     C         ISOTHERMAL COMPRESSIBILITY AS A FUNCTION OF DENSITY
00101      5*     C              (SLUG/CU.FT) AND TEMPERATURE (R) OF FC-43
00101      6*     C                                         UNITS SQ.FT/LBF
00101      7*     C
00103      8*            CAPPA = 0.0
00104      9*            RETURN
00105     10*            END
      END OF COMPILATION:        NO  DIAGNOSTICS.


@HDG,P  ******  CAPPA/CFFC75  ******
```

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******  CAPPA/CFFC75  ******                                          CATE 071372        PAGE     1

@FOR,S ME*NASA5.CAPPA/CFFC75,ME*NASA5.CAPPA/CFFC75
FOR S9A-07/13/72-20:53:19 (0,)

   FUNCTION CAPPA       ENTRY POINT 000010

   STORAGE USED: CODE(1) 000012; DATA(0) 000006; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   NERR3$

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

    0000 R 000000 CAPPA     0000   000001 INJP$


00101       1*            FUNCTION CAPPA(RHO,T)
00101       2*      C
00101       3*      C        THIS FUNCTION SUBPROGRAM COMPUTES :
00101       4*      C        ISOTHERMAL COMPRESSIBILITY AS A FUNCTION OF DENSITY
00101       5*      C             (SLUG/CU.FT) AND TEMPERATURE (R) OF FC-75
00101       6*      C                                     UNITS SQ.FT/LBF
00101       7*      C
00103       8*            CAPPA = 0.0
00104       9*            RETURN
00105      10*            END

     END OF COMPILATION:        NO  DIAGNOSTICS.


@HDG,P  ******  CAPPA/CFHE  ******
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```
@FOR,S ME*NASA5.CAPPA/CFHE,ME*NASA5.CAPPA/CFHE
FOR S9A-07/13/72-20:53:21 (0,)

   FUNCTION CAPPA       ENTRY POINT 000064

   STORAGE USED: CODE(1) 000067; DATA(0) 000031; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   NERR3$

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

    0000 R 000005 A         0000 R 000002 A1        0000 R 000003 B1        0000 R 000004 C         0000 R 000000 CAPPA
    0000 R 000013 DPDV      0000   000022 INJP$     0000 R 000001 R         0000 R 000006 RHOX      0000 R 000012 TM2
    0000 R 000007 TX        0000 R 000010 VM2       0000 R 000011 VM3


00101      1*          FUNCTION CAPPA(RHO,T)
00101      2*     C
00101      3*     C       THIS FUNCTION SUBPROGRAM COMPUTES :
00101      4*     C       ISOTHERMAL COMPRESSIBILITY AS A FUNCTION OF DENSITY
00101      5*     C            (SLUG/CU.FT) AND TEMPERATURE (R) OF HELIUM
00101      6*     C                                    UNITS SQ.FT/LBF
00101      7*     C
00103      8*          DATA R,A1,B1,C,A /2077.02,136.9595,3.5002295E-03,10.000658,1.49610
00103      9*         13E-02/
00111     10*          RHOX   = RHO*515.4275
00112     11*          TX     = T/1.8
00113     12*          VM2    = RHOX*RHOX
00114     13*          VM3    = RHOX*VM2
00115     14*          TM2    = 1.0/(TX*TX)
00116     15*          DPDV   =-R*TX*VM2*(1.0+2.0*RHOX*B1)+A1*VM3*(2.0-3.0*A*RHOX)+R*C*VM3
00116     16*         1*TM2*(2.0+3.0*B1*RHOX)
00117     17*          CAPPA =-47.872*RHOX/DPDV
00120     18*          RETURN
00121     19*          END

       END OF COMPILATION:        NO  DIAGNOSTICS.

@HDG,P  ******  CAPPA/CFNAK  ******
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****** CAPPA/CFNAK ******                                                                    DATE 071372        PAGE      1

@FOR,S ME*NASA5.CAPPA/CFNAK,ME*NASA5.CAPPA/CFNAK
FOR S9A-07/13/72-20:53:25 (0,)

   FUNCTION CAPPA        ENTRY POINT 000052

   STORAGE USED: CODE(1) 000055; DATA(0) 000032; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   NERR3$

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

    0000 R 000017 BETA      0000 R 000000 CAPPA     0000 R 000015 CP        0000 R 000010 C1        0000 R 000011 C2
    0000 R 000007 DT        0000   000023 INJP$     0000 R 000016 RHOF      0000 R 000014 THETA     0000 R 000006 T0
    0000 R 000020 VELS      0000 R 000012 V1        0000 R 000013 V2        0000 R 000001 X1        0000 R 000002 X2
    0000 R 000003 X3        0000 R 000004 X4        0000 R 000005 X5


00101             FUNCTION CAPPA(RHO,T)
00101       C
00101       C        THIS FUNCTION SUBPROGRAM COMPUTES :
00101       C        ISOTHERMAL COMPRESSIBILITY AS A FUNCTION OF DENSITY
00101       C              (SLUG/CU.FT) AND TEMPERATURE (R) OF NAK 78.6
00101       C                                       UNITS SQ.FT/LBF
00101       C
00103             DATA X1,X2,X3,X4,X5 /0.2255,-0.016292,0.005396,-0.000758,0.000054/
00103           1,T0,DT /659.67,300.0/,C1,C2 /58.773064,-0.008433/,V1,V2 /6296.9267
00103           2,0.99/
00117             THETA = (T-T0)/DT
00120             CP    = (((X5*THETA+X4)*THETA+X3)*THETA+X2)*THETA+X1
00121             RHOF  = C1+C2*T
00122             BETA  = -C2/RHOF
00123             VELS  = V1+V2*T
00124             CAPPA = (32.174/(VELS*VELS)+BETA*BETA*T/(CP*778.26))/RHOF
00125             RETURN
00126             END
       END OF COMPILATION:        NO  DIAGNOSTICS.


@HDG,P ****** CAPPA/CFSIL ******
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```
@FOR,S ME*NASA5.CAPPA/CFSIL,ME*NASA5.CAPPA/CFSIL
FOR S9A-07/13/72-20:54:12 (0,)

  FUNCTION CAPPA        ENTRY POINT 000132

  STORAGE USED: CODE(1) 000146; DATA(0) 000064; BLANK COMMON(2) 000000

  EXTERNAL REFERENCES (BLOCK, NAME)

   0003   PF
   0004   NWDU$
   0005   NIO2$
   0006   NERR3$

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

   0000    000023 1F       0000 R 000016 A       0000 R 000001 A1      0000 R 000002 A2        0000 R 000003 A3
   0000 R 000004 A4        0000 R 000005 A5      0000 R 000017 B       0000 R 000006 B1        0000 R 000007 B2
   0000 R 000010 B3        0000 R 000011 B4      0000 R 000012 B5      0000 R 000000 CAPPA     0000 R 000014 DT
   0000    000055 INJP$    0000 R 000020 P       0003 R 000000 PF      0000 R 000021 P1        0000 R 000015 THETA
   0000 R 000022 TK        0000 R 000013 T0


00101            FUNCTION CAPPA(RHO,T)
00101       C
00101       C       THIS FUNCTION SUBPROGRAM COMPUTES :
00101       C       ISOTHERMAL COMPRESSIBILITY AS A FUNCTION OF DENSITY
00101       C            (SLUG/CU.FT) AND TEMPERATURE (R) OF DOW CORNING
00101       C            200 SILICON OIL (1 CS)
00101       C                                    UNITS SQ.FT/LBF
00101       C            TEMPERATURE .GE. 359.67 AND .LE. 859.67
00101       C
00103            DATA A1,A2,A3,A4,A5 /12.35,2.98333,1.1,-0.48333,0.1/,B1,B2,B3,B4,
00103           1B5 /-1.5,-0.01333,-1.18,0.57333,-0.1/,T0,DT /559.67,50.0/
00120            THETA = (T-T0)/DT
00121            A  = ((((A5*THETA+A4)*THETA+A3)*THETA+A2)*THETA+A1)*1.0E-06
00122            B  = ((((B5*THETA+B4)*THETA+B3)*THETA+B2)*THETA+B1)*1.0E-09
00123            P  = PF(RHO,T)
00124            P1 = P/144.0-14.696
00125            TK = A+B*P1
00126            CAPPA = TK/144.0
00127            IF (T.LT.360.67.OR.T.GT.860.67.OR.P.GT.146116.224.OR.P.GT.110116.2
00127           124.AND.T.LT.460.67) WRITE(6,1) T,P
00134          1 FORMAT (1H0,61HISOTHERMAL COMPRESSIBILITY OF SILICON OIL, OUT OF R
00134           1ANGE, T = ,F10.5,6H, P = ,F15.5,/)
00135            RETURN
00136            END

     END OF COMPILATION:        NO  DIAGNOSTICS.
```

```
@FOR,S ME*NASA5.CNTLM,ME*NASA5.CNTLM
FOR S9A-07/13/72-20:54:17 (0,)

  SUBROUTINE CNTLM     ENTRY POINT 001771

  STORAGE USED: CODE(1) 002060; DATA(0) 003423; BLANK COMMON(2) 001115

   COMMON BLOCKS:

   0003   SRTCNV 000003
   0004   QRD    003670
   0005   QIN    001610
   0006   GEOM   000020
   0007   FLDINL 000457
   0010   DVCMFL 000002

  EXTERNAL REFERENCES (BLOCK, NAME)

   0011   THCFN
   0012   CPFN
   0013   DEFINT
   0014   YINT
   0015   HFL
   0016   CPTB
   0017   CPMP
   0020   FINT
   0021   SQRT
   0022   NERR2$
   0023   ALOG
   0024   NWDU$
   0025   NIO2$
   0026   NIO1$
   0027   NERR3$

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

   0001   000206 10L      0001   000471 100L     0001   000506 105L     0001   000162 147G     0001   000227 15L
   0001   000253 177G     0001   000110 2L       0001   000244 20L      0001   000347 230G     0001   000311 25L
   0001   000127 3L       0001   000332 30L      0001   000617 321G     0001   000632 330G     0001   000670 343G
   0001   000703 346G     0001   001061 374G     0001   001255 422G     0001   001274 426G     0001   001333 440G
   0001   001403 453G     0001   001437 464G     0001   000166 5L       0001   000340 50L      0001   000517 500L
   0001   000522 505L     0001   000542 506L     0001   000555 507L     0000   002504 509F     0000   002554 510F
   0001   001537 511G     0001   001002 513L     0001   001054 514L     0000   002605 515F     0000   003031 516F
   0001   001553 522G     0000   003057 530F     0001   001562 530G     0000   003064 535F     0001   001664 543L
   0001   001670 544L     0001   000405 55L      0000   003310 550F     0000   003317 555F     0000   003322 560F
   0001   001653 560G     0001   001176 600L     0001   000416 65L      0001   000147 7L       0001   000421 70L
   0000 R 002430 ASTR1    0000 R 002431 ASTR2    0000 R 000310 AUX1     0002 R 000562 AUX2     0000 R 000322 AUX3
   0000 R 000334 AUX4     0000 R 000346 AUX5     0002   000752 COB      0002 R 001107 COH      0000 R 002446 CONDMF
   0000 R 002454 COND1    0000 R 002455 COND2    0002 R 000574 CONFN    0000 R 002456 CONMF1   0002 R 000740 CONMP
   0012 R 000000 CPFN     0000 R 002467 CPFN1    0017 R 000000 CPMP     0000 R 002474 CPMP1    0016 R 000000 CPTB
   0000 R 002472 CPTB1    0002   001070 CPO      0004   003465 CSF      0000 R 002502 DEDOT    0000 R 002501 DEDT
   0013 R 000000 DEFINT   0002   001072 DELTA    0000 R 002464 DENTH    0000 R 002503 DIFE     0002   000764 DOB
   0000 R 002354 DSTFN    0000 R 002412 DSTMP    0000 R 002400 DSTTB    0000 R 000360 DTDZ1    0000 R 000372 DTDZ2
```

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0002 R 001110 DXI      0002   001053 DXIMP    0002   001052 DXITB    0004   003464 DXX2     0004   003472 DXX21
0000 R 000000 DY1      0002 R 001051 DZ       0004   003463 DZMFN    0004   003410 EBFN     0004   003441 EBMP
0003 R 000000 ELEV     0000 R 002463 ENTHE    0000 R 002462 ENTHI    0004 R 003467 EXTIFN   0004   003471 EXTIMP
0004 R 003466 EXTSFN   0004   003470 EXTSMP   0002 R 001103 FENTH    0002   001045 FFO      0007 R 000456 FLDINT
0006   000016 FLMASS   0002 R 001101 FLUX     0010   000001 FLUXI    0002   001041 FMACH    0000 R 002470 FNM
0002   001040 FNU      0002   001046 FOF      0002 R 000012 FP       0002   001042 FPR      0000 R 000404 FPRME
0000 R 002451 FPRM1    0000 R 002450 FPRM2    0002   001037 FR       0002   001050 FRAD     0002   001111 FRD
0002   001036 FRE      0002 R 001104 FREJ     0002   001043 FRL      0002   001044 FRM      0002 R 000036 FT
0002 R 000024 FW       0002   001113 FXHW     0002   001112 FXOH     0002   001047 FZ       0015 R 000000 HFL
0002 R 001105 HFN      0000 I 002432 I        0002   001003 IFLOW    0000 I 002465 IM2      0000   003361 INJPS
0000 I 002442 J        0000 I 002443 K        0002   001024 LC       0004   003461 LCT      0007 I 000001 LFLD
0002 I 001032 LIM      0002 I 001031 LIMWRT   0002   001011 LL1      0002   001012 LL2      0002   001013 LL3
0002 I 001014 LL4      0002 I 001015 LL5      0002   001016 LL6      0002   001017 LL7      0002   001006 LMP
0000 I 002500 LSKIP    0002 I 001004 LT       0002 I 001005 LTB      0002   001007 LTBMZ    0002   001010 LTB2MZ
0004   003462 LTT      0004   003460 MCVRD    0002   001030 MM1      0002 I 001033 MOD      0002 I 001025 MSTOTR
0002 I 000777 MZ       0002   001034 NCCZ     0002 I 001035 NCONV    0002   001002 NCTL     0002 I 001026 NCTM
0002 I 001023 NEQUS    0007   000000 NFLDTA   0002   001027 NM1      0002 I 001001 NRMP     0002   001020 NRMP1
0002   001022 NRMP2    0002   001000 NRTB     0002   001021 NRTB1    0005   001605 NSRD     0006 I 000012 NTBS
0005   001604 NTM      0002 I 000776 NX       0002   001063 PHIF     0002   001062 PHIM     0002   001071 PI
0006 R 000015 PLMASS   0002 R 001065 PO       0000 R 002445 QAERO    0005   000454 QIFN     0000 R 002425 QIRED
0005   001274 QITB     0002 R 001102 QREF     0002 R 000360 QRFN     0002 R 000524 QRMP     0005   000144 QSFN
0000 R 002424 QSOLR    0005   000764 QSTB     0005 R 001606 QTO      0000 R 002444 QTOT     0002 R 001074 RDTWRT
0002 R 001114 RHOFN    0002 R 001067 RHOO     0002 R 001073 RLIMIT   0000 R 002461 RRR      0002 R 001100 RTEND
0006 R 000000 SFN      0004   003473 SS       0000 R 002471 STFN     0000 R 002366 STFNX    0000 R 002475 STMP
0000 R 002477 STORG    0006 R 000017 STR      0000 R 002473 STTB     0000 R 002441 TABS     0003 R 000002 TATM
0006 R 000014 TBMASS   0002 R 000132 TEMP     0000 R 002452 TFNX1    0000 R 002453 TFNX2    0000 R 002426 TFN1
0000 R 002427 TFN2     0011 R 000000 THCFN    0002   001077 TI       0007   000146 TIFLD    0002   001076 TINTL
0005   000000 TM       0007   000002 TMEFLD   0002 R 000276 TMP      0006 R 000013 TNXL     0002 R 001075 TREF
0004   000000 TRMTX    0000 R 002466 TT       0000 R 002457 TTT      0002 R 000050 TW       0000 R 002440 TWRTE
0005   001607 TX       0002 R 001064 TO       0003 R 000001 VELS     0000 R 002435 W        0007   000312 WIFLD
0010 R 000000 WRAT     0000 R 002460 WWW      0000 R 002447 WWX      0002 R 001066 WO       0002 R 000536 XIFN
0002   000005 XIMP     0002   000000 XITB     0002 R 001106 XL       0000 R 002476 XLTW     0002   001054 XRE
0000 R 001370 XTIME    0002   001057 XX10     0002   001060 XX11     0002   001061 XX12     0004   003446 XX2
0002   001055 XX3      0002   001056 XX4      0014 R 000000 YINT     0000 R 002434 Z        0000 R 002436 ZCK
0000 R 002433 ZE       0002 R 000550 ZETA     0000 R 002437 ZT       0004   003453 ZZ2
```

```
00101             SUBROUTINE CNTLM(Y,DY,DX,X,NTRY,IFVD)
00101       C
00101       C   THIS SUBROUTINE :
00101       C     1- CONTROLS MAIN INTEGRATION
00101       C     2- CONTROLS OUTPUT OF MAIN INTEGRATION
00101       C     3- PROVIDES SYSTEM PERFORMANCE CHARACTERISTICS
00101       C   IS PART OF RKS AND DERIVM SUBROUTINES
00101       C
00103             COMMON XITB(5),XIMP(5),FP(10),FW(10),FT(10),TW(10,5),TEMP(10,10),
00103            1         TMP(10,5),QRFN(10,10),QRMP(10),XIFN(10),ZETA(10),AUX2(10),
00103            2         CONFN(10,10),CONMP(10),COB(10),DOB(10)
00104             COMMON NX,MZ,NRTB,NRMP,NCTL,IFLOW,LT,LTB,LMP,LTBMZ,LTB2MZ,LL1,
00104            1       LL2,LL3,LL4,LL5,LL6,LL7,NRMP1,NRTB1,NRMP2,NEQUS,LC,MSTOTR,
00104            2       NCTM,NM1,MM1,LIMWRT,LIM,MOD,NCCZ,NCONV
00105             COMMON FRE,FR,FNU,FMACH,FPR,FRL,FRM,FFO,FOF,FZ,FRAD,DZ,DXITB,DXIMP
00105            1         ,XRE,XX3,XX4,XX10,XX11,XX12,PHIM,PHIF,TO,PO,WO,RHOO,CPO,PI
00105            2         ,DELTA,RLIMIT,RDTWRT,TREF,TINTL,TI,RTEND,FLUX,QREF,FENTH,
00105            3         FREJ,HFN,XL,COH,DXI,FRD,FXOH,FXHW,RHOFN
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00106          COMMON /SRTCNV/ ELEV,VELS,TATM
00107          COMMON /QRD/ TRMTX(30,60),EBFN(5,5),EBMP(5),XX2(5),ZZ2(5),
00107         1            MCVRD,LCT,LTT,DZMFN,
00107         2            DXX2,CSF,EXTSFN,EXTIFN,EXTSMP,EXTIMP,DXX21,SS(5,5,5)
00110          COMMON /QIN/TM(100), QSFN(100,2), QIFN(100,2), QSTB(100,2),
00110         1           QITB(100,2), NTM, NSRD, QTO, TX
00111          COMMON /GEOM/ SFN(10),NTBS,TNXL,TBMASS,PLMASS,FLMASS,STR
00112          COMMON /FLDINL/ NFLDTA,LFLD,TMEFLD(100),TIFLD(100),WIFLD(100),
00112         1                FLDINT
00113          COMMON /DVCMFL/ WRAT,FLUXI
00113     C
00114          DIMENSION Y(200),DY(200),DY1(200),AUX1(10),AUX3(10),AUX4(10),
00114         1         AUX5(10),DTDZ1(10),DTDZ2(10),FPRME(500),XTIME(500)
00115          DIMENSION DSTFN(10),STFNX(10),DSTTB(10),DSTMP(10)
00115     C
00116          QSOLR   = EXTSFN*QTO
00117          QIRED   = EXTIFN*QTO
00117     C
00120          NCTM    = NCTM+1
00120     C
00121          TFN1    = TEMP(1,1)*TO
00122          TFN2    = TEMP(MZ,1)*TO
00123          ASTR1   = STR*SQRT(THCFN(TFN1)*CPFN(TFN1))
00124          ASTR2   = STR*SQRT(THCFN(TFN2)*CPFN(TFN2))
00125          IF (NCTM .GT. 500) GO TO 7
00125     C
00127          IF (X .LT. XTIME(NCTM-1)) GO TO 2
00131          FPRME(NCTM)    = ASTR1*DY(1)+ASTR2*DY(MZ)
00132          XTIME(NCTM)    = X
00133          GO TO 3
00134        2 FPRME(NCTM)    = FPRME(NCTM-1)
00135          XTIME(NCTM)    = XTIME(NCTM-1)
00136          FPRME(NCTM-1) = ASTR1*DY(1)+ASTR2*DY(MZ)
00137          XTIME(NCTM-1) = X
00137     C
00140        3 IF (NCTM .GT. 1) GO TO 5
00142          FPRME(NCTM) = ASTR1*DY(1)+ASTR2*DY(MZ)
00143          XTIME(NCTM) = X
00143     C
00144        7 IF (NCTM .GT. 1) GO TO 5
00146          DO 4  I = 1,NEQUS
00151        4 DY1(I)  = DY(I)
00153          GO TO 500
00154        5 IF(IFVD.EQ.1) GO TO 10
00156          IF(NTRY.EQ.3) GO TO 30
00160          GO TO (50,100),MSTOTR
00160     C
00161       10 IF(MSTOTR.EQ.1) GO TO 20
00163          ZE      = X-RTEND
00164          IF(ABS(ZE)/RDTWRT.LE.0.0005) GO TO 65
00166          IF(ZE.GT.0.0) GO TO 105
00170       15 IFVD    = 1
00171          DX      = RDTWRT
00172          IF(LIM.GT.LIMWRT) RETURN
00174          GO TO 500
00175       20 Z       = 0.0
00176          DO 25 I = 1,NEQUS
```

```
00201              IF(ABS(DY(I)).LT.1.0E-30) GO TO 25
00203              W        = ABS(DY1(I)/DY(I))
00204              IF(W.LE.0.0) GO TO 25
00206              ZCK      = ALOG(W)
00207              IF(ABS(ZCK).LT.1.0E-06) GO TO 25
00211              Z        = AMAX1(Z,ABS(DY(I)/ZCK)*DX)
00212           25 DY1(I)   = DY(I)
00214              IF(Z.LE.RLIMIT) GO TO 65
00216              IF(LIM.LE.LIMWRT) GO TO 15
00220              IFVD     = 0
00221              RETURN
00222           30 NTRY     = 1
00223              IF(MOD.EQ.1) GO TO 10
00225              GO TO 500
00225        C
00225        C
00226           50 Z        = 0.0
00227              DO 55 I = 1,NEQUS
00232              IF(ABS(DY(I)).LT.1.0E-30) GO TO 55
00234              W        = ABS(DY1(I)/DY(I))
00235              IF(W.LE.0.0) GO TO 55
00237              ZCK      = ALOG(W)
00240              IF(ABS(ZCK).LT.1.0E-06) GO TO 55
00242              Z        = AMAX1(Z,ABS(DY(I)/ZCK)*DX)
00243           55 DY1(I)   = DY(I)
00245              IF(Z.LE.RLIMIT) GO TO 65
00247              GO TO 70
00247        C
00250           65 NTRY     = 2
00251              GO TO 505
00251        C
00252           70 IF(LIM.GT.LIMWRT) RETURN
00254              ZT       = X-TWRTE
00255              IF(ABS(ZT)/RDTWRT.LE.0.0005) GO TO 500
00257              IF(ZT.LT.0.0) RETURN
00261              NTRY     = 3
00262              IF(DX.GE.RDTWRT) MOD = 1
00264              DX       = DX+TWRTE-X
00265              RETURN
00265        C
00266          100 ZE       = X-RTEND
00267              IF(ABS(ZE)/RDTWRT.LT.0.0005) GO TO 65
00271              IF(ZE.LT.0.0) GO TO 70
00273          105 NTRY     = 3
00274              DX       = DX+RTEND-X
00275              RETURN
00275        C
00275        C
00276          500 TWRTE    = X+RDTWRT
00277          505 TABS     = X+TREF
00300              IF(NCONV.GT.0) GO TO 506
00302              WRITE(6,510) TABS,X,NCTM
00307              GO TO 507
00310          506 WRITE(6,509) TABS,X,NCTM,ELEV,VELS,TATM
00310        C
00310        C
00320          507 DO 508 J=1,MZ
```

```
00323              FT(J)    = Y(LT+J)
00324              TW(J,1)      = Y(LTB+J)
00325              TMP(J,NRMP) = Y(LL5+J)
00326              TEMP(J,1)   = Y(LL4+J)
00327              DO 508 I=2,NX
00332              K           = MZ*(I-2)+J
00333          508 TEMP(J,I)   = Y(K)
00336              IF (LFLD .EQ. 2) FT(1) = FLDINT
00336        C
00336        C
00340          509 FORMAT(1H1,5X,20HELAPSED TIME IS       ,F12.4,6H HR , ,
00340            1           6X,20HRELATIVE TIME IS      ,F12.4,
00340            2           6X,I7,14H INTEGR. STEPS,/,
00340            3           6X,20HALTITUDE IS           ,F10.2,8H   FT , ,
00340            4          6X,20HVELOCITY IS           ,F10.2,10H FT/SEC , ,
00340            5           6X,22HATM. TEMPERATURE IS   ,F8.2,2H R,/)
00341          510 FORMAT(1H1,5X,25HELAPSED TIME IS           ,F12.4,11H HR         ,/,
00341            1           6X,25HRELATIVE TIME IS          ,F12.4,
00341            2           18X,12H**IN ORBIT**,20X,I7,14H INTEGR. STEPS,/)
00341        C
00341        C     LISTING OF FIN TEMPERATURE DISTRIBUTION
00341        C
00342              DO 512 J=1,MZ
00345              DO 511 I=1,NX
00350              AUX4(I) = CONFN(J,I)
00351          511 AUX1(I) = QRFN(J,I)
00353              AUX5(J) = DEFINT(AUX4,DXI,NX)+CONMP(J)*COH
00354          512 AUX3(J) =  DEFINT(AUX1,DXI,NX)+QRMP(J)*COH
00356              QTOT    = DEFINT(AUX3,DZ,MZ)*QREF*XL
00357              QAERO   = DEFINT(AUX5,DZ,MZ)*QREF*XL
00357        C
00357        C     CONDUCTION FROM MANIFOLD
00357        C
00360              IF (NCTM .GT. 500) GO TO 514
00362              IF (NCTM .GT. 3) GO TO 513
00364              CONDMF  = 0.66667*FPRME(1)*SQRT(XTIME(NCTM))
00365              GO TO 600
00366          513 WWX     = X/3.0
00367              FPRM2   = YINT(XTIME,FPRME,NCTM,3,WWX)
00370              WWX     = 2.0*WWX
00371              FPRM1   = YINT(XTIME,FPRME,NCTM,3,WWX)
00372              CONDMF  = SQRT(XTIME(NCTM))/105.0*(68.0*FPRME(NCTM)+90.0*FPRM1+
00372             1          36.0*FPRM2+16.0*FPRME(1))
00372        C
00373          514 DO 580 I=1,NX
00376              TFNX1     = TEMP(1,I)*T0
00377              DTDZ1(I) = -THCFN(TFNX1)*SFN(I)*(-3.0*TEMP(1,I)+4.0*TEMP(2,I)
00377             1          -TEMP(3,I))
00400              TFNX2     = TEMP(MZ,I)*T0
00401          580 DTDZ2(I) = THCFN(TFNX2)*SFN(I)*(3.0*TEMP(MZ,I)-4.0*TEMP(MZ-1,I)+
00401             1          TEMP(MZ-2,I))
00403              COND1     = DEFINT(DTDZ1,DXI,NX)
00404              COND2     = DEFINT(DTDZ2,DXI,NX)
00405              CONMF1    = (COND1+COND2)*NTBS*T0*HFN/(DZ*XL)
00406              IF (CONDMF .LE. CONMF1 .OR. NCTM .GT. 500) CONDMF = CONMF1
00406        C
00406        C     FLUID ENTHALPY REJECTION
```

```
00406       C
00410         600 TTT      = FT(1)*T0
00411             WWW      = FW(1)*W0
00412             RRR      = RHO0/FW(1)
00413             ENTHI    = FLUX*(HFL(RRR,TTT)+WWW**2/1556.36)*WRAT
00414             TTT      = FT(MZ)*T0
00415             WWW      = FW(MZ)*W0
00416             RRR      = RHO0/FW(MZ)
00417             ENTHE    = FLUX*(HFL(RRR,TTT)+WWW**2/1556.36)*WRAT
00420             DENTH    = ENTHI-ENTHE
00420       C
00420       C     ENERGY STORAGE RATE
00420       C
00420       C     FIN
00420       C
00421             DO 700 I=2,NX
00424             IM2      = I-2
00425             DO 700 J=1,MZ
00430             K        = IM2*MZ+J
00431             TT       = T0*TEMP(J,I)
00432             CPFN1    = CPFN(TT)
00433             DSTFN(J)= CPFN1*SFN(I)*DY(K)
00434         700 STFNX(I)= DEFINT(DSTFN,DZ,MZ)
00437             DO 705 J=1,MZ
00442             K        = LTB+J
00443             TT       = T0*TEMP(J,1)
00444             CPFN1    = CPFN(TT)
00445             DSTFN(J)= CPFN1*DY(K)
00446         705 STFNX(1)= DEFINT(DSTFN,DZ,MZ)*SFN(1)
00450             FNM      = 2.0*RHOFN*TNXL*HFN
00451             STFN     = DEFINT(STFNX,DXI,NX)*FNM
00451       C
00451       C     TUBE
00451       C
00452             DO 710 J=1,MZ
00455             K        = LTB+J
00456             TT       = T0*TEMP(J,1)
00457             CPTB1    = CPTB(TT)
00460         710 DSTTB(J)= CPTB1*DY(K)
00462             STTB     = DEFINT(DSTTB,DZ,MZ)*TBMASS
00462       C
00462       C     PROTECTION LAYER
00462       C
00463             DO 715 J=1,MZ
00466             K        = LTB+J
00467             TT       = T0*TEMP(J,1)
00470             CPMP1    = CPMP(TT)
00471         715 DSTMP(J)= CPMP1*DY(K)
00473             STMP     = DEFINT(DSTMP,DZ,MZ)*PLMASS
00473       C
00474             XLTW     = XL/(T0*W0*3600.0)
00475             STORG    = (STFN+STTB+STMP)/XLTW
00476             STORG    = DENTH+CONDMF+QAERO-QTOT
00476       C
00477             WRITE(6,515) T0,QSOLR,QREF,QIRED,QTOT,QAERO,CONDMF,STORG,
00477            1(XIFN(I),I=1,NX)
00515         515 FORMAT(1H0,15X,55HFIN TEMPERATURE DISTRIBUTION AND RADIANT HEAT RE
```

```
00515          1JECTION,/,16X,55H*******************************************************
00515          2******,//,
00515          3 2X,33HREFERENCE TEMPERATURE,      TOO  =,F10.3,13H R           ,/,
00515          4 2X,56HREF. RADIANT HEAT FLUX                                   ,
00515          5 8X,33HINCIDENT SOLAR FLUX,      QSOLR. =,E10.4,15H BTU/(HR SQ FT),
00515          6 /,
00515          7 2X,33H   PER UNIT AXIAL LENGTH, QREF  =,E10.4,13H BTU/(HR FT),
00515          8 8X,33HINCIDENT INFRARED FLUX,  QIRED  =,E10.4,15H BTU/(HR SQ FT),
00515          9 /,
00515          1 2X,33HTOT. RADIANT REJECTION    QTOT  =,E10.4,13H BTU/HR      ,
00515          2 8X,33HAERODYN. HEATING POWER,  QCONV  =,E10.4,7H BTU/HR,/,
00515          3 2X,33HCOND. FROM MANIFOLDS,   CONDMF  =,E10.4,13H BTU/HR      ,
00515          4 8X,33HENERGY STORAGE RATE,      STORG  =,E10.4,7H BTU/HR,//
00515          5/,6H AXIAL,4X,8HRELATIVE,14X,30HRELATIVE TEMPERATURE OF FIN, T,/,6
00515          6H DIST.,4X,9HRAD. HEAT,/,10X,9HREJECTION,15X,33HDISTANCE NORMAL TO
00515          7 FLOW DIRECTION,/,3H  Z,9X,1HQ,31X,1HX,/,20X,10F9.5,)
00516           WRITE(6,516)
00520      516 FORMAT(1H ,120H--------------------------------------------------------
00520          1--------------------------------------------------------------
00520          2---)
00521           DO 525 J=1,MZ
00524      525 WRITE(6,530) ZETA(J),AUX3(J),(TEMP(J,I),I=1,NX)
00535      530 FORMAT(1H ,F5.3,F11.4,2X,10F9.4)
00536           WRITE(6,555)
00536    C
00540           WRITE(6,535) TO,PO,WO,FENTH,ENTHI,ENTHE,DENTH
00551      535 FORMAT(1HO,15X,70HFLUID PROPERTIES AND SURFACE TEMPERATURE OF METE
00551          1OROID PROTECTION LAYER,/,16X,70H***********************************
00551          2***********************************,//,
00551          3 10X,33HREFERENCE TEMPERATURE, TOO       =,F15.3,12H R          ,/,
00551          4 10X,33HREFERENCE PRESSURE,     PUO       =,F15.3,12H LBF/SQ.FT  ,/,
00551          5 10X,33HREFERENCE VELOCITY,     WOO       =,F15.3,12H FT/SEC     ,/,
00551          6 6X,36HCOOLANT POWER, INLET  AT T=TO  HO = ,E11.6,7H BTU/HR,
00551          7 6X,36H              INLET CURRENTLY  HI = ,E11.6,7H BTU/HR,/,
00551          8 6X,36H              EXIT  CURRENTLY  EI = ,E11.6,7H BTU/HR,
00551          9 6X,36H              TOT. REJECTION   DH = ,E11.6,7H BTU/HR,//
00551          9 58X,8HPROTECT.,10X,18HENTHALPY REJECTION,/,36X,5HFLUID,7X,4HWALL,
00551          17X,5HLAYER,7X,13HPER UNIT TUBE,5X,8HFRACTION,/,6H AXIAL,5X,8HPRESS
00551          2URE,4X,8HVELOCITY,9X,23HT E M P E R A T U R E S,12X,6HLENGTH,11X,2
00551          3HOF,/,6H DIST.,8X,1HP,11X,1HW,11X,2HTF,9X,3HTWI,9X,3HTMP,9X,
00551          411HBTU/(HR FT),7X,5HTOTAL,/)
00551    C
00551    C      POWER FLUX, FLUID FLOW
00551    C
00552           LSKIP   = 1
00553           CALL FINT(AUX2,0.0,DZ,MZ,AUX1)
00554           DEDT    = AUX1(1)-AUX1(MZ)
00555           IF(ABS(DEDT).LT.1.0E-08) LSKIP = 2
00557           DO 545 J=1,MZ
00562           DEDOT   = 0.0
00563           GO TO (543,544), LSKIP
00564      543 DEDOT   = (AUX1(1)-AUX1(J))/DEDT
00565      544 DIFE    = AUX2(J)*FREJ
00566      545 WRITE(6,550) ZETA(J),FP(J),FW(J),FT(J),TW(J,1),TMP(J,NRMP),DIFE,
00566         1            DEDOT
00601      550 FORMAT(1H ,F5.3,F12.5,F11.4,3F12.4,F17.6,F14.5)
00602           WRITE(6,555)
```

```
00604   304*      555 FORMAT(1H ,7H (EXIT))
00604   305*    C
00605   306*          LIM     = LIM+1
00606   307*          IF (MSTOTR .EQ. 1 .AND. NTRY .EQ. 2) WRITE (6,560)
00611   308*      560 FORMAT (1H1,25H  STEADY STATE IS REACHED)
00612   309*          RETURN
00613   310*          END

        END OF COMPILATION:        NO  DIAGNOSTICS.

@HDG,P  ******  CNTLN  ******
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****** CNTLN ******                                                                    DATE 071372         PAGE    1

@FOR,S ME*NASA5.CNTLN,ME*NASA5.CNTLN
FOR S9A-07/13/72-20:54:26 (0,)

   SUBROUTINE CNTLN      ENTRY POINT 000075

   STORAGE USED: CODE(1) 000111; DATA(0) 000023; BLANK COMMON(2) 001115

    COMMON BLOCKS:

    0003    DRVLCM 000024
    0004    DRVLCN 000001

   EXTERNAL REFERENCES (BLOCK, NAME)

    0005    NWDU$
    0006    NI01$
    0007    NI02$
    0010    NERR3$

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

    0000    000001 1F        0001    000025 120G      0002    000562 AUX2      0004 R 000000 B2        0002    000752 COB
    0002    001107 COP       0002    000574 CONFN     0002    000740 CONMP     0002   001070 CP0       0002    001072 DELTA
    0002    000764 DOB       0002    001110 DXI       0002    001053 DXIMP     0002   001052 DXITB     0002    001051 DZ
    0002    001103 FENTH     0002    001045 FFO       0002    001101 FLUX      0002   001041 FMACH     0002    001040 FNU
    0002    001046 FOF       0002 R 000012 FP        0002    001042 FPR       0002   001037 FR        0002    001050 FRAD
    0002    001111 FRD       0002    001036 FRE       0002    001104 FREJ      0002   001043 FRL       0002    001044 FRM
    0002 R 000036 FT        0002 R 000024 FW        0002    001113 FXHW      0002   001112 FXOH      0002    001047 FZ
    0002    001105 HFN       0000 I 000000 I         0002 I 001003 IFLOW     0000   000007 INJP$     0002    001024 LC
    0002    001032 LIM       0002    001031 LIMWRT    0002    001011 LL1       0002   001012 LL2       0002    001013 LL3
    0002    001014 LL4       0002    001015 LL5       0002    001016 LL6       0002   001017 LL7       0002    001006 LMP
    0002    001004 LT        0002    001005 LTB       0002    001007 LTBMZ     0002   001010 LTB2MZ    0002    001030 MM1
    0002    001033 MOC       0002    001025 MSTOTR    0002 I 000777 MZ        0002   001034 NCCZ      0002    001035 NCONV
    0002 I 001002 NCTL      0002    001026 NCTM      0002    001023 NEQUS     0002   001027 NM1       0002    001001 NRMP
    0002    001020 NRMP1     0002    001022 NRMP2     0002    001000 NRTB      0002   001021 NRTB1     0002    000776 NX
    0002    001063 PHIF      0002    001062 PHIM      0002    001071 PI        0002   001065 PO        0002    001102 QREF
    0002    000360 QRFN      0002    000524 QRMP      0002    001074 RDTWRT    0002   001114 RHOFN     0002    001067 RHOO
    0002    001073 RLIMIT    0002    001100 RTEND     0003 R 000000 STRGE1    0003 R 000012 STRGE2    0002    000132 TEMP
    0002    001077 TI        0002    001076 TINTL     0002    000276 TMP       0002   001075 TREF      0002 R 000050 TW
    0002    001064 TO        0002    001066 WO        0002    000536 XIFN      0002   000005 XIMP      0002    000000 XITB
    0002    001106 XL        0002    001054 XRE       0002    001057 XX10      0002   001060 XX11      0002    001061 XX12
    0002    001055 XX3       0002    001056 XX4       0002    000550 ZETA


00101      1*            SUBROUTINE CNTLN (Y,DY,DXX,X,NTRY,IFVD)
00101      2*      C
00101      3*      C   THIS SUBROUTINE CONTROLS :
00101      4*      C     1- INTEGRATION OF COOLANT FLUID PRESSURE AND VELOCITY FIELDS
00101      5*      C     2- INTEGRATION FOR FLUID INITIAL CONDITIONS
00101      6*      C   IS PART OF RKSF AND DERIVL SUBROUTINES
00101      7*      C
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00103     8*        COMMON XITB(5),XIMP(5),FP(10),FW(10),FT(10),TW(10,5),TEMP(10,10),
00103     9*       1        TMP(10,5),QRFN(10,10),QRMP(10),XIFN(10),ZETA(10),AUX2(10),
00103    10*       2        CONFN(10,10),CONMP(10),COB(10),DOB(10)
00104    11*        COMMON NX,MZ,NRTB,NRMP,NCTL,IFLOW,LT,LTB,LMP,LTBMZ,LTB2MZ,LL1,
00104    12*       1       LL2,LL3,LL4,LL5,LL6,LL7,NRMP1,NRTB1,NRMP2,NEQUS,LC,MSTOTR,
00104    13*       2       NCTM,NM1,MM1,LIMWRT,LIM,MOD,NCCZ,NCONV
00105    14*        COMMON FRE,FR,FNU,FMACH,FPR,FRL,FRM,FFO,FOF,FZ,FRAD,DZ,DXITB,DXIMP
00105    15*       1        ,XRE,XX3,XX4,XX10,XX11,XX12,PHIM,PHIF,TO,PO,WO,RHOO,CPO,PI
00105    16*       2        ,DELTA,RLIMIT,RDTWRT,TREF,TINTL,TI,RTEND,FLUX,QREF,FENTH,
00105    17*       3        FREJ,HFN,XL,COH,DXI,FRD,FXOH,FXHW,RHOFN
00106    18*        COMMON /DRVLCM/ STRGE1(10),STRGE2(10)
00107    19*        COMMON /DRVLCN/ B2
00110    20*        DIMENSION Y(3),DY(3)                                                  04
00110    21*    C
00111    22*        STRGE1(NCTL) = B2
00112    23*        STRGE2(NCTL) = DY(3)
00113    24*        IF(IFLOW.EQ.1) WRITE (6,1) NCTL,X,(Y(I),I=1,3),TW(NCTL,1)
00125    25*        IF(NCTL.EQ.MZ) NTRY=2
00127    26*        FP(NCTL) = Y(1)                                                       08
00130    27*        FW(NCTL) = Y(2)                                                       09
00131    28*        IF (IFLOW .EQ. 1) FT(NCTL) = Y(3)
00133    29*        NCTL = NCTL+1                                                         011
00134    30*        RETURN                                                                012
00134    31*    C
00135    32*      1 FORMAT (15X,I5,F10.3,4F20.6)                                          014
00136    33*        END                                                                   015

        END OF COMPILATION:       NO  DIAGNOSTICS.

 QHDG,P  ******  CONVEC  ******
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QFOR,S ME*NASA5.CONVEC,ME*NASA5.CONVEC
FOR S9A-07/13/72-20:54:33 (0,)

   SUBROUTINE CONVEC     ENTRY POINT 000543

   STORAGE USED: CODE(1) 000561; DATA(0) 000144; BLANK COMMON(2) 001115

    COMMON BLOCKS:

    0003   VELALT 001132
    0004   CNV    000010
    0005   SRTCNV 000003
    0006   QRD    003721
    0007   SSF    000005

   EXTERNAL REFERENCES (BLOCK, NAME)

    0010   ALTVEL
    0011   ATMOS
    0012   ENTAIR
    0013   TNH
    0014   CPAIR
    0015   REFP
    0016   NUS
    0017   NEXP6$
    0020   NERR3$

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

    0001     000031 122G     0001     000033 125G     0001     000425 150L     0001     000401 211G     0001     000416 220G
    0001     000417 223G     0001     000431 231G     0001     000507 243G     0001     000510 246G     0001     000122 31L
    0001     000236 35L      0001     000253 37L      0001     000267 47L      0001     000045 5L       0001     000277 51L
    0002     001105 AL       0007     000002 ALPFN    0003 R 000310 ALTA     0003 R 000454 ALTR     0010 R 000000 ALTVEL
    0002     000562 AUX2     0000 R 000020 CATM     0002     000752 COB      0000 R 000043 COEF     0004     000007 COEFF
    0002     001107 COH      0002 R 000574 CONFN    0002 R 000740 CONMP    0014 R 000000 CPAIR    0000 R 000054 CPFIN
    0000 R 000045 CPMP     0002     001070 CP0      0006     003465 CSF      0002     001072 DELTA    0002     000764 DOB
    0004     000003 DX       0002     001110 DXI      0002     001053 DXIMP    0002     001052 DXITB    0006     003464 DXX2
    0006     003472 DXX21    0002     001051 DZ       0006     003463 DZMFN    0006     003410 EBFN     0006     003441 EBMP
    0005 R 000000 ELEV     0012 R 000000 ENTAIR   0000 R 000021 ENTATM   0000 R 000042 ENTAW    0000 R 000030 ENTFN
    0006     003467 EXTIFN   0006     003471 EXTIMP   0006     003466 EXTSFN   0006     003470 EXTSMP   0002     001103 FENTH
    0002     001045 FFO      0002     001101 FLUX     0002     001041 FMACH    0002     001040 FNU      0002     001046 FOF
    0002     000012 FP       0002     001042 FPR      0002     001037 FR       0002     001050 FRAD     0002     001111 FRD
    0002     001036 FRE      0002     001104 FREJ     0002     001043 FRL      0002     001044 FRM      0002     000036 FT
    0002     000024 FW       0002     001113 FXHW     0002     001112 FXOH     0002     001047 FZ       0002     001105 HFN
    0000 I 000051 I        0002     001003 IFLOW    0000 I 000024 II       0000     000116 INJP$    0004 I 000002 IOPTN
    0000 I 000050 J        0000 I 000025 JJ       0000 I 000053 L        0002     001024 LC       0006     003461 LCT
    0002     001032 LIM      0002     001031 LIMWRT   0002     001011 LL1      0002     001012 LL2      0002     001013 LL3
    0002     001014 LL4      0002     001015 LL5      0002     001016 LL6      0002     001017 LL7      0002     001006 LMP
    0002     001004 LT       0002     001005 LTB      0002     001007 LTBMZ    0002     001010 LTB2MZ   0006     003462 LTT
    0000 I 000026 M        0000 R 000000 MACHNO   0006 I 003460 MCVRD    0000 I 000017 MM       0002     001030 MM1
    0002     001033 MOD      0002     001025 MSTOTR   0000 R 000002 MWT      0002 I 000777 MZ       0003 I 001130 NA
    0002     001034 NCCZ     0002     001035 NCONV    0002     001002 NCTL     0002     001026 NCTM     0002     001023 NEQUS
    0002     001027 NM1      0000 I 000016 NN       0003 I 001131 NR       0002 I 001001 NRMP     0002     001020 NRMP1
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 0002   001022 NRMP2    0002   001000 NRTB     0002   001021 NRTB1    0004 I 000004 NSRAD    0000 R 000001 NUS1
 0002 I 000776 NX       0002   001063 PHIF     0002   001062 PHIM     0002   001071 PI       0002   001065 PO
 0002   001102 QREF     0002   000360 QRFN     0002   000524 QRMP     0002   001074 RDTWRT   0000 R 000031 RECFAC
 0000 R 000037 REFCP    0000 R 000032 REFENT   0000 R 000023 REFGAM   0000 R 000036 REFK     0000 R 000022 REFPR
 0000 R 000041 REFRHO   0000 R 000003 REFT     0000 R 000033 REFTP    0000 R 000035 REFVIS   0002   001114 RHOFN
 0002   001067 RHOO     0002   001073 RLIMIT   0002   001100 RTEND    0007   000003 R1       0007   000000 R2
 0004   000005 SMPC     0006   003473 SS       0006   003670 SSTT     0004 R 000000 STAGX    0004 R 000006 ST4
 0007   000001 T        0003 R 000000 TA       0005 R 000002 TATM     0002 R 000132 TEMP     0000 R 000052 TFIN
 0004   000005 THICK    0002   001077 TI       0002 R 001064 TIN      0002   001076 TINTL    0000 R 000044 TMET
 0000 R 000034 TMK      0002 R 000276 TMP      0000 R 000027 TMPE     0013 R 000000 TNH      0003 R 000144 TR
 0002   001075 TREF     0006   000000 TRMTX    0002   000050 TW       0002   001064 TO       0003 R 000620 VELA
 0003 R 000764 VELR     0005 R 000001 VELS     0004 R 000001 VERTX    0002   001066 WO       0002   000536 XIFN
 0002   000005 XIMP     0002   000000 XITB     0002   001106 XL       0002   001054 XRE      0007 R 000004 XSPM
 0000 R 000046 XXX      0002   001057 XX10     0002   001060 XX11     0002   001061 XX12     0006   003446 XX2
 0002   001055 XX3      0002   001056 XX4      0000 R 000047 YYY      0000 R 000040 Z        0002   000550 ZETA
 0000 R 000055 ZZZ      0006   003453 ZZ2


00101      1*            SUBROUTINE CONVEC (TIME)
00101      2*      C
00101      3*      C   THIS SUBROUTINE COMPUTES :
00101      4*      C     CONVECTIVE HEAT FLUX ON THE RADIATOR SYSTEM OF THE SHUTTLE
00101      5*      C     DURING EITHER ASCENT OR REENTRY
00101      6*      C
00103      7*            COMMON XITB(5),XIMP(5),FP(10),FW(10),FT(10),TW(10,5),TEMP(10,10),
00103      8*           1        TMP(10,5),QRFN(10,10),QRMP(10),XIFN(10),ZETA(10),AUX2(10),
00103      9*           2        CONFN(10,10),CONMP(10),COB(10),DOB(10)
00104     10*            COMMON NX,MZ,NRTB,NRMP,NCTL,IFLOW,LT,LTB,LMP,LTBMZ,LTB2MZ,LL1,
00104     11*           1       LL2,LL3,LL4,LL5,LL6,LL7,NRMP1,NRTB1,NRMP2,NEQUS,LC,MSTOTR,
00104     12*           2       NCTM,NM1,MM1,LIMWRT,LIM,MOD,NCCZ,NCONV
00105     13*            COMMON FRE,FR,FNU,FMACH,FPR,FRL,FRM,FFO,FOF,FZ,FRAD,DZ,DXITB,DXIMP
00105     14*           1        ,XRE,XX3,XX4,XX10,XX11,XX12,PHIM,PHIF,TO,PO,WO,RHOO,CPO,PI
00105     15*           2        ,DELTA,RLIMIT,RDTWRT,TREF,TINTL,TI,RTEND,FLUX,QREF,FENTH,
00105     16*           3        FREJ,HFN,XL,COH,DXI,FRD,FXOH,FXHW,RHOFN
00106     17*            COMMON/VELALT/TA(100),TR(100),ALTA(100),ALTR(100),VELA(100),
00106     18*           1             VELR(100),NA,NR
00107     19*            COMMON/CNV/STAGX,VERTX,IOPTN,DX,NSRAD,SMPC,ST4,COEFF
00110     20*            COMMON /SRTCNV/ ELEV,VELS,TATM
00111     21*            COMMON /QRD/ TRMTX(30,60),EBFN(5,5),EBMP(5),XX2(5),ZZ2(5),
00111     22*           1            MCVRD,LCT,LTT,DZMFN,
00111     23*           2            DXX2,CSF,EXTSFN,EXTIFN,EXTSMP,EXTIMP,DXX21,SS(5,5,5)
00111     24*           3            ,SSTT(5,5)
00112     25*            COMMON /SSF/R2, T, ALPFN,R1,XSPM
00113     26*            EQUIVALENCE (SMPC,THICK),(TIN,TO),(AL,HFN)
00114     27*            REAL MACHNO,NUS1,MWT
00115     28*            DIMENSION REFT (11)
00116     29*            ELEV   = ALTVEL(TIME,IOPTN,ALTA,ALTR,TA,TR,NA,NR)
00117     30*            IF (ELEV .LT. 528000.)  GO TO  5
00121     31*            DO 2 NN = 1,NX
00124     32*            DO 2 MM = 1,MZ
00127     33*            CONMP(MM)     =  0.0
00130     34*          2 CONFN(MM,NN)  =  0.0
00133     35*            RETURN
00134     36*          5 VELS   = ALTVEL(TIME,IOPTN,VELA,VELR,TA,TR,NA,NR)
00135     37*            CALL ATMOS (ELEV,TATM,CATM)
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      ENTATM  =  ENTAIR(TATM)
   20 MACHNO =  VELS/CATM
      REFPR   =  0.72
      REFGAM  =  1.3
      II      = MZ/2
      JJ      =  NX/2
      M      =  1
      TMPE    =  TEMP(II,JJ)*TIN
      ENTFN   =  ENTAIR(TMPE)
   31 RECFAC =  REFPR**((8.0+0.528*MACHNO**2)/(22.0+MACHNO**2))
   33 REFENT  =  0.5*(ENTATM+ENTFN)+0.11*RECFAC*
     1           (REFGAM-1.0)*MACHNO**2*ENTATM
      REFT(M) =  TNH(REFENT)
      REFTP   =  REFT(M)
      TMK    =  REFTP/1.8
      REFVIS =  ((1.458E-06*TMK**1.5)/(TMK+110.4))*0.671969
      REFK   = ((6.325E-07*TMK**1.5)/(TMK+245.4*10.0**(-12.0/TMK)))
     1          *0.671969
      REFCP   =  CPAIR(REFTP)
      REFPR  =  REFVIS*REFCP/REFK
      IF (ELEV .GT. 301000.)  GO TO 35
      REFGAM  =  REFCP/(REFCP-0.0686)
      GO TO 37
   35 Z      =  ELEV/(3280.8399)
      MWT    =  28.9644-0.0309491*(Z-90.0)
      REFGAM  =  REFCP/(REFCP-(1.98585/MWT))
   37 IF (M .EQ. 1)  GO TO 47
      IF (ABS(REFT(M)-REFT(M-1)) .LE. 5.0)  GO TO 51
   47 M      =  M+1
      IF (M .GT. 10) GO TO  51
      GO TO 31
   51 CONTINUE
      CALL REFP (ELEV,REFTP,REFPR,REFVIS,REFRHO,REFK,REFCP,
     1           REFGAM)
      ENTAW   =  ENTATM+RECFAC*VELS**2/50062.744
      CALL NUS(MACHNO,TATM,CATM,TIN,REFPR,REFVIS,REFRHO,
     1         STAGX,VERTX,NSRAD,NUS1)
      COEF    =  (3600.*REFK)/(STAGX*REFCP)
C
C DETERMINATION OF CONVECTION LOSS FROM METEOROID PROTECTION NODES
C
      TMET    = TMP(II,NRMP)*TIN
      CPMP    = CPAIR(TMET)
      XXX     =  COEF*NUS1
      YYY    =  CPMP*TIN
      DO 80 J = 1,MZ
   80 CONMP(J)  =  XXX*(ENTAW-YYY*TMP(J,NRMP))/(ST4*2.)
C
C DE3ERMINATION OF FRACTION OF FIN NODES COVERED BY PROTECTION LAYER
C
      IF (MCVRD .EQ. 0)  GO TO 150
      DO 140 I = 1,MCVRD
      DO 140 J = 1,MZ
  140 CONFN(J,I)  =  0.0
  150 DO 160 J = 1,MZ
      TFIN    =  TEMP(J,MCVRD+1)*TIN
      ENTFN   =  ENTAIR(TFIN)
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00235     95*       160 CONFN(J,MCVRD+1)  =  XSPM*COEF*NUS1*(ENTAW-ENTFN)/ST4
00237     96*           L        =  MCVRD+2
00237     97*     C
00237     98*     C DETERMINATION OF CONVECTION LOSS FROM FIN NODES
00237     99*     C
00240    100*           CPFIN  =  CPAIR(TMPE)
00241    101*           ZZZ    =  CPFIN*TIN
00242    102*           DO 180 I = L,NX
00245    103*           DO 180 J = 1,MZ
00250    104*       180 CONFN(J,I)  =  XXX*(ENTAW-ZZZ*TEMP(J,I))/ST4
00253    105*      1000 RETURN
00254    106*           END

      END OF COMPILATION:        NO  DIAGNOSTICS.


@HDG,P  ******  CPAIR  ******
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```
****** CPAIR ******                                                                          CATE 071372        PAGE     1

 @FOR,S ME*NASA5.CPAIR,ME*NASA5.CPAIR
 FOR S9A-07/13/72-20:54:38 (0,)

    FUNCTION CPAIR       ENTRY POINT 000074

    STORAGE USED: CODE(1) 000110; DATA(0) 000035; BLANK COMMON(2) 000000

    EXTERNAL REFERENCES (BLOCK, NAME)

     0003   POLY
     0004   SQRT
     0005   NERR3$

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

     0001    000054 10L      0001    000016 5L       0000 R 000001 A        0000 R 000000 CPAIR     0000 R 000012 CPN
     0000 R 000013 CPO       0000 R 000007 FMN       0000 R 000006 FMO      0000   000027 INJP$     0003 R 000000 POLY
     0000 R 000011 WMN       0000 R 000010 WMO


 00101      1*           FUNCTION CPAIR(T)
 00101      2*     C
 00101      3*     C        THIS FUNCTION SUBPROGRAM COMPUTES :
 00101      4*     C        THE SPECIFIC HEAT OF AIR /S A FUNCTION OF TEMPERATURE (R)
 00101      5*     C                                   UNITS BTU/(LBM.R)
 00101      6*     C
 00103      7*           DIMENSION A(5)
 00104      8*           DATA FMO,FMN,WMO,WMN / 0.234559 ,0.765441,31.9988,28.0134/
 00111      9*           DATA A(1),A(2),A(3),A(4),A(5)/0.34240E+00,-0.95225E-03,
 00111     10*          1      0.31862E-05,-0.45750E-08,0.23750E-11/
 00117     11*           IF (T .GT. 600.) GO TO 5
 00121     12*           CPAIR   =  POLY (5,A,T)
 00122     13*           RETURN
 00123     14*         5 CPN     =  9.47-3470./T+1160000./T**2
 00124     15*           CPO     =  11.151-172./SQRT(T)+1530./T
 00125     16*           IF (T .LT. 5000.) GO TO 10
 00127     17*           CPO     =  CPO+5.0E-05*(T-4000.)
 00130     18*        10 CPAIR   =  FMO*CPO/WMO+FMN*CPN/WMN
 00131     19*           RETURN
 00132     20*           END

      END OF COMPILATION:        NO  DIAGNOSTICS.


 @HDG,P  ******  CPF/CFFC43  ******
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```
******  CPF/CFFC43  ******                                                                      DATE 071372      PAGE    1

@FOR,S ME*NASA5.CPF/CFFC43,ME*NASA5.CPF/CFFC43
FOR S9A-07/13/72-20:54:41 (0,)

   FUNCTION CPF           ENTRY POINT 000014

   STORAGE USED: CODE(1) 000016; DATA(0) 000011; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   NERR3$

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

    0000 R 000000 CPF       0000   000004 INJP$     0000 R 000001 X1       0000 R 000002 X2


00101       1*           FUNCTION CPF(RHO,T)
00101       2*      C
00101       3*      C       THIS FUNCTION SUBPROGRAM COMPUTES :
00101       4*      C       SPECIFIC HEAT AT CONSTANT PRESSURE AS A FONCTION OF
00101       5*      C            DENSITY (SLUG/CU.FT) AND TEMPERATURE (R) OF FC-43
00101       6*      C                                 UNITS BTU/(SLUG.R)
00101       7*      C
00103       8*           DATA X1,X2 /-0.020092,5.4054E-04/
00106       9*           CPF = (X1+X2*T)*32.174
00107      10*           RETURN
00110      11*           END
      END OF COMPILATION:        NO  DIAGNOSTICS.


@HDG,P  ******  CPF/CFFC75  ******
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******  CPF/CFFC75  ******                                                           DATE 071372        PAGE     1

@FOR,S ME*NASA5.CPF/CFFC75,ME*NASA5.CPF/CFFC75
FOR S9A-07/13/72-20:54:43 (0,)

   FUNCTION CPF          ENTRY POINT 000014

   STORAGE USED: CODE(1) 000016; DATA(0) 000011; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   NERR3$

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

    0000 R 000000 CPF        0000    000004 INJP$     0000 R 000001 X1        0000 R 000002 X2


00101       1*             FUNCTION CPF(RHO,T)
00101       2*      C
00101       3*      C         THIS FUNCTION SUBPROGRAM COMPUTES :
00101       4*      C         SPECIFIC HEAT AT CONSTANT PRESSURE AS A FONCTION OF
00101       5*      C              DENSITY (SLUG/CU.FT) AND TEMPERATURE (R) OF FC-75
00101       6*      C                                  UNITS BTU/(SLUG.R)
00101       7*      C
00103       8*             DATA X1,X2 /0.115082,2.4333E-04/
00106       9*             CPF = (X1+X2*T)*32.174
00107      10*             RETURN
00110      11*             END

      END OF COMPILATION:        NO  DIAGNOSTICS.


@HDG,P  ******  CPF/CFHE  ******
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****** CPF/CFHE ******                                                                      DATE 071372        PAGE    1

@FOR,S ME*NASA5.CPF/CFHE,ME*NASA5.CPF/CFHE
FOR S9A-07/13/72-20:54:45 (0,)

   FUNCTION CPF        ENTRY POINT 000057

   STORAGE USED: CODE(1) 000071; DATA(0) 000031; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   BETA
    0004   CAPPA
    0005   NERR3$

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

    0000 R 000005 A        0000 R 000010 ALPHA     0000 R 000002 A1       0003 R 000000 BETA      0000 R 000003 B1
    0000 R 000004 C        0004 R 000000 CAPPA     0000 R 000000 CPF      0000 R 000011 CV        0000   000024 INJP$
    0000 R 000001 R        0000 R 000006 RHOX      0000 R 000007 TX       0000 R 000012 X1


00101      1*          FUNCTION CPF(RHO,T)
00101      2*     C
00101      3*     C       THIS FUNCTION SUBPROGRAM COMPUTES :
00101      4*     C       SPECIFIC HEAT AT CONSTANT PRESSURE AS A FUNCTION OF
00101      5*     C            DENSITY (SLUG/CU.FT) AND TEMPERATURE (R) OF HELIUM
00101      6*     C                                UNITS BTU/(SLUG.R)
00101      7*     C
00103      8*          DATA R,A1,B1,C,A /2077.02,136.9595,3.5002295E-03,10.000658,1.49610
00103      9*         13E-02/
00111     10*          RHOX  = RHO*515.4275
00112     11*          TX    = T/1.8
00113     12*          ALPHA = C*RHOX/(TX**3)
00114     13*          CV    = R*(1.5+6.0*ALPHA*(1.0+RHOX*B1*0.5))
00115     14*          X1    = BETA(RHO,T)*1.8
00116     15*          CPF   = (CV+(TX*X1*X1*47.872)/(RHOX*CAPPA(RHO,T)))*76.8624E-04
00117     16*          RETURN
00120     17*          END

       END OF COMPILATION:        NO  DIAGNOSTICS.


@HDG,P  ******  CPF/CFNAK  ******
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****** CPF/CFNAK ******                                                                          DATE 071372        PAGE      1

@FOR,S ME*NASA5.CPF/CFNAK,ME*NASA5.CPF/CFNAK
FOR S9A-07/13/72-20:54:47 (0,)

   FUNCTION CPF          ENTRY POINT 000071

   STORAGE USED: CODE(1) 000104; DATA(0) 000032; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   CAPPA
    0004   PF
    0005   ALOG
    0006   NERR3$

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

    0003 R 000000 CAPPA     0000 R 000014 CP        0000 R 000000 CPF       0000 R 000010 C1        0000 R 000011 C2
    0000 R 000007 DT        0000   000023 INJP$     0004 R 000000 PF        0000 R 000012 P0        0000 R 000016 P1
    0000 R 000013 THETA     0000 R 000015 TK        0000 R 000006 T0        0000 R 000001 X1        0000 R 000002 X2
    0000 R 000003 X3        0000 R 000004 X4        0000 R 000005 X5


00101      1*           FUNCTION CPF(RHO,T)
00101      2*      C
00101      3*      C       THIS FUNCTION SUBPROGRAM COMPUTES :
00101      4*      C       SPECIFIC HEAT AT CONSTANT PRESSURE AS A FUNCTION OF
00101      5*      C            DENSITY (SLUG/CU.FT) AND TEMPERATURE (R) OF NAK 78.6
00101      6*      C                                    UNITS BTU/(SLUG.R)
00101      7*      C
00103      8*           DATA X1,X2,X3,X4,X5 /0.2255,-0.016292,0.005396,-0.000758,0.000054/
00103      9*          1,T0,DT /659.67,300.0/,C1,C2 /58.773064,-0.008433/,P0 /2116.224/
00116     10*           THETA = (T-T0)/DT
00117     11*           CP    = ((((X5*THETA+X4)*THETA+X3)*THETA+X2)*THETA+X1
00120     12*           TK    = CAPPA(RHO,T)
00121     13*           P1    = PF(RHO,T)-P0
00122     14*           CPF   = (CP-(2.0*T*C2*C2*ALOG(1.0+TK*P1))/(TK*778.26*(C1+C2*T)**3)
00122     15*          1)*32.174
00123     16*           RETURN
00124     17*           END

      END OF COMPILATION:       NO  DIAGNOSTICS.


@HDG,P ****** CPF/CFSIL ******
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****** CPF/CFSIL ******                                                                     DATE 071372      PAGE    1

@FOR,S ME*NASA5.CPF/CFSIL,ME*NASA5.CPF/CFSIL
FOR S9A-07/13/72-20:54:50 (0,)

   FUNCTION CPF          ENTRY POINT 000350

   STORAGE USED: CODE(1) 000372; DATA(0) 000133; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   PF
    0004   POLY
    0005   NWDU$
    0006   NI02$
    0007   NERR3$

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

    0000   000055 1F        0000 R 000040 A       0000 R 000007 A1      0000 R 000041 A11     0000 R 000010 A2
    0000 R 000042 A22       0000 R 000011 A3      0000 R 000012 A4      0000 R 000013 A5      0000 R 000043 B
    0000 R 000014 B1        0000 R 000044 B11     0000 R 000015 B2      0000 R 000045 B22     0000 R 000016 B3
    0000 R 000017 B4        0000 R 000020 B5      0000 R 000046 C       0000 R 000037 CP      0000 R 000000 CPF
    0000 R 000021 C1        0000 R 000047 C11     0000 R 000022 C2      0000 R 000025 DT      0000 R 000033 DT2
    0000 R 000050 E1        0000 R 000051 E2      0000 R 000052 E3      0000 R 000054 FP      0000   000113 INJP$
    0000 R 000053 P         0003 R 000000 PF      0004 R 000000 POLY    0000 R 000034 THETA   0000 R 000035 THETA1
    0000 R 000036 THETA2    0000 R 000023 T0      0000 R 000024 T01     0000 R 000032 T02     0000 R 000026 X1
    0000 R 000027 X2        0000 R 000030 X3      0000 R 000031 X4      0000 R 000001 Z


 00101      1*          FUNCTION CPF(RHO,T)
 00101      2*     C
 00101      3*     C       THIS FUNCTION SUBPROGRAM COMPUTES :
 00101      4*     C       SPECIFIC HEAT AS A FUNCTION OF DENSITY (SLUG/CU.FT) AND
 00101      5*     C            TEMPERATURE (R) OF DOW CORNING 200 SILICON OIL (1 CS)
 00101      6*     C                                UNITS BTU/(SLUG.R)
 00101      7*     C            TEMPERATURE .GE. 359.67 AND .LE. 859.67
 00101      8*     C
 00103      9*          DIMENSION Z(6)
 00104     10*          DATA A1,A2,A3,A4,A5 /12.35,2.98333,1.1,-0.48333,0.1/,B1,B2,B3,B4,B
 00104     11*         15 /-1.5,-0.01333,-1.18,0.57333,-0.1/,C1,C2 /0.7767,-0.0288/,T0,T01
 00104     12*         2,DT /559.67,609.67,50.0/,X1,X2,X3,X4 /0.46,0.00471,0.00141,0.00004
 00104     13*         33/,T02,DT2 /539.67,80.0/
 00132     14*          THETA  = (T-T0)/DT
 00133     15*          THETA1 = (T-T01)/DT
 00134     16*          THETA2 = (T-T02)/DT2
 00135     17*          CP   = ((X4*THETA2+X3)*THETA2+X2)*THETA2+X1
 00136     18*          A    = ((((A5*THETA+A4)*THETA+A3)*THETA+A2)*THETA+A1)*1.0E-06
 00137     19*          A11 = (((4.0*A5*THETA+3.0*A4)*THETA+2.0*A3)*THETA+A2)*(1.0E-06)/DT
 00140     20*          A22 = ((12.0*A5*THETA+6.0*A4)*THETA+2.0*A3)*(1.0E-06)/(DT*DT)
 00141     21*          B    = ((((B5*THETA+B4)*THETA+B3)*THETA+B2)*THETA+B1)*1.0E-09
 00142     22*          B11 = (((4.0*B5*THETA+3.0*B4)*THETA+2.0*B3)*THETA+B2)*(1.0E-09)/DT
 00143     23*          B22 = ((12.0*B5*THETA+6.0*B4)*THETA+2.0*B3)*(1.0E-09)/(DT*DT)
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      C   = C1+C2*THETA1
      C11 = C2/DT
      E1  = A11*A11-B22/2.0+B11*C11/C
      E2  = 2.0*A11*C11/C-A22
      E3  = A*A-B
      P   = PF(RHO,T)/144.0-14.696
      Z(1)  = 0.0
      Z(2)  = 2.0*(C11/C)**2
      Z(3)  = (E2-A*Z(2))/2.0
      Z(4)  = (E1-A*E2+E3*Z(2)/2.0)/3.0
      Z(5)  = (A11*B11-A*E1+E3*E2/2.0+A*B*Z(2)/2.0)/4.0
      Z(6)  = (B11*B11/2.0-2.0*A*A11*B11+E1*E3+A*B*E2+B*B*Z(2)/2.0)/10.0
      FP  = POLY(6,Z,P)
      CPF = (CP-T*FP/(C*337.37))*32.174
      IF (T.GE.360.67.AND.T.LE.860.67) RETURN
      WRITE (6,1) T
    1 FORMAT (1H0,54HSPECIFIC HEAT OF SILICON OIL, TEMP. OUT OF RANGE, T
     1 = ,F8.3,/)
      RETURN
      END
```

END OF COMPILATION: NO DIAGNOSTICS.

@HDG,P ****** CPFN/FNAL ******

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******  CPFN/FNAL  ******                                                          DATE 071372        PAGE      1

@FOR,S ME*NASA5.CPFN/FNAL,ME*NASA5.CPFN/FNAL
FOR S9A-07/13/72-20:54:54 (0,)

   FUNCTION CPFN        ENTRY POINT 000056

   STORAGE USED: CODE(1) 000062; DATA(0) 000040; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   NWDU$
    0004   NIO2$
    0005   NERR3$

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

    0000   000012 1F        0000 R 000011 CP        0000 R 000000 CPFN      0000 R 000007 DT        0000   000032 INJP$
    0000 R 000010 THETA     0000 R 000006 T0        0000 R 000001 X1        0000 R 000002 X2        0000 R 000003 X3
    0000 R 000004 X4        0000 R 000005 X5


00101      1*            FUNCTION CPFN(T)
00101      2*      C
00101      3*      C        THIS FUNCTION SUBPROGRAM COMPUTES :
00101      4*      C        SPECIFIC HEAT AS A FUNCTION OF TEMPERATURE (R) OF ALUMINUM 7075
00101      5*      C                                  UNITS BTU/(SLUG.R)
00101      6*      C             TEMP. GE. 300.0.AND.LE. 1200.0 R
00101      7*      C
00103      8*            DATA X1,X2,X3,X4,X5 /0.182,0.03616,-0.011417,0.00233,-0.000083/,T0
00103      9*           1,DT /400.0,200.0/
00113     10*            THETA = (T-T0)/DT
00114     11*            CP = (((X5*THETA+X4)*THETA+X3)*THETA+X2)*THETA+X1
00115     12*            CPFN = CP*32.174
00116     13*            IF (T.GE.300.0.AND.T.LE.1200.0) RETURN
00120     14*            WRITE (6,1) T
00123     15*          1 FORMAT (1H0,51HSPECIFIC HEAT OF ALUMINUM, TEMP. OUT OF RANGE, T =
00123     16*           1,F8.3,/)
00124     17*            RETURN
00125     18*            END

     END OF COMPILATION:        NO  DIAGNOSTICS.


@HDG,P  ******  CPFN/FNBR  ******
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****** CPFN/FNBR ******                                                              DATE 071372      PAGE    1

@FOR,S ME*NASA5.CPFN/FNBR,ME*NASA5.CPFN/FNBR
FOR S9A-07/13/72-20:54:57 (0,)

   FUNCTION CPFN        ENTRY POINT 000054

   STORAGE USED: CODE(1) 000060; DATA(0) 000037; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   NWDU$
    0004   NIO2$
    0005   NERR3$

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

    0000   000011 1F        0000 R 000010 CP        0000 R 000000 CPFN      0000 R 000006 DT        0000   000031 INJP$
    0000 R 000007 THETA     0000 R 000005 T0        0000 R 000001 X1        0000 R 000002 X2        0000 R 000003 X3
    0000 R 000004 X4


00101      1*           FUNCTION CPFN(T)
00101      2*     C
00101      3*     C        THIS FUNCTION SUBPROGRAM COMPUTES :
00101      4*     C        SPECIFIC HEAT AS A FUNCTION OF TEMPERATURE (R) OF BERYLIUM WITH
00101      5*     C             0.84-1.68 BEO
00101      6*     C                                        UNITS BTU/(SLUG.R)
00101      7*     C             TEMP. GE. 400.0 AND LE. 1700.0 R
00101      8*     C
00103      9*           DATA X1,X2,X3,X4 /0.536,0.05667,-0.0085,0.00083/,T0,DT /800.,200./
00112     10*           THETA = (T-T0)/DT
00113     11*           CP = ((X4*THETA+X3)*THETA+X2)*THETA+X1
00114     12*           CPFN = CP*32.174
00115     13*           IF (T.GE.400.0.AND.T.LE.1700.0) RETURN
00117     14*           WRITE (6,1) T
00122     15*         1 FORMAT (1H0,51HSPECIFIC HEAT OF BERYLIUM= TEMP. OUT OF RANGE, T =
00122     16*          1,F8.3,/)
00123     17*           RETURN
00124     18*           END

       END OF COMPILATION:        NO  DIAGNOSTICS.


@HDG,P ****** CPFN/FNCU ******
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****** CPFN/FNCU ******                                                                                  DATE 071372        PAGE    1

@FOR,S ME*NASA5.CPFN/FNCU,ME*NASA5.CPFN/FNCU
FOR S9A-07/13/72-20:54:59 (0,)

   FUNCTION CPFN        ENTRY POINT 000045

   STORAGE USED: CODE(1) 000051; DATA(0) 000031; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   NWDU$
    0004   NIO2$
    0005   NERR3$

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

    0000    000004 1F        0000 R 000003 CP        0000 R 000000 CPFN      0000    000023 INJP$     0000 R 000001 X1
    0000 R 000002 X2


00101      1*          FUNCTION CPFN(T)
00101      2*     C
00101      3*     C       THIS FUNCTION SUBPROGRAM COMPUTES :
00101      4*     C       SPECIFIC HEAT AS A FUNCTION OF TEMPERATURE (R) OF COPPER
00101      5*     C                                      UNITS BTU/(SLUG.R)
00101      6*     C            TEMP. GE. 400.0 AND LE. 1800.0 R
00101      7*     C
00103      8*          DATA X1,X2 /0.08375,1.375E-05/
00106      9*          CP = X2*T+X1
00107     10*          CPFN = CP*32.174
00110     11*          IF (T.GE.400.0.AND.T.LE.1800.0) RETURN
00112     12*          WRITE (6,1) T
00115     13*        1 FORMAT (1H0,49HSPECIFIC HEAT OF COPPER, TEMP. OUT OF RANGE, T = ,
00115     14*         1F8.3,/)
00116     15*          RETURN
00117     16*          END

      END OF COMPILATION:        NO  DIAGNOSTICS.


@HDG,P  ******  CPMP/MPAL  ******
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****** CPMP/MPAL ******                                                              DATE 071372      PAGE    1

@FOR,S ME*NASA5.CPMP/MPAL,ME*NASA5.CPMP/MPAL
FOR S9A-07/13/72-20:55:01 (0,)

   FUNCTION CPMP         ENTRY POINT 000056

   STORAGE USED: CODE(1) 000062; DATA(0) 000040; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   NWDU$
    0004   NIO2$
    0005   NERR3$

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

    0000    000012 1F        0000 R 000011 CP        0000 R 000000 CPMP      0000 R 000007 DT        0000    000032 INJP$
    0000 R 000010 THETA      0000 R 000006 T0        0000 R 000001 X1        0000 R 000002 X2        0000 R 000003 X3

        R                        R
    0000   00000  X          0000   00000  X
                4  4                      5  5

00101      1*           FUNCTION CPMP(T)
00101      2*      C
00101      3*      C       THIS FUNCTION SUBPROGRAM COMPUTES :
00101      4*      C       SPECIFIC HEAT AS A FUNCTION OF TEMPERATURE (R) OF ALUMINUM 7075
00101      5*      C                                    UNITS BTU/(SLUG.R)
00101      6*      C            TEMP. GE. 300.0.AND.LE. 1200.0 R
00101      7*      C
00103      8*           DATA X1,X2,X3,X4,X5 /0.182,0.03616,-0.011417,0.00233,-0.000083/,T0
00103      9*          1,DT /400.0,200.0/
00113     10*           THETA = (T-T0)/DT
00114     11*           CP = (((X5*THETA+X4)*THETA+X3)*THETA+X2)*THETA+X1
00115     12*           CPMP = CP*32.174
00116     13*           IF (T.GE.300.0.AND.T.LE.1200.0) RETURN
00120     14*           WRITE (6,1) T
00123     15*         1 FORMAT (1H0,51HSPECIFIC HEAT OF ALUMINUM, TEMP. OUT OF RANGE, T =
00123     16*          1,F8.3,/)
00124     17*           RETURN
00125     18*           END

     END OF COMPILATION:        NO  DIAGNOSTICS.

@HDG,P ****** CPMP/MPBR ******
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```
@FOR,S ME*NASA5.CPMP/MPBR,ME*NASA5.CPMP/MPBR
FOR S9A-07/13/72-20:55:03 (0,)

   FUNCTION CPMP        ENTRY POINT 000054

   STORAGE USED: CODE(1) 000060; DATA(0) 000037; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   NWDU$
    0004   NIO2$
    0005   NERR3$

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

    0000   000011 1F       0000 R 000010 CP      0000 R 000000 CPMP     0000 R 000006 DT     0000   000031 INJP$
    0000 R 000007 THETA    0000 R 000005 T0      0000 R 000001 X1       0000 R 000002 X2     0000 R 000003 X3
    0000 R 000004 X4


 00101      1*          FUNCTION CPMP(T)
 00101      2*     C
 00101      3*     C       THIS FUNCTION SUBPROGRAM COMPUTES :
 00101      4*     C       SPECIFIC HEAT AS A FUNCTION OF TEMPERATURE (R) OF BERYLIUM WITH
 00101      5*     C            0.84-1.68 BEO
 00101      6*     C                                    UNITS BTU/(SLUG.R)
 00101      7*     C            TEMP. GE. 400.0 AND LE. 1700.0 R
 00101      8*     C
 00103      9*          DATA X1,X2,X3,X4 /0.536,0.05667,-0.0085,0.00083/,T0,DT /800.,200./
 00112     10*          THETA = (T-T0)/DT
 00113     11*          CP = ((X4*THETA+X3)*THETA+X2)*THETA+X1
 00114     12*          CPMP = CP*32.174
 00115     13*          IF (T.GE.400.0.AND.T.LE.1700.0) RETURN
 00117     14*          WRITE (6,1) T
 00122     15*        1 FORMAT (1H0,51HSPECIFIC HEAT OF BERYLIUM= TEMP. OUT OF RANGE, T =
 00122     16*         1,F8.3,/)
 00123     17*          RETURN
 00124     18*          END

      END OF COMPILATION:        NO  DIAGNOSTICS.


 @HDG,P  ******  CPMP/MPCU  ******
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```
@FOR,S ME*NASA5.CPMP/MPCU,ME*NASA5.CPMP/MPCU
FOR S9A-07/13/72-20:55:06 (0,)

   FUNCTION CPMP        ENTRY POINT 000045

   STORAGE USED: CODE(1) 000051; DATA(0) 000031; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   NWDU$
    0004   NIO2$
    0005   NERR3$

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

    0000   000004 1F        0000 R 000003 CP        0000 R 000000 CPMP      0000   000023 INJP$     0000 R 000001 X1
    0000 R 000002 X2


00101      1*            FUNCTION CPMP(T)
00101      2*      C
00101      3*      C        THIS FUNCTION SUBPROGRAM COMPUTES :
00101      4*      C        SPECIFIC HEAT AS A FUNCTION OF TEMPERATURE (R) OF COPPER
00101      5*      C                                  UNITS BTU/(SLUG.R)
00101      6*      C             TEMP. GE. 400.0 AND LE. 1800.0 R
00101      7*      C
00103      8*            DATA X1,X2 /0.08375,1.375E-05/
00106      9*            CP = X2*T+X1
00107     10*            CPMP = CP*32.174
00110     11*            IF (T.GE.400.0.AND.T.LE.1800.0) RETURN
00112     12*            WRITE (6,1) T
00115     13*          1 FORMAT (1H0,49HSPECIFIC HEAT OF COPPER, TEMP. OUT OF RANGE, T = ,
00115     14*           1F8.3,/)
00116     15*            RETURN
00117     16*            END

       END OF COMPILATION:       NO  DIAGNOSTICS.


@HDG,P  ******  CPTB/TBAL  ******
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****** CPTB/TBAL ******                                                                          DATE 071372        PAGE    1

@FOR,S ME*NASA5.CPTB/TBAL,ME*NASA5.CPTB/TBAL
FOR S9A-07/13/72-20:55:08 (0,)

   FUNCTION CPTB       ENTRY POINT 000056

   STORAGE USED: CODE(1) 000062; DATA(0) 000040; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   NWDU$
    0004   NI02$
    0005   NERR3$

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

    0000   000012 1F       0000 R 000011 CP       0000 R 000000 CPTB      0000 R 000007 DT      0000   000032 INJP$
    0000 R 000010 THETA    0000 R 000006 T0       0000 R 000001 X1        0000 R 000002 X2      0000 R 000003 X3
    0000 R 000004 X4       0000 R 000005 X5


00101      1*          FUNCTION CPTB(T)
00101      2*     C
00101      3*     C       THIS FUNCTION SUBPROGRAM COMPUTES :
00101      4*     C       SPECIFIC HEAT AS A FUNCTION OF TEMPERATURE (R) OF ALUMINUM 7075
00101      5*     C                                 UNITS BTU/(SLUG,R)
00101      6*     C            TEMP. GE. 300.0.AND.LE. 1200.0 R
00101      7*     C
00103      8*          DATA X1,X2,X3,X4,X5 /0.182,0.03616,-0.011417,0.00233,-0.000083/,T0
00103      9*         1,DT /400.0,200.0/
00113     10*          THETA = (T-T0)/DT
00114     11*          CP = (((X5*THETA+X4)*THETA+X3)*THETA+X2)*THETA+X1
00115     12*          CPTB = CP*32.174
00116     13*          IF (T.GE.300.0.AND.T.LE.1200.0) RETURN
00120     14*          WRITE (6,1) T
00123     15*        1 FORMAT (1H0,51HSPECIFIC HEAT OF ALUMINUM, TEMP. OUT OF RANGE, T =
00123     16*         1,F8.3,/)
00124     17*          RETURN
00125     18*          END

      END OF COMPILATION:        NO  DIAGNOSTICS.


@HDG,P  ******  CPTB/TBBR  ******
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****** CPTB/TBBR ******                                                           DATE 071372        PAGE     1

@FOR,S ME*NASA5.CPTB/TBBR,ME*NASA5.CPTB/TBBR
FOR S9A-07/13/72-20:55:10 (0,)

   FUNCTION CPTB        ENTRY POINT 000054

   STORAGE USED: CODE(1) 000060; DATA(0) 000037; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   NWDU$
    0004   NIO2$
    0005   NERR3$

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

    0000   000011 1F        0000 R 000010 CP       0000 R 000000 CPTB     0000 R 000006 DT       0000   000031 INJP$
    0000 R 000007 THETA     0000 R 000005 T0       0000 R 000001 X1       0000 R 000002 X2       0000 R 000003 X3
    0000 R 000004 X4


00101      1*             FUNCTION CPTB(T)
00101      2*       C
00101      3*       C        THIS FUNCTION SUBPROGRAM COMPUTES :
00101      4*       C        SPECIFIC HEAT AS A FUNCTION OF TEMPERATURE (R) OF BERYLIUM WITH
00101      5*       C             0.84-1.68 BEO
00101      6*       C                                     UNITS BTU/(SLUG.R)
00101      7*       C             TEMP. GE. 400.0 AND LE. 1700.0 R
00101      8*       C
00103      9*             DATA X1,X2,X3,X4 /0.536,0.05667,-0.0085,0.00083/,T0,DT /800.,200./
00112     10*             THETA = (T-T0)/DT
00113     11*             CP = ((X4*THETA+X3)*THETA+X2)*THETA+X1
00114     12*             CPTB = CP*32.174
00115     13*             IF (T.GE.400.0.AND.T.LE.1700.0) RETURN
00117     14*             WRITE (6,1) T
00122     15*           1 FORMAT (1H0,51HSPECIFIC HEAT OF BERYLIUM= TEMP. OUT OF RANGE, T =
00122     16*            1,F8.3,/)
00123     17*             RETURN
00124     18*             END

      END OF COMPILATION:       NO  DIAGNOSTICS.


@HDG,P  ******  CPTB/TBCU  ******
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****** CPTB/TBCU ******                                                                          DATE 071372        PAGE     1

@FOR,S ME*NASA5.CPTB/TBCU,ME*NASA5.CPTB/TBCU
FOR S9A-07/13/72-20:55:13 (0,)

  FUNCTION CPTB       ENTRY POINT 000045

  STORAGE USED: CODE(1) 000051; DATA(0) 000031; BLANK COMMON(2) 000000

  EXTERNAL REFERENCES (BLOCK, NAME)

   0003   NWDU$
   0004   NIO2$
   0005   NERR3$

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

   0000   000004 1F       0000 R 000003 CP       0000 R 000000 CPTB      0000   000023 INJP$     0000 R 000001 X1
   0000 R 000002 X2



00101      1*             FUNCTION CPTB(T)
00101      2*      C
00101      3*      C         THIS FUNCTION SUBPROGRAM COMPUTES :
00101      4*      C         SPECIFIC HEAT AS A FUNCTION OF TEMPERATURE (R) OF COPPER
00101      5*      C                                        UNITS BTU/(SLUG.R)
00101      6*      C              TEMP. GE. 400.0 AND LE. 1800.0 R
00101      7*      C
00103      8*             DATA X1,X2 /0.08375,1.375E-05/
00106      9*             CP = X2*T+X1
00107     10*             CPTB = CP*32.174
00110     11*             IF (T.GE.400.0.AND.T.LE.1800.0) RETURN
00112     12*             WRITE (6,1) T
00115     13*           1 FORMAT (1H0,49HSPECIFIC HEAT OF COPPER, TEMP. OUT OF RANGE, T = ,
00115     14*           1F8.3,/)
00116     15*             RETURN
00117     16*             END
     END OF COMPILATION:       NO  DIAGNOSTICS.


@HDG,P ****** DDX ******
```

```
****** DDX ******                                                          DATE 071372        PAGE    1

@FOR,S ME*NASA5.DDX,ME*NASA5.DDX
FOR S9A-07/13/72-20:55:15 (0,)

   SUBROUTINE DDX       ENTRY POINT 000127

   STORAGE USED: CODE(1) 000153; DATA(0) 000046; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   NWDU$
    0004   NI02$
    0005   NERR3$

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

    0001   000061 112G      0001   000102 2L       0000   000003 3F       0000 R 000000 DX1       0000 I 000002 I
    0000   000016 INJP$     0000 I 000001 N1


00101       1*            SUBROUTINE DDX (Y,DY,DX,N)                                    1
00101       2*      C
00101       3*      C   THIS SUBROUTINE.COMPUTES :
00101       4*      C     THE FIRST DERIVATIVE OF THE EQUALLY-SPACED ARRAY Y(N)
00101       5*      C
00103       6*            DIMENSION Y(N),DY(N)                                          2
00104       7*            IF (N.LT.3) GO TO 2
00106       8*            DX1 = 2.0*DX                                                  5
00107       9*            DY(1) = (-3.0*Y(1)+4.0*Y(2)-Y(3))/DX1
00110      10*            N1 = N-1                                                      6
00111      11*            DO 1 I=2,N1                                                   7
00114      12*          1 DY(I) = (Y(I+1)-Y(I-1))/DX1                                   8
00116      13*            DY(N) = (Y(N-2)-4.0*Y(N-1)+3.0*Y(N))/DX1
00117      14*            RETURN                                                       10
00120      15*          2 WRITE (6,3)                                                  11
00122      16*          3 FORMAT (25HDDX NOT ENOUGH NODAL PTS.,/)                      12
00123      17*            RETURN                                                       13
00124      18*            END                                                          14

       END OF COMPILATION:       NO  DIAGNOSTICS.


@HDG,P  ******  DEFINT  ******
```

```
@FOR,S ME*NASA5.DEFINT,ME*NASA5.DEFINT
FOR S9A-07/13/72-20:55:18 (0,)

   FUNCTION DEFINT      ENTRY POINT 000203

   STORAGE USED: CODE(1) 000225; DATA(0) 000046; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   NERR3$

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

    0001   000166 10L       0001   000117 131G      0001   000126 136G      0001   000032 2L        0001   000054 4L
    0000 R 000000 DEFINT    0000   000024 INJP$     0000 I 000011 K         0000 I 000005 M         0000 I 000006 NC
    0000 I 000010 NEVE      0000 I 000007 NODD      0000 I 000003 N1        0000 I 000004 N2        0000 R 000001 SEVE
    0000 R 000002 SODD


00101         FUNCTION DEFINT(Y,DX,N)
00101       C
00101       C THIS FUNCTION SUBPROGRAM COMPUTES :
00101       C   THE DEFINITE INTEGRAL BY SIMPSONS RULE OF THE EQUALLY-SPACED
00101       C   ARRAY Y(N)
00101       C
00103         DIMENSION Y(N)
00104         IF(N-3)10,1,2
00107       1 DEFINT = (DX/3.)*(Y(1)+4.*Y(2)+Y(3))
00110         RETURN
00111       2 IF(N-4)10,3,4
00114       3 DEFINT = (3.*DX/8.)*(Y(1)+3.*(Y(2)+Y(3))+Y(4))
00115         RETURN
00116       4 SEVE = 0.
00117         SODD = 0.
00120         N1 = N/2
00121         N2 = 2*N1
00122         M  = N
00123         NC = M-N2
00124         IF(NC.EQ.0) M=N-1
00126         NODD = M-1
00127         NEVE = M-2
00130         DO 7 K=2,NODD,2
00133       7 SODD = SODD+Y(K)
00135         DO 8 K=3,NEVE,2
00140       8 SEVE = SEVE+Y(K)
00142         DEFINT=(DX/3.)*(Y(1)+Y(M)+4.*SODD+2.*SEVE)
00143         IF(NC)10,9,10
00146       9 DEFINT = DEFINT+(DX/24.)*(9.*Y(N)+19.*Y(N-1)-5.*Y(N-2)+Y(N-3))
00147      10 RETURN
00150         END
```

```
****** DEFINT ******
       END OF COMPILATION:        NO  DIAGNOSTICS.

@HDG.P  ******  DEFNT  ******
```

```
****** DEFNT ******                                                                                     DATE 071372        PAGE      1

@FOR,S ME*NASA5.DEFNT,ME*NASA5.DEFNT
FOR S9A-07/13/72-20:55:22 (0,)

   FUNCTION DEFNT       ENTRY POINT 000046

   STORAGE USED: CODE(1) 000060; DATA(0) 000023; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   NERR3$

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

    0001   000020 107G      0000 R 000000 DEFNT     0000 I 000003 I         0000   000007 INJP$     0000 I 000001 L1
    0000 R 000002 Z


00101           FUNCTION DEFNT(Y,DX,N)
00101        C
00101        C   THIS SUBROUTINE COMPUTES :
00101        C     THE DEFINITE INTEGRAL BY TRAPEZOIDAL RULE OF THE EQUALLY-SPACED
00101        C     ARRAY Y(N)
00101        C
00103              DIMENSION Y(N)
00104              L1    = N-1
00105              Z     = 0.0
00106              DO 5 I= 2,L1
00111            5 Z     = Z+Y(I)
00113              DEFNT = DX*(Y(1)+2.0*Z+Y(N))/2.0
00114              RETURN
00115              END

      END OF COMPILATION:        NO  DIAGNOSTICS.


@HDG,P  ******  DERIVL  ******
```

```
@FOR,S ME*NASA5.DERIVL,ME*NASA5.DERIVL
FOR S9A-07/13/72-20:55:25 (0,)

 SUBROUTINE DERIVL     ENTRY POINT 000245

  STORAGE USED: CODE(1) 000257; DATA(0) 000053; BLANK COMMON(2) 001115

   COMMON BLOCKS:

   0003    FLCMP  000024

  EXTERNAL REFERENCES (BLOCK, NAME)

   0004    RHOF
   0005    CAPPA
   0006    BETA
   0007    CPF
   0010    NERR2$
   0011    NERR3$

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

   0001     000177 10L       0001     000132 5L        0002     000562 AUX2      0000 R 000012 A11       0000 R 000013 A13
   0000 R 000017 A21       0000 R 000020 A23       0000 R 000014 A31       0000 R 000015 A32       0000 R 000016 A33
   0006 R 000000 BETA      0000 R 000021 B1        0000 R 000022 B2        0005 R 000000 CAPPA     0002     000752 COB
   0002     001107 COH       0002     000574 CONFN     0002     000740 CONMP     0007 R 000000 CPF       0002 R 001070 CP0
   0000 R 000023 C1        0000 R 000024 C2        0000 R 000025 C3        0002     001072 DELTA     0002     000764 DOB
   0003 R 000000 DTHETA    0002     001110 DXI       0002     001053 DXIMP     0002     001052 DXITB     0002     001051 DZ
   0002     001103 FENTH     0002     001045 FFO       0002     001101 FLUX      0002 R 001041 FMACH     0002 R 001040 FNU
   0002     001046 FOF       0002     000012 FP        0002 R 001042 FPR       0002 R 001037 FR        0002     001050 FRAD
   0002     001111 FRD       0002     001036 FRE       0002     001104 FREJ      0002     001043 FRL       0002     001044 FRM
   0002 R 000036 FT        0002     000024 FW        0002     001113 FXHW      0002     001112 FXOH      0002 R 001047 FZ
   0000 R 000010 GBETA     0000 R 000011 GCP       0000 R 000007 GKAPPA    0002     001105 HFN       0002 I 001003 IFLOW
   0000     000030 INJP$     0002     001024 LC        0002     001032 LIM       0002     001031 LIMWRT    0002     001011 LL1
   0002     001012 LL2       0002     001013 LL3       0002     001014 LL4       0002     001015 LL5       0002     001016 LL6
   0002     001017 LL7       0002     001006 LMP       0002     001004 LT        0002     001005 LTR       0002     001007 LTBMZ
   0002     001010 LTB2MZ    0002     001030 MM1       0002     001033 MOD       0002     001025 MSTOTR    0002     000777 MZ
   0002     001034 NCCZ      0002     001035 NCONV     0002 I 001002 NCTL      0002     001026 NCTM      0002     001023 NEQUS
   0002     001027 NM1       0002     001001 NRMP      0002     001020 NRMP1     0002     001022 NRMP2     0002     001000 NRTB
   0002     001021 NRTB1     0002     000776 NX        0000 R 000000 P         0002     001063 PHIF      0002     001062 PHIM
   0002     001071 PI        0000 R 000003 PP        0002 R 001065 PO        0002     001102 QREF      0002     000360 QRFN
   0002     000524 CRMP      0002     001074 RDTWRT    0000 R 000006 RHO       0004 R 000000 RHOF      0002     001114 RHOFN
   0002 R 001067 RHOO      0002     001073 RLIMIT    0000 R 000005 RRHO      0002     001100 RTEND     0000 R 000002 T
   0002     000132 TEMP      0002     001077 TI        0002     001076 TINTL     0002     000276 TMP       0002     001075 TREF
   0000 R 000004 TT        0002 R 000050 TW        0002 R 001064 TO        0000 R 000001 W         0002     001066 W0
   0002     000536 XIFN      0002     000005 XIMP      0002     000000 XITB      0002     001106 XL        0002     001054 XRE
   0002     001057 XX10      0002     001060 XX11      0002     001061 XX12      0002     001055 XX3       0002     001056 XX4
   0002     000550 ZETA


00101      1*          SUBROUTINE DERIVL (Y,DY,X)
```

```
00101        C
00101        C     THIS SUBROUTINE COMPUTES :
00101        C       SPATIAL DERIVATIVES DY OF Y
00101        C
00103              COMMON XITB(5),XIMP(5),FP(10),FW(10),FT(10),TW(10,5),TEMP(10,10),
00103             1        TMP(10,5),QRFN(10,10),QRMP(10),XIFN(10),ZETA(10),AUX2(10),
00103             2        CONFN(10,10),CONMP(10),COB(10),DOB(10)
00104              COMMON NX,MZ,NRTB,NRMP,NCTL,IFLOW,LT,LTB,LMP,LTBMZ,LTB2MZ,LL1,
00104             1      LL2,LL3,LL4,LL5,LL6,LL7,NRMP1,NRTB1,NRMP2,NEQUS,LC,MSTOTR,
00104             2      NCTM,NM1,MM1,LIMWRT,LIM,MOD,NCCZ,NCONV
00105              COMMON FRE,FR,FNU,FMACH,FPR,FRL,FRM,FFO,FOF,FZ,FRAD,DZ,DXITB,DXIMP
00105             1        ,XRE,XX3,XX4,XX10,XX11,XX12,PHIM,PHIF,T0,P0,W0,RHO0,CP0,PI
00105             2        ,DELTA,RLIMIT,RDTWRT,TREF,TINTL,TI,RTEND,FLUX,QREF,FENTH,
00105             3        FREJ,HFN,XL,COH,DXI,FRD,FXOH,FXHW,RHOFN
00106              COMMON/FLCMP/DTHETA(20)
00106        C
00107              DIMENSION Y(3),DY(3)
00107        C
00110              P   = Y(1)
00111              W   = Y(2)                                              07
00112              T   = Y(3)                                              08
00113              IF (IFLOW .EQ. 2) T = FT(NCTL)
00113        C
00115              PP     = P0*P
00116              TT     = T0*T
00117              RRHO   = RHOF(PP,TT)
00120              RHO    = RRHO/RHO0
00121              GKAPPA = CAPPA(RRHO,TT)*P0
00122              GBETA  = BETA(RRHO,TT)*T0
00123              GCP    = CPF(RRHO,TT)/CP0
00123        C                                                         010
00124              A11 = FPR                                           011
00125              A13 = W*RHO                                         012
00126              A31 = GKAPPA
00127              A32 = -GBETA
00130              A33 = 1.0/W
00131              A21 = FZ*(1.0+T*A32)/(RHO*GCP)
00132              A23 = W*FMACH/GCP
00132        C                                                         017
00133              B1  = (-FR*RHO*W**2)/2.0                            01
00134              B2  = FNU*(TW(NCTL,1)-T)                            019
00135              GO TO (5,10), IFLOW
00135        C                                                         020
00136           5  C1  = A21*A32-A31
00137              C2  = A23*A32-A33
00140              C3  = A11*C2-A13*C1                                 023
00140        C
00141              DY(1) = (B1*C2-A13*A32*B2)/C3
00142              DY(2) = (A11*A32*B2-B1*C1)/C3
00143              DY(3) = -(A31*DY(1)+A33*DY(2))/A32
00144              RETURN
00144        C                                                         028
00144        C
00145          10  C1    = DTHETA(NCTL)*A32
00146              C2    = A11*A33-A13*A31
00146        C
00147              DY(1) = (A13*C1+A33*B1)/C2
```

```
00150     59*          DY(2) = -(A11*C1+A31*B1)/C2
00151     60*          RETURN
00152     61*          END

      END OF COMPILATION:      . NO  DIAGNOSTICS.


@HDG,P  ******  DERIVM  ******
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```
@FOR,S ME*NASA5.DERIVM,ME*NASA5.DERIVM
FOR S9A-07/13/72-20:55:28 (0,)

   SUBROUTINE DERIVM     ENTRY POINT 002331

   STORAGE USED: CODE(1) 002360; DATA(0) 001061; BLANK COMMON(2) 001115

    COMMON BLOCKS:

    0003   DVM      000002
    0004   QIN      001610
    0005   FLDINL   000457
    0006   DVCMFL   000002

   EXTERNAL REFERENCES (BLOCK, NAME)

    0007   CONVEC
    0010   QRAD
    0011   DDX
    0012   D2DX2
    0013   THCFN
    0014   DTHCFN
    0015   CPFN
    0016   YINT
    0017   RHOF
    0020   VISC
    0021   THCF
    0022   CPF
    0023   FLSTRT
    0024   CAPPA
    0025   BETA
    0026   THCTB
    0027   CPTB
    0030   DTHCTB
    0031   THCMP
    0032   CPMP
    0033   DTHCMP
    0034   EXP
    0035   NERR3$

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

    0001   000041 114G    0001   000047 121G    0001   000061 125G    0001   000173 130L    0001   000075 133G
    0001   000220 140L    0001   000111 142G    0001   000124 146G    0001   000141 154G    0001   000146 160G
    0001   000204 170G    0001   000243 205G    0001   000263 210G    0001   000310 217G    0001   000323 226G
    0001   000341 231G    0001   000366 240G    0001   000401 247G    0001   000420 253G    0001   000536 271G
    0001   000575 277G    0001   000772 336G    0001   001121 366G    0001   001137 371G    0001   001154 377G
    0001   001174 405G    0001   001211 414G    0001   001235 420G    0001   001272 431G    0001   001361 443G
    0001   001377 446G    0001   001414 454G    0001   001434 462G    0001   001451 471G    0001   001475 475G
    0001   000633 502L    0001   001534 506G    0001   000760 506L    0001   001055 510L    0001   001056 515L
    0001   001731 527G    0001   001755 537G    0001   002116 555G    0001   002262 605G    0001   002112 900L
    0001   002177 901L    0001   002215 902L    0001   002221 903L    0002 R 000562 AUX2    0025 R 000000 BETA
    0024 R 000000 CAPPA   0000 R 000722 CCP     0002 R 000752 COB     0002   001107 COH     0000 R 000676 CON
```

```
0000 R 000702 COND     0002 R 000574 CONFN    0002 R 000740 CONMP    0000 R 000701 CPARM    0022 R 000000 CPF
0015 R 000000 CPFN     0032 R 000000 CPMP     0027 R 000000 CPTB     0002 R 001070 CP0      0000 R 000677 DCON
0002 R 001072 DELTA    0000 R 000700 DIFF     0002 R 000764 DOB      0000 R 000024 DP       0000 R 000012 DTF
0014 R 000000 DTHCFN   0033 R 000000 DTHCMP   0030 R 000000 DTHCTB   0000 R 000036 DW       0002 R 001110 DXI
0002 R 001053 DXIMP    0002 R 001052 DXITB    0000 R 000050 DXTW     0002 R 001051 DZ       0000 R 000214 DZTW
0000 R 000000 D2TF     0000 R 000360 D2XTW    0000 R 000524 D2ZTW    0002   001103 FENTH    0002 R 001045 FFO
0005 R 000456 FLDINT   0002   001101 FLUX     0006 R 000001 FLUXI    0002 R 001041 FMACH    0002 R 001040 FNU
0002 R 001046 FOF      0002 R 000012 FP       0002   001042 FPR      0002 R 001037 FR       0002 R 001050 FRAD
0002 R 001111 FRD      0002   001036 FRE      0002   001104 FREJ     0002   001043 FRL      0002   001044 FRM
0002 R 000036 FT       0002 R 000024 FW       0002 R 001113 FXHW     0002 R 001112 FXOH     0002 R 001047 FZ
0000 R 000724 GBETA    0000 R 000725 GCP      0000 R 000733 GDTHC    0000 R 000734 GFNU     0000 R 000732 GFO
0000 R 000723 GKAPPA   0002   001105 HFN      0000 I 000671 I        0002   001003 IFLOW    0000 I 000674 IM2
0000   001014 INJPS    0000 I 000670 J        0000 I 000672 K        0000 I 000761 KZ       0000 I 000760 K1
0002 I 001024 LC       0005 I 000001 LFLD     0002   001032 LIM      0002   001031 LIMWRT   0000 I 000726 LLT
0002 I 001011 LL1      0002 I 001012 LL2      0002 I 001013 LL3      0002 I 001014 LL4      0002 I 001015 LL5
0002 I 001016 LL6      0002 I 001017 LL7      0002 I 001006 LMP      0002 I 001004 LT       0002 I 001005 LTB
0002 I 001007 LTBMZ    0002 I 001010 LTB2MZ   0002 I 001030 MM1      0002   001033 MOD      0002   001025 MSTOTR
0002 I 000777 MZ       0002   001034 NCCZ     0002 I 001035 NCONV    0002   001002 NCTL     0002   001026 NCTM
0002   001023 NEQUS    0005 I 000000 NFLDTA   0002 I 001027 NM1      0000 I 000703 NM2      0002 I 001001 NRMP
0002 I 001020 NRMP1    0002 I 001022 NRMP2    0002 I 001000 NRTB     0002 I 001021 NRTB1    0004   001605 NSRD
0004   001604 NTM      0002 I 000776 NX       0000 R 000707 PFLC     0002 R 001063 PHIF     0002 R 001062 PHIM
0002   001071 PI       0000 R 000717 PP       0000 R 000714 PRTR     0002 R 001065 P0       0000 R 000756 QFN
0004   000454 QIFN     0004   001274 QITB     0000 R 000757 QMP      0002   001102 QREF     0002 R 000360 QRFN
0002 R 000524 QRMP     0004   000144 QSFN     0004   000764 QSTB     0004   001606 QTO      0002   001074 RDTWRT
0000 R 000713 RETR     0000 R 000720 RHO      0000 R 000710 RHOC     0017 R 000000 RHOF     0002 R 001114 RHOFN
0002 R 001067 RHOO     0002   001073 RLIMIT   0000 R 000721 RRHO     0002   001100 RTEND    0000 R 000673 TABS
0002 R 000132 TEMP     0000 R 000706 TFLC     0000 R 000715 TFLIN    0021 R 000000 THCF     0013 R 000000 THCFN
0031 R 000000 THCMP    0026 R 000000 THCTB    0002   001077 TI       0005 R 000146 TIFLD    0002 R 001076 TINTL
0004   000000 TM       0005 R 000002 TMEFLD   0002 R 000276 TMP      0000 R 000755 TMPGRD   0002 R 001075 TREF
0000 R 000675 TT       0000 R 000731 TTB      0000 R 000750 TTHCMP   0000 R 000736 TTM      0000 R 000747 TTMBAR
0002 R 000050 TW       0004 R 001607 TX       0002 R 001064 TO       0020 R 000000 VISC     0005 R 000312 WIFLD
0000 R 000705 WIFLDT   0006 R 000000 WRAT     0002   001066 W0       0002   000536 XIFN     0002 R 000005 XIMP
0002 R 000000 XITB     0002   001106 XL       0002 R 001054 XRE      0000 R 000737 XT       0000 R 000712 XTHCF
0000 R 000741 XTHCT    0000 R 000704 XTME     0000 R 000711 XVISC    0000 R 000742 XX1      0002 R 001057 XX10
0002 R 001060 XX11     0002 R 001061 XX12     0000 R 000743 XX2      0003 R 000000 XX20     0002 R 001055 XX3
0002 R 001056 XX4      0003 R 000001 XX48     0000 R 000744 XX5      0000 R 000745 XX6      0000 R 000716 X00
0000 R 000753 X01      0000 R 000754 X03      0000 R 000727 X1       0000 R 000730 X2       0000 R 000740 X3
0000 R 000751 X4       0000 R 000752 X5       0016 R 000000 YINT     0000 R 000746 YY1      0000 R 000735 Y1
0002   000550 ZETA
```

```
00101         SUBROUTINE DERIVM(Y,DY,TIME)
00101      C
00101      C   THIS SUBROUTINE COMPUTES :
00101      C     ALL DERIVATIVES OF THE VARIABLE Y WITH RESPECT TO TIME
00101      C
00103         COMMON XITB(5),XIMP(5),FP(10),FW(10),FT(10),TW(10,5),TEMP(10,10),
00103        1        TMP(10,5),QRFN(10,10),QRMP(10),XIFN(10),ZETA(10),AUX2(10),
00103        2        CONFN(10,10),CONMP(10),COB(10),DO3(10)
00104         COMMON NX,MZ,NRTB,NRMP,NCTL,IFLOW,LT,LTB,LMP,LTBMZ,LTB2MZ,LL1,
00104        1       LL2,LL3,LL4,LL5,LL6,LL7,NRMP1,NRTB1,NRMP2,NEQUS,LC,MSTOTR,
00104        2       NCTM,NM1,MM1,LIMWRT,LIM,MOD,NCCZ,NCONV
00105         COMMON FRE,FR,FNU,FMACH,FPR,FRL,FRM,FFO,FOF,FZ,FRAD,DZ,DXITB,DXIMP
00105        1        ,XRE,XX3,XX4,XX10,XX11,XX12,PHIM,PHIF,TO,PO,WO,RHOO,CPO,PI
00105        2        ,DELTA,RLIMIT,RDTWRT,TREF,TINTL,TI,RTEND,FLUX,QREF,FENTH,
```

```
     3        FREJ,HFN,XL,COH,DXI,FRD,FXOH,FXHW,RHOFN
      COMMON/DVM/XX20,XX48
      COMMON /QIN/TM(100), QSFN(100,2), QIFN(100,2), QSTB(100,2),
     1            QITB(100,2), NTM, NSRD, QTO, TX
      COMMON /FLDINL/ NFLDTA,LFLD,TMEFLD(100),TIFLD(100),WIFLD(100),
     1                FLDINT
      COMMON /DVCMFL/ WRAT,FLUXI
C
      DIMENSION Y(200),DY(200),D2TF(10),DTF(10),DP(10),DW(10),
     1        DXTW(10,10),DZTW(10,10),D2XTW(10,10),D2ZTW(10,10)
C
      DO 100 J=1,MZ
  100 TEMP(J,1)  = Y(LL4+J)
      DO 105 I=2,NX
      K          = MZ*(I-2)
      DO 105 J=1,MZ
  105 TEMP(J,I)  = Y(K+J)
C
      DO 110 J=1,MZ
  110 TMP(J,1)   = Y(LL4+J)
      IF(NRTB.EQ.0) GO TO 130
      DO 115 I=2,NRMP
      K           = LMP+(I-2)*MZ
      DO 115 J=1,MZ
  115 TMP(J,I)   = Y(K+J)
      DO 120 J=1,MZ
      TW(J,NRTB) = Y(LL4+J)
      DO 120 I=1,NRTB1
      K           = LTB+(I-1)*MZ+J
  120 TW(J,I)     = Y(K)
C
      GO TO 140
  130 DO 135 J=1,MZ
      K             = LL4+J
      TW(J,1)       = Y(K)
      TMP(J,NRMP) = Y(K)
  135 TEMP(J,1)     = Y(K)
C
  140 TABS    =  TIME*TREF*3600.0
      TX      = TABS/60.0
      IF(NCONV.GT.0) CALL CONVEC (TABS)
      CALL QRAD
C
C
C     FIN
C
C
      DO 2 I=2,NM1
      DO 1 J=1,MZ
    1 DTF(J)  = TEMP(J,I)
      CALL DDX  (DTF,DP,DZ,MZ)
      CALL D2DX2(DTF, DW,DZ,MZ)
      DO 2 J=2,MM1
      DZTW(J,I)    = DP(J)
    2 D2ZTW(J,I)  = DW(J)
C
      DO 4 J=2,MM1
```

```
00230            DO 3 I=1,NX
00233          3 DTF(I)  = TEMP(J,I)
00235            CALL DDX  (DTF,DP,DXI,NX)
00236            CALL D2DX2(DTF,DW,DXI,NX)
00237            DO 4 I=2,NM1
00242            DXTW(J,I)    = DP(I)
00243          4 D2XTW(J,I)   = DW(I)
00243      C
00246            DO 9 I=2,NM1
00251            IM2      = I-2
00252            DO 9 J=2,MM1
00255            K        = IM2*MZ+J
00256            TT       = TO*TEMP(J,I)
00257            CON        = THCFN(TT)
00260            DCON     = DTHCFN(TT)*TO
00261            DIFF       = CON/(RHOFN*CPFN(TT))*FXHW
00262            CPARM    = FRD/CON
00262      C
00263            COND     = D2XTW(J,I)+FXOH*D2ZTW(J,I)-COB(I)*DXTW(J,I)
00263         1             +DCON*(DXTW(J,I)**2+FXOH*DZTW(J,I)**2)
00264          9 DY(K)    = DIFF*(COND-DOB(I)*CPARM*(QRFN(J,I)-CONFN(J,I)))
00264      C
00264      C     TIP OF FIN
00264      C
00267            NM2      = NX-2
00270            DO 11 J=2,MM1
00273            K          = NM2*MZ+J
00274         11 DY(K)    = (18.*DY(K-MZ)-9.*DY(K-2*MZ)+2.*DY(K-3*MZ))/11.
00274      C
00274      C
00274      C
00274      C
00274      C     FLUID FLOW VARIABLES
00274      C
00274      C
00276            DO 500 I=1,MZ
00301        500 FT(I) = Y(I+LT)
00301      C
00303            IF (LFLD .EQ. 1) GO TO 502
00305            XTME  = TIME*TREF
00306            FT(1) = YINT(TMEFLD,TIFLD,NFLDTA,3,XTME)/TO
00307            FLDINT = FT(1)
00310            WIFLDT = YINT(TMEFLD,WIFLD,NFLDTA,3,XTME)
00311            WRAT     = WIFLDT/FLUXI
00311      C
00312        502 TFLC  = FT(LC)*TO
00313            PFLC  = FP(LC)*PO
00314            RHOC  = RHOF(PFLC,TFLC)
00315            XVISC = VISC(RHOC,TFLC)
00316            XTHCF = THCF(RHOC,TFLC)
00317            RETR  = XRE/XVISC
00320            PRTR  = (XVISC*CPF(RHOC,TFLC))/XTHCF
00321            TFLIN = Y(LT+1)
00322            CALL FLSTRT(RETR,PRTR,DELTA)
00323            X00        = DELTA*RETR*PRTR*XTHCF/4.0
00323      C
00324            CALL DDX(FW,DW,DZ,MZ)
```

```
              CALL DDX(FT,DTF,DZ,MZ)
        C
              DY(LT+1) = 0.0
              IF (LFLD .EQ. 2) GO TO 506
              IF(TIME.LE.2.5) DY(LT+1) = 7.0*EXP(-7.0*TIME)*(1.0-TINTL)
          506 AUX2(1) = FNU*(TW(1,1)-FT(1))
              AUX2(1) = -X00*AUX2(1)
        C
              DO 520 I=2,MZ
              PP     = P0*FP(I)
              TT     = T0*FT(I)
              RHO    = 1.0/FW(I)
              RRHO   = RHO0*RHO
              CCP    = CPF(RRHO,TT)
        C
              GKAPPA = CAPPA(RRHO,TT)*P0
              GBETA  = BETA(RRHO,TT)*T0
              GCP    = CCP/CP0
              AUX2(I) = FNU*(TW(I,1)-FT(I))
              LLT     = LT+I
              IF (GKAPPA .LT. 1.0E-08) GO TO 510
              X1      = FZ*GBETA*FT(I)/(GKAPPA*GCP*RHO)
              GO TO 515
          510 X1      = 0.0
          515 X2      = 1.0-X1*GBETA
              DY(LLT) = ((AUX2(I)+FMACH*FR*(FW(I)**2)/2.0)/(RHO*GCP)-X1*DW(I))/
             1          X2-FW(I)*DTF(I)
          520 AUX2(I) = -X00*AUX2(I)
        C
        C
        C     TUBE WALL TEMPERATURE
        C
              IF(NRTB.EQ.0) GO TO 900
              DO 625 J=1,MZ
              DO 615 I=1,NRTB
          615 DTF(I)  = TW(J,I)
              CALL DDX(DTF,D2TF,DXITB,NRTB)
              DO 620 I=1,NRTB
          620 DP(I)   = XITB(I)*D2TF(I)
              CALL DDX(DP,DTF,DXITB,NRTB)
              DO 625 I=2,NRTB1
              D2XTW(J,I)     = DTF(I)/XITB(I)
          625 DXTW(J,I)      = (D2TF(I))**2
        C
              DO 630 I=2,NRTB1
              K       = LTB+(I-1)*MZ
              DO 630 J=1,MZ
              TTB     = TW(J,I)*T0
              GFO     = THCTB(TTB)/CPTB(TTB)*FFO
              GDTHC   = T0*DTHCTB(TTB)
          630 DY(K+J) = GFO*(D2XTW(J,I)+GDTHC*(DXTW(J,I)))
              DO 635 J=1,MZ
              TTB     = TW(J,1)*T0
              GFNU    = XTHCF*FNU/(4.0*THCTB(TTB))*RETR*PRTR*DELTA*DXITB
              Y1      = TW(J,1)-FT(J)
              X1      = 4.0*DY(LTBMZ+J)-DY(LTB2MZ+J)
              X2      = 3.0+GFNU*(1.0-T0*DTHCTB(TTB)*Y1)
```

```
00440      635 DY(LTB+J) = (X1+GFNU*DY(LT+J))/X2
00440    C
00440    C
00440    C
00440    C     PROTECTION LAYER TEMPERATURE
00440    C
00440    C
00442          DO 730 J=1,MZ
00445          DO 720 I=1,NRMP
00450      720 DTF(I) = TMP(J,I)
00452          CALL DDX(DTF,D2TF,DXIMP,NRMP)
00453          DO 725 I=1,NRMP
00456      725 DP(I)    = XIMP(I)*D2TF(I)
00460          CALL DDX(DP,DTF,DXIMP,NRMP)
00461          DO 730 I=2,NRMP1
00464          D2XTW(J,I)    = DTF(I)/XIMP(I)
00465      730 DXTW(J,I)     = D2TF(I)**2
00465    C
00470          DO 735 I=2,NRMP1
00473          K        = LMP+(I-2)*MZ
00474          DO 735 J=1,MZ
00477          TTM      = TMP(J,I)*T0
00500          GFO      = THCMP(TTM)/CPMP(TTM)*FOF
00501          GDTHC    = T0*DTHCMP(TTM)
00502      735 DY(K+J) = GFO*(D2XTW(J,I)+GDTHC*(DXTW(J,I)))
00502    C
00502    C
00502    C
00502    C     FIN - TUBE - PROTECTION LAYER INTERFACE
00502    C
00505          DO 740 J=1,MZ
00510          XT       = TW(J,1)*T0
00511          X1       = DTHCTB(XT)
00512          X2       = DTHCMP(XT)
00513          X3       = DTHCFN(XT)
00514          XTHCT    = THCTB(XT)
00515          XX1      = PHIM*THCMP(XT)/XTHCT
00516          XX2      = PHIF*THCFN(XT)/XTHCT
00517          XX5      = (X2-X1)*XX3*(-3.0*TW(J,NRTB)+4.0*TMP(J,2)-TMP(J,3))*T0
00520          XX6      = (X3-X1)*XX4*(-3.0*TW(J,NRTB)+4.0*TEMP(J,2)-TEMP(J,3))*T0
00520    C
00521          YY1      = 4.0*DY(LL1+J)-DY(LL2+J)
00522          YY1      = YY1+XX1*XX3*(4.0*DY(LMP+J)-DY(LL3+J))
00523          YY1      = YY1+XX2*XX4*(4.0*DY(J)-DY(MZ+J))
00524      740 DY(LL4+J) = YY1/(3.0+XX1*(3.0*XX3-XX5)+XX2*(3.0*XX4-XX6))
00524    C
00524    C
00524    C     MANIFOLD-FIN INTERFACE
00524    C
00524    C
00526          DO 750 I=1,NM1
00531          K        = I*MZ-(MZ-1)
00532          DY(K)    = DY(LL4+1)
00533          K        = I*MZ
00534      750 DY(K)    = DY(LL4+MZ)
00534    C
00534    C
```

```
00534          C
00534          C
00534          C     OUTER BOUNDARY OF PROTECTION LAYER
00534          C
00534          C
00536                DO 810 J=1,MZ
00541                TTMBAR  = (8.0*TMP(J,NRMP)+5.0*TMP(J,NRMP1)-TMP(J,NRMP2))*T0/12.
00542                TTHCMP  = THCMP(TTM)
00543                GFO     = TTHCMP*FOF/CPMP(TTMBAR)
00544                GDTHC   = T0*DTHCMP(TTM)
00545                X1      = TMP(J,NRMP)-TMP(J,NRMP1)
00546                X2      = 1.0-GDTHC*(3.0*TMP(J,NRMP)-4.0*TMP(J,NRMP1)+
00546               1              TMP(J,NRMP2))/4.0
00547                X4      = FRAD*XX12*(QRMP(J)+CONMP(J))/TTHCMP
00550                X5      = -X1*XX11*X2-X4
00551            810 DY(LL5+J) = (12.0*X5*GFO-5.0*DY(LL6+J)+DY(LL7+J))/8.0
00551          C
00553                RETURN
00553          C
00554            900 DO 905 J=1,MZ
00557                K       = LL4+J
00560                TT      = Y(K)*T0
00561                TFLC    = T0*FT(J)
00562                RHOC    = RHO0/FW(J)
00563                X01     = XX10*CPTB(TT)+XX11*CPMP(TT)+XX12*CPFN(TT)
00564                X03     = XX4*THCFN(TT)
00565                IF(J.NE.1) GO TO 901
00567                TMPGRD  = (5.0*(TEMP(2,2)-TEMP(2,1))+TEMP(3,1)-TEMP(3,2))/XX48
00570                GO TO 903
00571            901 IF(J.NE.MZ) GO TO 902
00573                TMPGRD  = (5.0*(TEMP(MM1,2)-TEMP(MM1,1))+TEMP(LL6,1)
00573               1          -TEMP(LL6,2))/XX48
00574                GO TO 903
00575            902 TMPGRD  = (TEMP(J,2)-TEMP(J,1))/DXI
00576            903 QFN     = QRFN(J,1)+CONFN(J,1)
00577                QMP     = QRMP(J)+CONMP(J)
00600            905 DY(K)   = (AUX2(J)-FRAD*(QMP+XX20*QFN)+X03*TMPGRD)/X01
00600          C
00602                K1      = LL4+1
00603                KZ      = LL4+MZ
00604                DO 910 I=1,NM1
00607                K       = I*MZ
00610                DY(K)   = DY(KZ)
00611                K       = K-MZ+1
00612            910 DY(K)   = DY(K1)
00614                RETURN
00615                END

        END OF COMPILATION:        NO  DIAGNOSTICS.


QHOG.P  ******  DTHCFN/FNAL  ******
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```
@FOR,S ME*NASA5.DTHCFN/FNAL,ME*NASA5.DTHCFN/FNAL
FOR S9A-07/13/72-20:55:36 (0,)

  FUNCTION DTHCFN      ENTRY POINT 000033

  STORAGE USED: CODE(1) 000040; DATA(0) 000017; BLANK COMMON(2) 000000

  EXTERNAL REFERENCES (BLOCK, NAME)

   0003   THCFN
   0004   NERR3$

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

   0000 R 000006 DT       0000 R 000011 DTHC     0000 R 000000 DTHCFN   0000   000012 INJP$     0000 R 000010 THC
   0003 R 000000 THCFN    0000 R 000007 THETA    0000 R 000005 TO       0000 R 000001 X1        0000 R 000002 X2
   0000 R 000003 X3       0000 R 000004 X4


00101      1*          FUNCTION DTHCFN (T)
00101      2*     C
00101      3*     C       THIS FUNCTION SUBPROGRAM COMPUTES :
00101      4*     C       (1/K)(DK/DT) AS A FUNCTION OF TEMPERATURE (R) OF ALUMINUM 7075
00101      5*     C                                    UNITS (1/R)
00101      6*     C            TEMP. GE. 300.0.AND.LE. 1200.0 R
00101      7*     C
00103      8*          DATA X1,X2,X3,X4 /13.0665,0.6655,-5.25,1.015/,TO,DT /400.0,200.0/
00112      9*          THETA  = (T-TO)/DT
00113     10*          THC    = THCFN(T)
00114     11*          DTHC   = (((X4*THETA+X3)*THETA+X2)*THETA+X1)/DT
00115     12*          DTHCFN = DTHC/THC
00116     13*          RETURN
00117     14*          END

     END OF COMPILATION:       NO  DIAGNOSTICS.


@HDG,P  ******  DTHCFN/FNBR  ******
```

```
****** DTHCFN/FNBR ******                                                              DATE 071372        PAGE    1

@FOR,S ME*NASA5.DTHCFN/FNBR,ME*NASA5.DTHCFN/FNBR
FOR S9A-07/13/72-20:55:39 (0,)

   FUNCTION DTHCFN      ENTRY POINT 000033

   STORAGE USED: CODE(1) 000040; DATA(0) 000017; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   THCMP
    0004   NERR3$

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

    0000 R 000006 DT        0000 R 000011 DTHC      0000 R 000000 DTHCFN    0000   000012 INJP$      0000 R 000010 THC
    0003 R 000000 THCMP     0000 R 000007 THETA     0000 R 000005 TO        0000 R 000001 X1         0000 R 000002 X2
    0000 R 000003 X3        0000 R 000004 X4


00101      1*              FUNCTION DTHCFN(T)
00101      2*     C
00101      3*     C           THIS FUNCTION SUBPROGRAM COMPUTES :
00101      4*     C           (1/K)(DK/DT) AS A FUNCTION OF TEMPERA3URE (R) OF BERYLIUM WITH
00101      5*     C                0.84-1.68 BEO
00101      6*     C                                         UNITS (1/R)
00101      7*     C                TEMP. GE. 400.0 AND LE. 1700.0 R
00101      8*     C
00103      9*              DATA X1,X2,X3,X4 /-10.5643,1.65366,-0.60501,0.080668/,TO,DT /400.0
00103     10*             1,200.0/
00112     11*              THETA  = (T-TO)/DT
00113     12*              THC    = THCMP(T)
00114     13*              DTHC   = (((X4*THETA+X3)*THETA+X2)*THETA+X1)/DT
00115     14*              DTHCFN = DTHC/THC
00116     15*              RETURN
00117     16*              END

     END OF COMPILATION:        NO  DIAGNOSTICS.


@HDG,P  ******  DTHCFN/FNCU  ******
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```
@FOR,S ME*NASA5.DTHCFN/FNCU,ME*NASA5.DTHCFN/FNCU
FOR S9A-07/13/72-20:55:41 (0,)

   FUNCTION DTHCFN      ENTRY POINT 000030

   STORAGE USED: CODE(1) 000035; DATA(0) 000015; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   THCTB
    0004   NERR3$

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

    0000 R 000004 DT        0000 R 000007 DTHC      0000 R 000000 DTHCFN    0000    000010 INJP$     0000 R 000006 THC
    0003 R 000000 THCTB     0000 R 000005 THETA     0000 R 000003 T0        0000 R 000001 X1         0000 R 000002 X2


00101       1*             FUNCTION DTHCFN(T)
00101       2*      C
00101       3*      C         THIS FUNCTION SUBPROGRAM COMPUTES :
00101       4*      C         (1/K)(DK/DT) AS A FUNCTION OF TEMPERATURE (R) OF COPPER
00101       5*      C                                        UNITS (1/R)
00101       6*      C              TEMP. GE. 500.0 AND LE. 1800.0 R
00101       7*      C
00103       8*             DATA X1,X2 /-2.62067,-0.121/,T0,DT /600.0,200.0/
00110       9*             THETA  = (T-T0)/DT
00111      10*             THC    = THCTB(T)
00112      11*             DTHC   = (X2*THETA*THETA+X1)/DT
00113      12*             DTHCFN = DTHC/THC
00114      13*             RETURN
00115      14*             END

     END OF COMPILATION:        NO  DIAGNOSTICS.


@HDG,P  ******  DTHCMP/MPAL  ******
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```
****** DTHCMP/MPAL ******                                                     DATE 071372        PAGE      1

@FOR,S ME*NASA5.DTHCMP/MPAL,ME*NASA5.DTHCMP/MPAL
FOR S9A-07/13/72-20:55:44 (0,)

  FUNCTION DTHCMP      ENTRY POINT 000033

  STORAGE USED: CODE(1) 000040; DATA(0) 000017; BLANK COMMON(2) 000000

  EXTERNAL REFERENCES (BLOCK, NAME)

   0003   THCFN
   0004   NERR3$

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

   0000 R 000006 DT       0000 R 000011 DTHC      0000 R 000000 DTHCMP    0000   000012 INJP$     0000 R 000010 THC
   0003 R 000000 THCFN    0000 R 000007 THETA     0000 R 000005 TO        0000 R 000001 X1         0000 R 000002 X2
   0000 R 000003 X3       0000 R 000004 X4


00101      1*           FUNCTION DTHCMP(T)
00101      2*     C
00101      3*     C        THIS FUNCTION SUBPROGRAM COMPUTES :
00101      4*     C        (1/K)(DK/DT) AS A FUNCTION OF TEMPERATURE (R) OF ALUMINUM 7075
00101      5*     C                                    UNITS (1/R)
00101      6*     C           TEMP. GE. 300.0.AND.LE. 1200.0 R
00101      7*     C
00103      8*           DATA X1,X2,X3,X4 /13.0665,0.6655,-5.25,1.015/,TO,DT /400.0,200.0/
00112      9*           THETA  = (T-TO)/DT
00113     10*           THC    = THCFN(T)
00114     11*           DTHC   = (((X4*THETA+X3)*THETA+X2)*THETA+X1)/DT
00115     12*           DTHCMP = DTHC/THC
00116     13*           RETURN
00117     14*           END

     END OF COMPILATION:        NO  DIAGNOSTICS.

@HDG,P  ******  DTHCMP/MPBR  ******
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```
@FOR,S ME*NASA5.DTHCMP/MPBR,ME*NASA5.DTHCMP/MPBR
FOR S9A-07/13/72-20:55:46 (0,)

   FUNCTION DTHCMP       ENTRY POINT 000033

   STORAGE USED: CODE(1) 000040; DATA(0) 000017; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   THCMP
    0004   NERR3$

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

    0000 R 000006 DT       0000 R 000011 DTHC       0000 R 000000 DTHCMP    0000   000012 INJP$     0000 R 000010 THC
    0003 R 000000 THCMP    0000 R 000007 THETA      0000 R 000005 T0        0000 R 000001 X1        0000 R 000002 X2
    0000 R 000003 X3       0000 R 000004 X4


00101      1*             FUNCTION DTHCMP (T)
00101      2*      C
00101      3*      C         THIS FUNCTION SUBPROGRAM COMPUTES :
00101      4*      C         (1/K)(DK/DT) AS A FUNCTION OF TEMPERA3URE (R) OF BERYLIUM WITH
00101      5*      C              0.84-1.68 BEO
00101      6*      C                                      UNITS (1/R)
00101      7*      C              TEMP. GE. 400.0 AND LE. 1700.0 R
00101      8*      C
00103      9*             DATA X1,X2,X3,X4 /-10.5643,1.65366,-0.60501,0.080668/,T0,DT /400.0
00103     10*            1,200.0/
00112     11*             THETA  = (T-T0)/DT
00113     12*             THC    = THCMP(T)
00114     13*             DTHC   = (((X4*THETA+X3)*THETA+X2)*THETA+X1)/DT
00115     14*             DTHCMP = DTHC/THC
00116     15*             RETURN
00117     16*             END

        END OF COMPILATION:        NO  DIAGNOSTICS.


@HDG,P  ******  DTHCMP/MPCU  ******
```

```
****** DTHCMP/MPCU ******                                                              DATE 071372        PAGE    1

@FOR,S ME*NASA5.DTHCMP/MPCU,ME*NASA5.DTHCMP/MPCU
FOR S9A-07/13/72-20:55:50 (0,)

   FUNCTION DTHCMP      ENTRY POINT 000030

   STORAGE USED: CODE(1) 000035; DATA(0) 000015; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   THCTB
    0004   NERR3$

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

    0000 R 000004 DT       0000 R 000007 DTHC      0000 R 000000 DTHCMP    0000    000010 INJP$     0000 R 000006 THC
    0003 R 000000 THCTB    0000 R 000005 THETA     0000 R 000003 T0        0000 R 000001 X1         0000 R 000002 X2


00101      1*            FUNCTION DTHCMP(T)
00101      2*      C
00101      3*      C        THIS FUNCTION SUBPROGRAM COMPUTES :
00101      4*      C        (1/K)(DK/DT) AS A FUNCTION OF TEMPERATURE (R) OF COPPER
00101      5*      C                                     UNITS (1/R)
00101      6*      C            TEMP. GE. 500.0 AND LE. 1800.0 R
00101      7*      C
00103      8*            DATA X1,X2 /-2.62067,-0.121/,T0,DT /600.0,200.0/
00110      9*            THETA  = (T-T0)/DT
00111     10*            THC    = THCTB(T)
00112     11*            DTHC   = (X2*THETA*THETA+X1)/DT
00113     12*            DTHCMP = DTHC/THC
00114     13*            RETURN
00115     14*            END

      END OF COMPILATION:        NO  DIAGNOSTICS.


@HDG,P  ******  DTHCTB/TBAL  ******
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```
@FOR,S ME*NASA5.DTHCTB/TBAL,ME*NASA5.DTHCTB/TBAL
FOR S9A-07/13/72-20:55:53 (0,)

   FUNCTION DTHCTB       ENTRY POINT 000033

   STORAGE USED: CODE(1) 000040; DATA(0) 000017; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003    THCFN
    0004    NERR3$

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

    0000 R 000006 DT        0000 R 000011 DTHC       0000 R 000000 DTHCTB    0000   000012 INJP$      0000 R 000010 THC
    0003 R 000000 THCFN     0000 R 000007 THETA      0000 R 000005 TO        0000 R 000001 X1         0000 R 000002 X2
    0000 R 000003 X3        0000 R 000004 X4


00101      1*            FUNCTION DTHCTB(T)
00101      2*      C
00101      3*      C        THIS FUNCTION SUBPROGRAM COMPUTES :
00101      4*      C        (1/K)(DK/DT) AS A FUNCTION OF TEMPERATURE (R) OF ALUMINUM 7075
00101      5*      C                                     UNITS (1/R)
00101      6*      C               TEMP. GE. 300.0.AND.LE. 1200.0 R
00101      7*      C
00103      8*            DATA X1,X2,X3,X4 /13.0665,0.6655,-5.25,1.015/,TO,DT /400.0,200.0/
00112      9*            THETA  = (T-TO)/DT
00113     10*            THC    = THCFN(T)
00114     11*            DTHC   = (((X4*THETA+X3)*THETA+X2)*THETA+X1)/DT
00115     12*            DTHCTB = DTHC/THC
00116     13*            RETURN
00117     14*            END

      END OF COMPILATION:        NO  DIAGNOSTICS.


@HDG,P  ******  DTHCTB/TBBR  ******
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```
@FOR,S ME*NASA5.DTHCTB/TBBR,ME*NASA5.DTHCTB/TBBR
FOR S9A-07/13/72-20:55:56 (0,)

   FUNCTION DTHCTB      ENTRY POINT 000033

   STORAGE USED: CODE(1) 000040; DATA(0) 000017; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   THCMP
    0004   NERR3$

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

    0000 R 000006 DT       0000 R 000011 DTHC     0000 R 000000 DTHCTB   0000   000012 INJP$     0000 R 000010 THC
    0003 R 000000 THCMP    0000 R 000007 THETA    0000 R 000005 T0       0000 R 000001 X1       0000 R 000002 X2
    0000 R 000003 X3       0000 R 000004 X4


00101        FUNCTION DTHCTB(T)
00101     C
00101     C     THIS FUNCTION SUBPROGRAM COMPUTES :
00101     C     (1/K)(DK/DT) AS A FUNCTION OF TEMPERA3URE (R) OF BERYLIUM WITH
00101     C          0.84-1.68 BEO
00101     C                                         UNITS (1/R)
00101     C          TEMP. GE. 400.0 AND LE. 1700.0 R
00101     C
00103        DATA X1,X2,X3,X4 /-10.5643,1.65366,-0.60501,0.080668/,T0,DT /400.0
00103       1,200.0/
00112        THETA  = (T-T0)/DT
00113        THC    = THCMP(T)
00114        DTHC   = (((X4*THETA+X3)*THETA+X2)*THETA+X1)/DT
00115        DTHCTB = DTHC/THC
00116        RETURN
00117        END

      END OF COMPILATION:       NO  DIAGNOSTICS.


@HDG,P  ******  DTHCTB/TBCU  ******
```

```
@FOR,S ME*NASA5.DTHCTB/TBCU,ME*NASA5.DTHCTB/TBCU
FOR S9A-07/13/72-20:55:58 (0,)

   FUNCTION DTHCTB      ENTRY POINT 000030

   STORAGE USED: CODE(1) 000035; DATA(0) 000015; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   THCTB
    0004   NERR3$

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

    0000 R 000004 DT      0000 R 000007 DTHC     0000 R 000000 DTHCTB   0000   000010 INJP$   0000 R 000006 THC
    0003 R 000000 THCTB   0000 R 000005 THETA    0000 R 000003 T0       0000 R 000001 X1       0000 R 000002 X2


00101          FUNCTION DTHCTB (T)
00101     C
00101     C       THIS FUNCTION SUBPROGRAM COMPUTES :
00101     C       (1/K)(DK/DT) AS A FUNCTION OF TEMPERATURE (R) OF COPPER
00101     C                                   UNITS (1/R)
00101     C            TEMP. GE. 500.0 AND LE. 1800.0 R
00101     C
00103          DATA X1,X2 /-2.62067,-0.121/,T0,DT /600.0,200.0/
00110          THETA  = (T-T0)/DT
00111          THC    = THCTB(T)
00112          DTHC   = (X2*THETA*THETA+X1)/DT
00113          DTHCTB = DTHC/THC
00114          RETURN
00115          END
       END OF COMPILATION:        NO  DIAGNOSTICS.


@HDG,P  ******  D2DX2  ******
```

```
****** D2DX2 ******                                                                          DATE 071372        PAGE     1

@FOR,S ME*NASA5.D2DX2,ME*NASA5.D2DX2
FOR S9A-07/13/72-20:56:00 (0,)

   SUBROUTINE D2DX2     ENTRY POINT 000137

   STORAGE USED: CODE(1) 000163; DATA(0) 000046; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   NWDU$
    0004   NIO2$
    0005   NERR3$

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

    0001   000064 112G      0001   000112 2L        0000   000003 3F        0000 R 000000 DX2       0000 I 000002 I
    0000   000016 INJP$     0000 I 000001 N1


00101      1*          SUBROUTINE D2DX2 (Y,D2Y,DX,N)                                          1
00101      2*      C
00101      3*      C   THIS SUBROUTINE COMPUTES :
00101      4*      C     THE SECOND DERIVATIVE OF THE EQUALLY-SPACED ARRAY Y(N)
00101      5*      C
00103      6*          DIMENSION Y(N),D2Y(N)                                                  2
00104      7*          IF (N.LT.4) GO TO 2                                                    3
00106      8*          DX2 = DX**2                                                            4
00107      9*          D2Y(1) = (2.0*Y(1)-5.0*Y(2)+4.0*Y(3)-Y(4))/DX2                         5
00110     10*          N1 = N-1                                                               6
00111     11*          DO 1 I=2,N1                                                            7
00114     12*        1 D2Y(I) = (Y(I+1)-2.0*Y(I)+Y(I-1))/DX2                                  8
00116     13*          D2Y(N) = (2.0*Y(N)-5.0*Y(N-1)+4.0*Y(N-2)-Y(N-3))/DX2                   9
00117     14*          RETURN                                                                10
00120     15*        2 WRITE (6,3)                                                           11
00122     16*        3 FORMAT (27HD2DX2 NOT ENOUGH NODAL PTS.,/)                             12
00123     17*          RETURN                                                                13
00124     18*          END                                                                   14
       END OF COMPILATION:        NO  DIAGNOSTICS.


@HDG,P ****** EFFICY ******
```

```
@FOR,S ME*NASA5.EFFICY,ME*NASA5.EFFICY
FOR S9A-07/13/72-20:56:02 (0,)

   SUBROUTINE EFFICY    ENTRY POINT 000134

   STORAGE USED: CODE(1) 000161; DATA(0) 000131; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   POLY
    0004   NERR3$

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

    0001    000007 116G      0001    000011 121G      0001    000040 132G      0001    000042 135G      0001    000073 146G
    0000 R  000064 A         0000 R  000104 AK        0000 R  000073 APR       0000 R  000000 C         0000 R  000050 COEF
    0000 R  000055 COEFF     0000 R  000043 COF       0000 I  000102 I         0000    000114 INJP$     0000 I  000103 J
    0000 I  000105 K         0003 R  000000 POLY


00101              SUBROUTINE EFFICY (NC,NCPR,TSOTB,TB,ETA,ETAPR)
00103              DIMENSION C(5,7),COF(5),COEF(5),COEFF(7),A(7),APR(7)
00104              REAL NC,NCPR
00105              DATA(C(I,2),I=1,5)/-1.1632,.1633405,-1.629484,3.735489,-2.75355/,
00105             1 (C(I,3),I=1,5)/1.438967,-.5483718,5.091788,-11.26815,7.905002/,
00105             2 (C(I,4),I=1,5)/-1.158833,.7783245,-6.866955,14.98945,-10.35581/,
00105             3 (C(I,5),I=1,5)/.537,-.5282332,4.460133,-9.675815,6.65502/,
00105             4 (C(I,6),I=1,5)/-.1294667,.1666654,-1.360822,2.94164,-2.020815/,
00105             5 (C(I,7),I=1,5)/.01253334,-.01962952,.1562953,-.3370346,.2314797/
00114              A(1)    =  1.0
00115              DO 20  I=2,7
00120              DO 10  J=1,5
00123           10 COEF(J) =  C(J,I)
00125           20 A(I)    =  POLY (5,COEF,TSOTB)
00127              ETA     =  POLY (7,A,NC)
00130              APR(1)  =  0.0
00131              DO 40  I=2,7
00134              DO 30  J=1,5
00137              AK      =  J-1
00140           30 COF(J)  =  AK*C(J,I)
00142           40 APR(I)  =  -(1.0/TB)*POLY(5,COF,TSOTB)
00144              COEFF(7)=  APR(7)*NC**4
00145              DO 50  I=1,6
00150              K       =  I+1
00151              AK      =  I
00152           50 COEFF(I)=  APR(I)*AK*A(K)*NCPR
00154              ETAPR   =  POLY (7,COEFF,NC)
00155              RETURN
00156              END

      END OF COMPILATION:        NO  DIAGNOSTICS.
```

QHDG,P ****** ELAS/MPAL ******

```
QFOR,S ME*NASA5.ELAS/MPAL,ME*NASA5.ELAS/MPAL
FOR S9A-07/13/72-20:56:06 (0,)

   FUNCTION ELAS        ENTRY POINT 000055

   STORAGE USED: CODE(1) 000061; DATA(0) 000040; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   NWDU$
    0004   NI02$
    0005   NERR3$

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

    0000   000010 1F        0000 R 000006 DT        0000 R 000000 ELAS       0000   000032 INJP$      0000 R 000007 THETA
    0000 R 000005 T0        0000 R 000001 X1        0000 R 000002 X2         0000 R 000003 X3          0000 R 000004 X4


00101      1*              FUNCTION ELAS(T)
00101      2*     C
00101      3*     C           THIS FUNCTION SUBPROGRAM COMPUTES :
00101      4*     C         MODULUS OF ELASTICITY AS A FUNCTION OF TEMPERATURE (R) OF
00101      5*     C               ALUMINUM 7075
00101      6*     C                                       UNITS LBF/SQ.FT
00101      7*     C               TEMP. GE. 300.0.AND.LE. 1200.0 R
00101      8*     C
00103      9*              DATA X1,X2,X3,X4 /10.71,-0.63,-0.115,-0.06/,T0,DT /459.67,200.0/
00112     10*              THETA = (T-T0)/DT
00113     11*              ELAS = (((X4*THETA+X3)*THETA+X2)*THETA+X1)*1.0E06
00114     12*              ELAS = ELAS*144.0
00115     13*              IF (T.GE.300.0.AND.T.LE.1200.0) RETURN
00117     14*              WRITE (6,1) T
00122     15*            1 FORMAT (1H0,59HMODULUS OF ELASTICITY OF ALUMINUM, TEMP. OUT OF RAN
00122     16*             1GE, T = ,F8.3,/)
00123     17*              RETURN
00124     18*              END

      END OF COMPILATION:       NO  DIAGNOSTICS.


QHDG,P  ******  ELAS/MPBR  ******
```

```
****** ELAS/MPBR ******                                                                    DATE 071372       PAGE    1

@FOR,S ME*NASA5.ELAS/MPBR,ME*NASA5.ELAS/MPBR
FOR S9A-07/13/72-20:56:10 (0,)

   FUNCTION ELAS        ENTRY POINT 000055

   STORAGE USED: CODE(1) 000061; DATA(0) 000040; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   NWDU$
    0004   NIO2$
    0005   NERR3$

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

    0000   000010 1F       0000 R 000006 DT       0000 R 000000 ELAS      0000   000032 INJP$     0000 R 000007 THETA
    0000 R 000005 T0       0000 R 000001 X1       0000 R 000002 X2        0000 R 000003 X3         0000 R 000004 X4


00101      1*           FUNCTION ELAS(T)
00101      2*      C
00101      3*      C       THIS FUNCTION SUBPROGRAM COMPUTES :
00101      4*      C      MODULUS OF ELASTICITY AS A FUNCTION OF TEMPERATURE (R) OF
00101      5*      C            BERYLIUM WITH 0.84-1.68 BEO
00101      6*      C                                   UNITS LBF/SQ.FT
00101      7*      C            TEMP. GE. 400.0 AND LE. 1700.0 R
00101      8*      C
00103      9*           DATA X1,X2,X3,X4 /44.36,-3.755,0.335,-0.53/,T0,DT /459.67,400.0/
00112     10*           THETA = (T-T0)/DT
00113     11*           ELAS = (((X4*THETA+X3)*THETA+X2)*THETA+X1)*1.0E06
00114     12*           ELAS = ELAS*144.0
00115     13*           IF (T.GE.400.0.AND.T.LE.1700.0) RETURN
00117     14*           WRITE (6,1) T
00122     15*         1 FORMAT (1H0,59HMODULUS OF ELASTICITY OF BERYLIUM, TEMP. OUT OF RAN
00122     16*          1GE, T = ,F8.3,/)
00123     17*           RETURN
00124     18*           END

      END OF COMPILATION:      NO  DIAGNOSTICS.


@HDG,P  ******  ELAS/MPCU  ******
```

```
****** ELAS/MPCU ******                                                                              DATE 071372        PAGE     1

QFOR,S ME*NASA5.ELAS/MPCU,ME*NASA5.ELAS/MPCU
FOR S9A-07/13/72-20:56:13 (0,)

   FUNCTION ELAS        ENTRY POINT 000055

   STORAGE USED: CODE(1) 000061; DATA(0) 000040; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   NWDU$
    0004   NIO2$
    0005   NERR3$

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

    0000   000010 1F        0000 R 000006 DT        0000 R 000000 ELAS      0000   000032 INJP$      0000 R 000007 THETA
    0000 R 000005 T0        0000 R 000001 X1        0000 R 000002 X2        0000 R 000003 X3          0000 R 000004 X4


00101      1*            FUNCTION ELAS(T)
00101      2*      C
00101      3*      C        THIS FUNCTION SUBPROGRAM COMPUTES :
00101      4*      C      MODULUS OF ELASTICITY AS A FUNCTION OF TEMPERATURE (R) OF
00101      5*      C             COPPER
00101      6*      C                                    UNITS LBF/SQ.FT
00101      7*      C             TEMP. GE. 400.0 AND LE. 1800.0 R
00101      8*      C
00103      9*            DATA X1,X2,X3,X4 /16.55,-0.4933,-1.935,0.2283/,T0,DT /459.67,400./
00112     10*            THETA = (T-T0)/DT
00113     11*            ELAS = (((X4*THETA+X3)*THETA+X2)*THETA+X1)*1.0E06
00114     12*            ELAS = ELAS*144.0
00115     13*            IF (T.GE.400.0.AND.T.LE.1800.0) RETURN
00117     14*            WRITE (6,1) T
00122     15*          1 FORMAT (1H0,57HMODULUS OF ELASTICITY OF COPPER, TEMP. OUT OF RANGE
00122     16*           1, T = ,F8.3,/)
00123     17*            RETURN
00124     18*            END

       END OF COMPILATION:        NO  DIAGNOSTICS.


QHDG,P  ******  EMIT/SCZ93  ******
```

```
****** EMIT/SCZ93 ******                                                    DATE 071372        PAGE      1

@FOR,S ME*NASA5.EMIT/SCZ93,ME*NASA5.EMIT/SCZ93
FOR S9A-07/13/72-20:56:16 (0,)

   FUNCTION EMIT        ENTRY POINT 000030

   STORAGE USED: CODE(1) 000035; DATA(0) 000016; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   POLY
    0004   NERR3$

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

    0001   000016 1L       0000 R 000001 A        0000 R 000000 EMIT      0000   000011 INJP$     0003 R 000000 POLY


00101      1*            FUNCTION EMIT(T)
00101      2*      C
00101      3*      C   THIS SUBROUTINE COMPUTES :
00101      4*      C     THE TOTAL HEMISPHERICAL EMITTANCE AS A FUNCTION OF THE SURFACE
00101      5*      C     TEMPERATURE (R)
00101      6*      C
00103      7*            DIMENSION A(5)
00104      8*            DATA  A(1),A(2),A(3),A(4),A(5)/0.8990103E+00, -0.1400633E-03,
00104      9*          1       0.3879700E-06, -0.3937509E-09, 0.1015627E-12/
00112     10*            IF(T.GE.1600.0) GO TO 1
00114     11*            EMIT  = POLY(5,A,T)
00115     12*            RETURN
00116     13*          1 EMIT  = 0.228
00117     14*            RETURN
00120     15*            END

      END OF COMPILATION:       NO  DIAGNOSTICS.


@HDG,P  ******  ENTAIR  ******
```

```
@FOR,S ME*NASA5.ENTAIR,ME*NASA5.ENTAIR
FOR S9A-07/13/72-20:56:20 (0,)

   FUNCTION ENTAIR        ENTRY POINT 000204

   STORAGE USED: CODE(1) 000225; DATA(0) 000071; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   ALOG
    0004   SQRT
    0005   NERR3$

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

    0001    000157 10L     0001    000103 5L      0000 R 000001 A       0000 R 000000 ENTAIR    0000 R 000032 ENTN
    0000 R 000033 ENTJ     0000 R 000013 ENTO     0000 R 000015 ENT00   0000 R 000007 FMN       0000 R 000006 FMO
    0000   000053 INJP$    0000 R 000031 TLOG     0000 R 000030 TMT     0000 R 000026 TMO       0000 R 000027 TOT
    0000 R 000012 TTO      0000 R 000014 T00      0000 R 000022 T02     0000 R 000023 T03       0000 R 000024 T04
    0000 R 000025 T05      0000 R 000016 T2       0000 R 000017 T3      0000 R 000020 T4        0000 R 000021 T5
    0000 R 000011 WMN      0000 R 000010 WMO


00101                FUNCTION ENTAIR(T)
00101          C
00101          C        THIS FUNCTION SUBPROGRAM COMPUTES :
00101          C        ENTHALPY OF AIR AS A FUNCTION OF TEMPERATURE (R)
00101          C                                    UNITS BTU/LBM
00101          C
00103                DIMENSION A(5)
00104                DATA A(1),A(2),A(3),A(4),A(5)/0.34240E+00,-0.95225E-03,
00104               1      0.31862E-05,-0.45750E-08,0.23750E-11/
00112                DATA FMO,FMN,WMO,WMN,TTO,ENTO/0.234559,0.765441,31.9988,28.0134,
00112               1 600.,143.47 /
00121                DATA T00,ENT00/300.,71.61/
00124                T2     = T**2
00125                T3     = T2*T
00126                T4     = T2*T2
00127                T5     = T2*T3
00130                T02    = T00**2
00131                T03    = T02*T00
00132                T04    = T02*T02
00133                T05    = T03*T02
00134                TMO    = T-T00
00135                TOT    = T/TTO
00136                TMT    = T-TTO
00137                TLOG   = LOG(TOT)
00140                IF (T .GT. 600.) GO TO 5
00142                ENTAIR = ENT00+A(1)*TMO+(A(2)/2.)*(T2-T02)+(A(3)/3.)*
00142               1        (T3-T03)+(A(4)/4.)*(T4-T04)+(A(5)/5.)*(T5-T05)
00143                RETURN
```

```
    5 ENTN   = 9.47*TMT-3470.*TLOG-1.16E+06*(1./T-1./TT0)
      ENTO   = 11.515*TMT-344.*(SQRT(T)-SQRT(TT0))+1530.*TLOG
      IF (T .LT. 5000.) GO TO 10
      ENTO   = ENTO+5.E-05*((T2-TT0**2)/2.-4000.*TMT)
   10 ENTAIR  =  ENTO+FMO*ENTO/WMO+FMN*ENTN/WMN
      RETURN
      END
```

END OF COMPILATION: NO DIAGNOSTICS.

@HDG,P ****** EXITAV ******

```
@FOR,S ME*NASA5.EXITAV,ME*NASA5.EXITAV
FOR S9A-07/13/72-20:56:23 (0,)

   SUBROUTINE EXITAV    ENTRY POINT 000076

   STORAGE USED: CODE(1) 000110; DATA(0) 000030; BLANK COMMON(2) 000000

    COMMON BLOCKS:

    0003    QRD     003721
    0004    QIN     001610
    0005    ABSRST  000601

   EXTERNAL REFERENCES (BLOCK, NAME)

    0006    NERR3$

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

    0001    000012 111G      0001    000021 114G      0005 R 000000 ALPHFN    0005 R 000226 ALPHMP    0003    003465 CSF
    0003    003464 DXX2      0003    003472 DXX21     0003    003463 DZMFN     0003 R 003410 EBFN      0003 R 003441 EBMP
    0005 R 000461 EMITFN    0005 R 000512 EMITMP    0003 R 003467 EXTIFN    0003 R 003471 EXTIMP    0003 R 003466 EXTSFN
    0003 R 003470 EXTSMP    0005 R 000517 EXTVCT    0000 I 000002 I         0000    000010 INJP$     0000 I 000003 J
    0000 I 000004 K         0003    003461 LCT       0003    003462 LTT       0003    003460 MCVRD     0004    001605 NSRD
    0004    001604 NTM       0004    000454 QIFN      0004    001274 QITB      0004    000144 QSFN      0004    000764 QSTB
    0004    001606 QTO       0003    003473 SS        0003    003670 SSTT      0004    000000 TM        0003    000000 TRMTX
    0004    001607 TX        0003    003446 XX2       0000 R 000000 ZFN       0000 R 000001 ZMP       0003    003453 ZZ2


00101                   SUBROUTINE EXITAV
00101            C
00101            C    THIS SUBROUTINE COMPUTES :
00101            C      THE EXITATION VECTOR NECESSARY FOR THE CALCULATION OF THE INCIDENT
00101            C      NET RADIANT FLUX
00101            C
00103                   COMMON /QRD/ TRMTX(30,60),EBFN(5,5),EBMP(5),XX2(5),ZZ2(5),
00103                 1              MCVRD,LCT,LTT,DZMFN,
00103                 2              DXX2,CSF,EXTSFN,EXTIFN,EXTSMP,EXTIMP,DXX21,SS(5,5,5)
00103                 3              ,SSTT(5,5)
00104                   COMMON /QIN/TM(100), QSFN(100,2), QIFN(100,2), QSTB(100,2),
00104                 1             QITB(100,2), NTM, NSRD, QTO, TX
00105                   COMMON /ABSRST/ALPHFN(5,5,6),ALPHMP(5,31),EMITFN(5,5),EMITMP(5),
00105                 1                EXTVCT(50)
00106                   ZFN    = EXTSFN+EXTIFN
00107                   ZMP    = EXTSMP+EXTIMP
00110                   DO 16 I=1,5
00113                   DO 15 J=1,5
00116                   K      =(I-1)*5 +J
00117                15 EXTVCT(K) = EMITFN(J,I)*EBFN(J,I)+(1.0-ALPHFN(I,J,6))*ZFN
00121                   K      =I+25
00122                16 EXTVCT(K) = EMITMP(I)*EBMP(I)+(1.0-ALPHMP(I,31))*ZMP
```

```
00124     23*          RETURN
00125     24*          END

      END OF COMPILATION:        NO  DIAGNOSTICS.

@HDG,P  ******  FINT  ******
```

```
@FOR,S ME*NASA5.FINT,ME*NASA5.FINT
FOR S9A-07/13/72-20:56:25 (0,)

   SUBROUTINE FINT      ENTRY POINT 000075

   STORAGE USED: CODE(1) 000111; DATA(0) 000027; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   NERR3$

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

    0001   000043 111G      0000 R 000000 DDX       0000   000010 INJP$     0000 I 000001 J


00101          SUBROUTINE FINT(Y,Y0,DX,N,F)
00101    C
00101    C   THIS SUBROUTINE COMPUTES :
00101    C     THE INDEFINITE INTEGRAL BY SIMPSONS RULE OF THE EQUALLY-SPACED
00101    C     ARRAY Y(N)
00101    C
00103          DIMENSION Y(N),F(N)
00104          F(1) = Y0
00105          DDX = DX/24.
00106          F(2) = F(1)+DDX*(9.*Y(1)+19.*Y(2)-5.*Y(3)+Y(4))
00107          F(3) = F(2)+DDX*(-Y(1)+13.*(Y(2)+Y(3))-Y(4))
00110          DO 1 J=4,N
00113        1 F(J) = F(J-1)+DDX*(9.*Y(J)+19.*Y(J-1)-5.*Y(J-2)+Y(J-3))
00115          RETURN
00116          END
      END OF COMPILATION:        NO  DIAGNOSTICS.


@HDG,P  ******  FLSTRT  ******
```

```
@FOR,S ME*NASA5.FLSTRT,ME*NASA5.FLSTRT
FOR S9A-07/13/72-20:56:28 (0,)

   SUBROUTINE FLSTRT     ENTRY POINT 000231

   STORAGE USED: CODE(1) 000245; DATA(0) 000233; BLANK COMMON(2) 001115

    COMMON BLOCKS:

    0003   DVCMFL 000002
    0004   FLCMP  000024

   EXTERNAL REFERENCES (BLOCK, NAME)

    0005   DERIVL
    0006   CNTLN
    0007   RHOF
    0010   CPF
    0011   TRNSPT
    0012   DDX
    0013   RKSF
    0014   NERR2$
    0015   NWDJ$
    0016   NIO2$
    0017   NERR3$

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

    0001     000046 10L      0000     000051 115F     0000     000127 120F     0001     000076 15L      0001     000120 20L
    0001     000143 25L      0001     000010 5L       0000 R 000006 AL       0002     000562 AUX2     0006 R 000000 CNTLN
    0002     000752 COB      0002     001107 COH      0002     000574 CONFN    0002     000740 CONMP    0010 R 000000 CPF
    0002 R 001070 CPD      0002     001072 DELTA    0000 R 000014 DELY     0005 R 000000 DERIVL   0002     000764 DOB
    0004 R 000000 DTHETA   0002     001110 DXI      0002     001053 DXIMP    0002     001052 DXITB    0000 R 000003 DY
    0000 R 000030 DYST     0002 R 001051 DZ       0002     001103 FENTH    0002     001045 FFO      0002     001101 FLUX
    0003     000001 FLUXI    0002 R 001041 FMACH    0002 R 001040 FNU      0002     001046 FOF      0002     000012 FP
    0002 R 001042 FPR      0002 R 001037 FR       0002     001050 FRAD     0002     001111 FRD      0002     001036 FRE
    0002     001104 FREJ     0002     001043 FRL      0002     001044 FRM      0002 R 000036 FT       0000 R 000047 FT1
    0002     000024 FW       0002     001113 FXHW     0002     001112 FXOH     0002 R 001047 FZ       0002     001105 HFN
    0000 I 000043 IBKP     0000 I 000045 IERR     0002 I 001003 IFLOW    0000     000223 INJP$    0000 I 000042 ISTP
    0002     001024 LC       0002     001032 LIM      0002     001031 LIMWRT   0002     001011 LL1      0002     001012 LL2
    0002     001013 LL3      0002     001014 LL4      0002     001015 LL5      0002     001016 LL6      0002     001017 LL7
    0002     001006 LMP      0002     001004 LT       0002     001005 LTB      0002     001007 LTBMZ    0002     001010 LTB2MZ
    0002     001030 MM1      0002     001033 MOD      0002     001025 MSTOTR   0002 I 000777 MZ       0002     001034 NCCZ
    0002     001035 NCONV    0002 I 001002 NCTL     0002     001026 NCTM     0000 I 000046 NEQ      0002     001023 NEQUS
    0002     001027 NM1      0002     001001 NRMP     0002     001020 NRMP1    0002     001022 NRMP2    0002     001000 NRTB
    0002     001021 NRTB1    0000 I 000044 NTRY     0002     000776 NX       0000 R 000017 PD       0002     001063 PHIF
    0002     001062 PHIM     0002     001071 PI       0002 R 001065 PO       0002     001102 QREF     0002     000360 QRFN
    0002     000524 QRMP     0002     001074 RDTWRT   0007 R 000000 RHOF     0002     001114 RHOFN    0002 R 001067 RHOO
    0000 R 000011 RL       0002     001073 RLIMIT   0002     001100 RTEND    0000 R 000022 SD       0002     000132 TEMP
    0002 R 001077 TI       0002     001076 TINTL    0002     000276 TMP      0002     001075 TREF     0002     000050 TW
    0002 R 001064 TO       0003 R 000000 WRAT     0002 R 001066 WO       0002     000536 XIFN     0002     000005 XIMP
    0002     000000 XITB     0002     001106 XL       0000 R 000050 XP       0002     001054 XRE      0002     001057 XX10
    0002     001060 XX11     0002     001061 XX12     0002     001055 XX3      0002     001056 XX4      0000 R 000000 Y
```

```
0000 R 000025 YS       0000 R 000036 YSIMP     0000 R 000033 YST       0000 R 000041 Z        0002   000550 ZETA

00101             SUBROUTINE FLSTRT(RE,PRL,DLTA)
00101       C
00101       C   THIS SUBROUTINE PROVIDES :
00101       C     1- FLUID FLOW (INITIAL AND CURRENT) CONDITIONS
00101       C     2- TABLE HEADING FOR INITIAL CONDITIONS
00101       C
00103             COMMON XITB(5),XIMP(5),FP(10),FW(10),FT(10),TW(10,5),TEMP(10,10),
00103            1        TMP(10,5),QRFN(10,10),QRMP(10),XIFN(10),ZETA(10),AUX2(10),
00103            2        CONFN(10,10),CONMP(10),COB(10),DOB(10)
00104             COMMON NX,MZ,NRTB,NRMP,NCTL,IFLOW,LT,LTB,LMP,LTBMZ,LTB2MZ,LL1,
00104            1       LL2,LL3,LL4,LL5,LL6,LL7,NRMP1,NRTB1,NRMP2,NEQUS,LC,MSTOTR,
00104            2       NCTM,NM1,MM1,LIMWRT,LIM,MOD,NCCZ,NCONV
00105             COMMON FRE,FR,FNU,FMACH,FPR,FRL,FRM,FFO,FOF,FZ,FRAD,DZ,DXITB,DXIMP
00105            1        ,XRE,XX3,XX4,XX10,XX11,XX12,PHIM,PHIF,TO,P0,W0,RHO0,CP0,PI
00105            2        ,DELTA,RLIMIT,RDTWRT,TREF,TINTL,TI,RTEND,FLUX,QREF,FENTH,
00105            3        FREJ,HFN,XL,COH,DXI,FRD,FXOH,FXHW,RHOFN
00106             COMMON /DVCMFL/ WRAT,FLUXI
00107             COMMON /FLCMP/ DTHETA(20)
00107       C
00110             DIMENSION Y(3),DY(3),AL(3),RL(3),DELY(3),PD(3),SD(3),YS(3),          04
00110            1          DYST(3),YST(3),YSIMP(3)                                    05
00111             EXTERNAL DERIVL,CNTLN                                               06
00111       C
00112             GO TO (5,10), IFLOW
00113           5 RHO0 = RHOF(P0,T0)                                                   08
00114             CP0 =  CPF(RHO0,T0)
00115             FPR = P0/(RHO0*W0**2)                                               09
00116             FZ = P0/(RHO0*T0*CP0*778.16)
00117             FMACH   = W0**2/(T0*CP0*778.16)
00120          10 CALL TRNSPT (RE,PRL,DLTA,FR,FNU)
00120       C                                                                      012
00120       C     INITIALIZATION                                                   013
00121             Z    = 0.0
00122             ISTP = 1                                                           016
00123             IBKP = 1                                                           017
00124             NTRY = 1                                                           018
00125             IERR = 0                                                           019
00126             NCTL = 1                                                           020
00127             Y(1) = 1.0
00130             GO TO (15,20),IFLOW
00131          15 Y(2) = RHO0/RHOF(P0,TI)*WRAT
00132             Y(3) = FT(1)
00133             NEQ  = 3
00134             WRITE (6,115)
00136             GO TO 25
00137          20 FT1  = FT(1)*T0
00140             Y(2) = RHO0/RHOF(P0,FT1)*WRAT
00141             NEQ  = 2
00142             CALL DDX(FT,DTHETA,DZ,MZ)
00143          25 CALL RKSF (DERIVL,CNTLN,Y,DY,AL,RL,Z,DZ,NEQ,ISTP,IBKP,NTRY,
00143            1          IERR,DELY,PD,SD,YS,YST,DYST,YSIMP)                    031
00144             IF(IFLOW.EQ.2) RETURN
```

```
00146     53*           XP    = FPR/2.0                                                     032
00147     54*           WRITE (6,120) PO,WO,TO,RE,PRL,DLTA,XP
00160     55*           IFLOW    = 2
00161     56*           RETURN                                                              041
00162     57*       115 FORMAT(1H1,15X,23HINITIAL LINE CONDITIONS,/,16X,23H******* **** **   25
00162     58*          1********,/,25X,31H(ALL QUANTITIES ARE NORMALIZED),/,83X,5HFLUID,15  026
00162     59*          2X,4HWALL,/,15X,16HPT.NO.  POSITION,11X,8HPRESSURE,12X,8HVELOCITY,   027
00162     60*          311X,11HTEMPERATURE,9X,11HTEMPERATURE,/,26X,1HZ,18X,1HP,19X,1HW,19X  028
00162     61*          4,1HT,18X,3HTWI,/)                                                   029
00163     62*       120 FORMAT(1H0,5X,25HINLET PRESSURE    PO  =  ,F10.3,11H  LBF/SQ.FT,/,  034
00163     63*          1            6X,25HREF.  VELOCITY    WO  =  ,F10.5,11H  FT/SEC    ,/, 035
00163     64*          2            6X,25HREF. TEMPERATURE TOO  =  ,F10.3,11H  R         ,// 036
00163     65*          3            6X,25H      REYNOLDS NO      =  ,E20.5,/,
00163     66*          4            6X,25H      PRANDTL  NO      =  ,F20.6,/,               038
00163     67*          5            6X,25H      DELTA            =  ,F20.6,/,
00163     68*          6            6X,25H      REL.PRESSURE IS     ,E20.6,//)              039
00163     69*     C                                                                         040
00164     70*           END                                                                 042
```

END OF COMPILATION: NO DIAGNOSTICS.

@HDG,P ****** FMINV ******

```
@FOR,S ME*NASA5.FMINV,ME*NASA5.FMINV
FOR S9A-07/13/72-20:56:31 (0,)

   SUBROUTINE FMINV     ENTRY POINT 000254

   STORAGE USED: CODE(1) 000306; DATA(0) 001260; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   NERR3$

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

    0001    000046 105G     0001    000151 11L      0001    000051 111G     0001    000071 117G     0001    000104 123G
    0001    000125 133G     0001    000130 137G     0001    000172 150G     0001    000175 154G     0001    000227 164G
    0001    000212 20L      0000 R 001214 AA        0000 R 001217 B         0000 I 001212 I         0000    001224 INJP$
    0000 I 001215 I1        0000 I 001220 I2        0000 I 001213 J         0000 I 001216 K         0000 R 000000 XMAT

00101           SUBROUTINE FMINV (A,X,N,M)
00103           DIMENSION A(N,N),X(N),XMAT(25,26)
00104           DO 1 I=1,N
00107           XMAT(I,M) = X(I)
00110           DO 1 J=1,N
00113         1 XMAT(I,J) = A(I,J)
00116           DO 20 I=1,N
00121           AA = XMAT(I,I)
00122           DO 5 J=1,M
00125         5 XMAT(I,J) = XMAT(I,J)/AA
00127           IF (I.EQ.1) GO TO 11
00131           I1 = I-1
00132           DO 10 K=1,I1
00135           B = XMAT(K,I)
00136           DO 10 J=1,M
00141        10 XMAT(K,J) = XMAT(K,J) - XMAT(I,J) * B
00144           IF (I.EQ.N) GO TO 20
00146        11 I2 = I+1
00147           DO 15 K=I2,N
00152           B = XMAT(K,I)
00153           DO 15 J=1,M
00156        15 XMAT(K,J) = XMAT(K,J) - XMAT(I,J) * B
00161        20 CONTINUE
00163           DO 25 I=1,N
00166        25 X(I) = XMAT(I,M)
00170           RETURN
00171           END

      END OF COMPILATION:        NO  DIAGNOSTICS.
```

```
****** HFL/CFFC43 ******                                                                DATE 071372        PAGE     1

@FOR,S ME*NASA5.HFL/CFFC43,ME*NASA5.HFL/CFFC43
FOR S9A-07/13/72-20:56:34 (0,)

   FUNCTION HFL          ENTRY POINT 000022

   STORAGE USED: CODE(1) 000024; DATA(0) 000014; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   NERR3$

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

    0000 R 000000 HFL       0000   000007 INJP$      0000 R 000004 THETA     0000 R 000003 T0         0000 R 000001 X1
    0000 R 000002 X2


00101       1*            FUNCTION HFL(RHO,T)
00101       2*      C        ENTHALPY AS A FUNCTION OF DENSITY (SLUG/CU.FT) AND
00101       3*      C             TEMPERATURE (R) OF FC-43
00101       4*      C                                    UNITS BTU/SLUG
00103       5*            DATA X1,X2 /-0.020092,5.4054E-04/,T0 /401.67/
00107       6*            THETA = T-T0
00110       7*            HFL   = (X1+X2*(T+T0)/2.0)*THETA*32.174
00111       8*            RETURN
00112       9*            END

       END OF COMPILATION:        NO  DIAGNOSTICS.

@HDG,P  ****** HFL/CFFC75  ******
```

```
@FOR,S ME*NASA5.HFL/CFFC75,ME*NASA5.HFL/CFFC75
FOR S9A-07/13/72-20:56:36 (0,)

   FUNCTION HFL         ENTRY POINT 000022

   STORAGE USED: CODE(1) 000024; DATA(0) 000014; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   NERR3$

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

    0000 R 000000 HFL       0000   000007 INJP$     0000 R 000004 THETA     0000 R 000003 TO        0000 R 000001 X1
    0000 R 000002 X2


00101      1*          FUNCTION HFL(RHO,T)
00101      2*     C
00101      3*     C       THIS FUNCTION SUBPROGRAM COMPUTES :
00101      4*     C       ENTHALPY AS A FUNCTION OF DENSITY (SLUG/CU.FT) AND
00101      5*     C            TEMPERATURE (R) OF FC-75
00101      6*     C                                    UNITS BTU/SLUG
00101      7*     C
00103      8*          DATA X1,X2 /0.115082,2.4333E-04/,TO /324.67/
00107      9*          THETA = T-TO
00110     10*          HFL   = (X1+X2*(T+TO)/2.0)*THETA*32.174
00111     11*          RETURN
00112     12*          END

      END OF COMPILATION:         NO  DIAGNOSTICS.


@HDG,P  ******  HFL/CFHE  ******
```

```
****** HFL/CFHE ******                                                    DATE 071372        PAGE    1

QFOR,S ME*NASA5.HFL/CFHE,ME*NASA5.HFL/CFHE
FOR S9A-07/13/72-20:56:37 (0,)

   FUNCTION HFL        ENTRY POINT 000110

   STORAGE USED: CODE(1) 000124; DATA(0) 000047; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   PF
    0004   NERR3$

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

    0000 R 000005 A         0000 R 000002 A1       0000 R 000003 B1        0000 R 000004 C        0000 R 000016 DRHO
    0000 R 000017 DRHO2     0000 R 000013 DT       0000 R 000015 DTM2      0000 R 000000 HFL      0000   000034 INJP$
    0000 R 000022 P         0003 R 000000 PF       0000 R 000001 R         0000 R 000011 RHOX     0000 R 000010 RHO0
    0000 R 000014 TM2       0000 R 000012 TX       0000 R 000007 T0        0000 R 000021 UFL      0000 R 000006 U0
    0000 R 000020 Y


00101       1*          FUNCTION HFL(RHO,T)
00101       2*     C
00101       3*     C       THIS FUNCTION SUBPROGRAM COMPUTES :
00101       4*     C       ENTHALPY AS A FUNCTION OF DENSITY (SLUG/CU.FT) AND
00101       5*     C            TEMPERATURE (R) OF HELIUM
00101       6*     C                                     UNITS BTU/SLUG
00101       7*     C
00103       8*          DATA R,A1,B1,C,A /2077.02,136.9595,3.5002295E-03,10.000658,1.49610
00103       9*         13E-02/,U0,T0,RHO0 /39922.0,10.938889,4.669193/
00114      10*          RHOX = RHO*515.4275
00115      11*          TX   = T/1.8
00116      12*          DT   = TX-T0
00117      13*          TM2  = 1.0/(TX*TX)
00120      14*          DTM2 = 1.0/(T0*T0)-TM2
00121      15*          DRHO = RHO0-RHOX
00122      16*          DRHO2= RHOX*RHOX-RHO0*RHO0
00123      17*          Y    = 3.0*R*C*TM2
00124      18*          UFL  = U0+R*(1.5*DT+141.22973*DTM2)+(Y+A1)*DRHO-(Y*B1-A1*A)*DRHO2/
00124      19*         12.0
00125      20*          P    = PF(RHO,T)
00126      21*          HFL  = UFL*0.013844+P/(RHO*778.26)
00127      22*          RETURN
00130      23*          END

      END OF COMPILATION:       NO  DIAGNOSTICS.


QHDG,P ****** HFL/CFNAK. ******
```

```
****** HFL/CFNAK ******                                                    DATE 071372        PAGE      1

@FOR,S ME*NASA5.HFL/CFNAK,ME*NASA5.HFL/CFNAK
FOR S9A-07/13/72-20:56:40 (0,)

   FUNCTION HFL         ENTRY POINT 000100

   STORAGE USED: CODE(1) 000112; DATA(0) 000037; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   CAPPA
    0004   PF
    0005   ALOG
    0006   NERR3$

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

    0000 R 000017 C        0003 R 000000 CAPPA     0000 R 000010 C1       0000 R 000011 C2        0000 R 000007 DT
    0000 R 000000 HFL      0000 R 000014 H1        0000 R 000020 H2       0000   000030 INJP$     0004 R 000000 PF
    0000 R 000012 P0       0000 R 000016 P1        0000 R 000013 THETA    0000 R 000015 TK        0000 R 000006 T0
    0000 R 000001 X1       0000 R 000002 X2        0000 R 000003 X3       0000 R 000004 X4        0000 R 000005 X5


00101              FUNCTION HFL(RHO,T)
00101        C
00101        C        THIS FUNCTION SUBPROGRAM COMPUTES :
00101        C        ENTHALPY AS A FUNCTION OF DENSITY (SLUG/CU.FT) AND
00101        C              TEMPERATURE (R) OF NAK 78.6
00101        C                                              UNITS BTU/SLUG
00101        C
00103              DATA X1,X2,X3,X4,X5 /0.2255,-0.016292,0.005396,-0.000758,0.000054/
00103             1,T0,DT /469.67,300.0/,C1,C2 /58.773064,-0.008433/,P0 /2116.224/
00116              THETA = (T-T0)/DT
00117              H1    = ((((X5*THETA/5.0+X4/4.0)*THETA+X3/3.0)*THETA+X2/2.0)*THETA
00117             1+X1)*(T-T0)
00120              TK    = CAPPA(RHO,T)
00121              P1    = PF(RHO,T)-P0
00122              C     = C1+C2*T
00123              H2    = ((1.0+T*C2/C)*ALOG(1.0+TK*P1))/(C*TK*778.26)
00124              HFL   = (H1+H2)*32.174
00125              RETURN
00126              END
        END OF COMPILATION:        NO  DIAGNOSTICS.


@HDG,P ****** HFL/CFSIL ******
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```
@FOR,S ME*NASA5.HFL/CFSIL,ME*NASA5.HFL/CFSIL
FOR S9A-07/13/72-20:56:42 (0,)

   FUNCTION HFL         ENTRY POINT 000300

   STORAGE USED: CODE(1) 000326; DATA(0) 000132; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   PF
    0004   POLY
    0005   NWDU$
    0006   NIO2$
    0007   NERR3$

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

    0000   000051 1F       0000 R 000040 A        0000 R 000007 A1     0000 R 000041 A11    0000 R 000010 A2
    0000 R 000011 A3       0000 R 000012 A4       0000 R 000013 A5     0000 R 000042 B      0000 R 000014 B1
    0000 R 000043 B11      0000 R 000015 B2       0000 R 000016 B3     0000 R 000017 B4     0000 R 000020 B5
    0000 R 000044 C        0000 R 000021 C1       0000 R 000045 C11    0000 R 000022 C2     0000 R 000025 DT
    0000 R 000033 DT2      0000 R 000000 HFL      0000 R 000037 H1     0000 R 000050 H2     0000   000114 INJP$
    0000 R 000046 P        0003 R 000000 PF       0004 R 000000 POLY   0000 R 000047 P1     0000 R 000034 THETA
    0000 R 000035 THETA1   0000 R 000036 THETA2   0000 R 000023 T0     0000 R 000024 T01    0000 R 000032 T02
    0000 R 000026 X1       0000 R 000027 X2       0000 R 000030 X3     0000 R 000031 X4     0000 R 000001 Z


00101          FUNCTION HFL(RHO,T)
00101     C
00101     C       THIS FUNCTION SUBPROGRAM COMPUTES :
00101     C       ENTHALPY AS A FUNCTION OF DENSITY (SLUG/CU.FT) AND
00101     C            TEMPERATURE (R) OF DOW CORNING 200 SILICON OIL (1 CS)
00101     C                                UNITS BTU/SLUG
00101     C            TEMPERATURE .GE. 359.67 AND .LE. 859.67
00101     C
00103          DIMENSION Z(6)
00104          DATA A1,A2,A3,A4,A5 /12.35,2.98333,1.1,-0.48333,0.1/,B1,B2,B3,B4,B
00104         15 /-1.5,-0.01333,-1.18,0.57333,-0.1/,C1,C2 /0.7767,-0.0288/,T0,T01
00104         2,DT /559.67,609.67,50.0/,X1,X2,X3,X4 /0.46,0.00471,0.00141,0.00004
00104         33/,T02,DT2 /539.67,80.0/
00132          THETA  = (T-T0)/DT
00133          THETA1 = (T-T01)/DT
00134          THETA2 = (T-T02)/DT2
00135         H1   = (((X4*THETA2/4.0+X3/3.0)*THETA2+X2/2.0)*THETA2+X1)*(T-T02)
00136         A    = ((((A5*THETA+A4)*THETA+A3)*THETA+A2)*THETA+A1)*1.0E-06
00137         A11 = (((4.0*A5*THETA+3.0*A4)*THETA+2.0*A3)*THETA+A2)*(1.0E-06)/DT
00140         B    = ((((B5*THETA+B4)*THETA+B3)*THETA+B2)*THETA+B1)*1.0E-09
00141         B11 = (((4.0*B5*THETA+3.0*B4)*THETA+2.0*B3)*THETA+B2)*(1.0E-09)/DT
00142         C    = C1+C2*THETA1
00143         C11  = C2/DT
00144         P   = PF(RHO,T)
```

```
00145     25*          P1 = P/144.0-14.696
00146     26*          Z(1)= 0.0
00147     27*          Z(2)= 1+T*C11/C
00150     28*          Z(3)= (A11*T-A*Z(2))/2.0
00151     29*          Z(4)= (T*(B11-A*A11)-B*Z(2))/6.0
00152     30*          Z(5)= -(A*B11+A11*B)*T/8.0
00153     31*          Z(6)= -B*B11*T/20.0
00154     32*          H2  = POLY(6,Z,P1)
00155     33*          HFL = (H1+H2/(C*337.37))*32.174
00156     34*          IF (T.LT.360.67.OR.T.GT.860.67.OR.P.GT.146116.224.OR.P.GT.110116.2
00156     35*         124.AND.T.LT.460.67) WRITE(6,1) T,P
00163     36*        1 FORMAT (1H0,43HENTHALPY OF SILICON OIL, OUT OT RANGE, T = ,F10.5,6
00163     37*         1H, P = ,F15.5,/)
00164     38*          RETURN
00165     39*          END

       END OF COMPILATION:        NO  DIAGNOSTICS.


@HDG,P  ******  INTERP  ******
```

```
@FOR,S ME*NASA5.INTERP,ME*NASA5.INTERP
FOR S9A-07/13/72-20:56:45 (0,)

   SUBROUTINE INTERP    ENTRY POINT 000171

   STORAGE USED: CODE(1) 000226; DATA(0) 000063; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   YINT
    0004   NERR3$

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

    0001   000037 105G      0001   000054 110G      0001   000062 115G      0001   000106 124G      0001   000122 127G
    0001   000130 134G      0000 I 000012 I         0000   000022 INJP$     0000 I 000014 J         0000 I 000013 K
    0000 R 000015 P         0003 R 000000 YINT      0000 R 000000 YY


00101             SUBROUTINE INTERP(NX1,MZ1,XX1,ZZ1,YY1,NX2,MZ2,XX2,ZZ2,YY2)
00101        C
00101        C  THIS SUBROUTINE MAPS A TWO-DIMENSIONAL FUNCTION YY1 FROM ONE GRID
00101        C  (XX1,ZZ1) ONTO ANOTHER TWO-DIMENSIONAL FUNCTION YY2 WITH ANOTHER GRID
00101        C  (XX2,ZZ2)
00101        C    NX1,MZ1  NUMBER OF NODAL POINTS OF THE ORIGINAL GRID (EACH LESS
00101        C             THAN OR EQUAL TO 10)
00101        C    NX2,MZ2  NUMBER OF NODAL POINTS OF THE NEW GRID (EACH LESS THAN
00101        C             OR EQUAL TO 10)
00101        C
00103             DIMENSION XX1(NX1), ZZ1(MZ1), YY1(10,10), YY(10), XX2(NX2),
00103            1          ZZ2(MZ2), YY2(10,10)
00104             DO 2 I  = 1,NX1
00107             DO 1 K  = 1,MZ1
00112           1 YY(K)   = YY1(K,I)
00114             DO 2 J  = 1,MZ2
00117             P       = ZZ2(J)
00120           2 YY2(J,I)= YINT(ZZ1,YY,MZ1,3,P)
00123             DO 4 J  = 1,MZ2
00126             DO 3 K  = 1,NX1
00131           3 YY(K)   = YY2(J,K)
00133             DO 4 I  = 1,NX2
00136             P       = XX2(I)
00137           4 YY2(J,I)= YINT(XX1,YY,NX1,3,P)
00142             RETURN
00143             END

      END OF COMPILATION:        NO  DIAGNOSTICS.


@HDG,P  ******  MAIN  ******
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```
@FOR,S ME*NASA5.MAIN,ME*NASA5.MAIN
FOR S9A-07/13/72-20:56:47 (0,)

  MAIN PROGRAM

  STORAGE USED: CODE(1) 003774; DATA(0) 006145; BLANK COMMON(2) 001115

   COMMON BLOCKS:

   0003   ADBH   000352
   0004   DVM    000002
   0005   VELALT 001132
   0006   CNV    000010
   0007   QRD    003721
   0010   QIN    001610
   0011   TC     000042
   0012   ABSRST 000601
   0013   SSF    000010
   0014   GEOM   000020
   0015   FLDINL 000457
   0016   DVCMFL 000002

  EXTERNAL REFERENCES (BLOCK, NAME)

   0017   DERIVM
   0020   CNTLM
   0021   TCALC
   0022   CLOSE
   0023   ADIABH
   0024   QINCID
   0025   TK
   0026   RHOF
   0027   VISC
   0030   CPF
   0031   THCF
   0032   HFL
   0033   FLSTRT
   0034   THCTB
   0035   THCMP
   0036   DEFINT
   0037   SHAPEF
   0040   RKS
   0041   NINTR$
   0042   NRNL$
   0043   NWDU$
   0044   NIO1$
   0045   NIO2$
   0046   NRDU$
   0047   NRBU$
   0050   NWBU$
   0051   NWNL$
   0052   SQRT
   0053   ASIN
   0054   NSTOP$
```

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

```
0000   005361 1055F   0001   002064 1076G   0001   001320 1100L   0001   002075 1104G   0001   002104 1112G
0001   002113 1120G   0001   002203 1140G   0001   002245 1151G   0000   005372 1155F   0001   002275 1163G
0001   000732 12L     0001   002730 1246G   0001   002731 1251G   0000   005403 1255F   0001   002735 1256G
0001   002742 1264G   0001   003113 1324G   0000   005406 1355F   0001   003360 1410G   0001   003363 1413G
0001   003431 1424G   0001   003434 1427G   0001   003477 1440G   0001   003506 1443G   0001   003530 1452G
0000   005425 1455F   0001   003537 1461G   0001   003662 1500G   0000   005167 155F    0000   005436 1555F
0000   005454 16F     0000   005447 2F      0001   000136 200L    0001   000032 2000L   0001   001360 2100L
0000   005455 22F     0001   000120 227G    0001   000160 237G    0001   001110 24L     0001   000161 242G
0001   000221 254G    0000   005207 255F    0001   000235 263G    0001   001167 28L     0000   005450 3F
0001   001217 30L     0001   000141 300L    0001   002761 312L    0000   005457 313F    0001   003107 314L
0001   000336 316G    0000   005476 320F    0000   005722 321F    0001   000364 325G    0001   000410 337G
0001   001472 34L     0001   003461 341L    0001   000426 346G    0000   005243 355F    0001   000444 355G
0001   000456 363G    0001   003656 364L    0001   000474 372G    0000   005452 4F      0001   000506 400G
0001   000524 407G    0001   000552 416G    0001   000564 424G    0001   000576 432G    0001   000610 440G
0000   005257 455F    0001   000644 455G    0001   000656 463G    0001   000670 472G    0001   000702 500G
0001   000171 500L    0001   000714 506G    0001   000726 514G    0001   000764 535G    0001   001012 543G
0001   001022 550G    0001   001030 554G    0000   005274 555F    0001   001036 560G    0001   001053 571G
0001   001070 603G    0000   005310 655F    0001   001211 665G    0001   001247 676G    0001   001255 703G
0001   001315 715G    0001   001336 722G    0001   001345 727G    0001   001416 740G    0000   005320 755F
0001   000614 8L      0001   000240 800L    0000   005332 855F    0000   005344 955F    0000   006017 9998F
0001   003770 9999L   0000 R 000621 A       0011 R 000003 ABEMF   0000 R 004355 AITB    0003 R 000001 AL
0000 R 004270 ALIMIT  0013   000002 ALPFN   0000 R 004256 ALPHA   0012   000000 ALPHFN  0012   000226 ALPHMP
0005 R 000310 ALTA    0005 R 000454 ALTR    0000 R 004265 AMAN    0000 R 004264 AN      0000 R 004300 ANGINC
0000 R 004263 AT?     0000 R 004371 ATOT    0002   000562 AUX2    0000 R 004361 BIOTNO  0000 R 004350 BOL
0000 R 004257 BT?     0020 R 000000 CNTLM   0002 R 000752 COB     0006 R 000007 COEFF   0002 R 001107 COH
0003   000161 CO'FL   0002 R 000574 CONFN   0003   000173 CONFNA  0002 R 000740 CONMP   0003   000147 CP
0030 R 000000 CPF     0002 R 001070 CPO     0007   003465 CSF     0013 R 000002 CTA     0003 R 000000 D
0036 R 000000 DEFINT  0002 R 001072 DELTA   0000 R 001441 DELY    0017 R 000000 DERIVM  0000 R 004325 DITB
0000 R 004241 DITBI   0002 R 000764 DOB     0000 R 004347 DTA     0003   000326 DTL     0000 R 004401 DTME
0000 R 004266 DT.RTE  0006 R 000003 DX      0002 R 001110 DXI     0000 R 004344 DXIFN   0002 R 001053 DXIMP
0002 R 001052 DXITB   0007 R 003464 DXX2    0007 R 003472 DXX21   0000 R 000311 DY      0000 R 003101 DYST
0002 R 001051 DZ      0007 R 003463 DZMFN   0007   003410 EBFN    0007   003441 EBMP    0003 R 000244 EFF
0003   000205 EMIS    0012   000461 EMITFN  0012   000512 EMITMP  0007   003467 EXTIFN  0007   003471 EXTIMP
0007   003466 EXTSFN  0007   003470 EXTSMP  0012   000517 EXTVCT  0002 R 001103 FENTH   0002 R 001045 FFO
0000   004600 FI?     0000   004444 FINA    0015   000456 FLDINT  0000 R 004364 FLMASI  0014 R 000016 FLMASS
0000   004565 FLOW    0000 R 004316 FLU     0000 R 004317 FLUID   0000   004457 FLUIDA  0002 R 001101 FLUX
0016 R 000001 FLUXI   0002   001041 FMACH   0000 R 004314 FNM     0000 R 004365 FNMASI  0000 R 004362 FNMASS
0000 R 004315 FN'TL   0002 R 001040 FNU     0002 R 001046 FOF     0002 R 000012 FP      0002   001042 FPR
0002   001037 FR      0002 R 001050 FRAD    0002 R 001111 FRD     0002 R 001036 FRE     0002 R 001104 FREJ
0002 R 001043 FRL     0002 R 001044 FRM     0002 R 000036 FT      0002 R 000024 FW      0002 R 001113 FXHW
0002 R 001112 FXOH    0002   001047 FZ      0000 R 004260 GAMMA   0000   004750 GINPT   0003 R 000013 H
0003 R 000231 HAB     0000 R 004231 HDG     0032 R 000000 HFL     0000 R 004356 HFLO    0002 R 001105 HFN
0000 R 004246 HF'I    0000 I 004301 I       0000 I 004404 IBKP    0011 I 000001 ICASE   0000 I 004405 IERR
0002 I 001003 IFLOW   0000 I 004403 IFVD    0000 I 004304 IH1     0000 I 004305 IH2     0006 I 000002 IOPTN
0000 I 004237 ISYM    0000 I 004323 IT      0011 I 000000 ITAPE   0000 I 004276 IU      0000 I 004322 IUL
0000 I 004277 IW      0000 I 004324 I1      0000 I 004302 J       0000 I 004311 K       0000 I 004307 K1
0000 I 004310 K2      0002 I 001024 LC      0007 I 003461 LCT     0015 I 000001 LFLD    0002 I 001032 LIM
0002 I 001031 LIMWRT  0002 I 001011 LL1     0002 I 001012 LL2     0002 I 001013 LL3     0002 I 001014 LL4
0002 I 001015 LL5     0002 I 001016 LL6     0002 I 001017 LL7     0002 I 001006 LMP     0002 I 001004 LT
0002 I 001005 LTB     0000 I 004376 LTBJ    0002 I 001007 LTBMZ   0002 I 001010 LTB2MZ  0000 I 004271 LTS
0007 I 003462 LTT     0003 R 000064 M       0000   004700 MANIFD  0007 I 003460 MCVRD   0002 R 001101 MDOT
0000 R 000000 MDOTI   0000 I 004345 MMEP    0002 I 001030 MM1     0002 I 001033 MODA    0000   004474 MRI
0000 I 004272 MRSTRT  0002 I 001025 MSTOTR  0002 I 000777 MZ      0005 I 001130 NA      0002 I 001034 NCCZ
0002 I 001035 NCONV   0002   001002 NCTL    0002 I 001026 NCTM    0002 I 001023 NEQUS   0015 I 000000 NFLDTA
0002 I 001027 NM1     0005 I 001131 NR      0002 I 001001 NRMP    0002 I 001020 NRMP1   0002 I 001022 NRMP2
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0002 I 001000 NRTB     0000 I 004244 NRTBI    0002 I 001021 NRTB1    0000 I 004306 NS       0006 I 000004 NSRAD
0010 I 001605 NSRD     0003 I 000076 NT       0014 I 000012 NTBS     0000 I 004274 NTF      0010 I 001604 NTM
0000 I 004402 NTRY     0000 I 004275 NT1      0002 I 000776 NX       0000 R 001751 PD       0000 R 004372 PFLD
0000 R 004261 PHI      0002 R 001063 PHIF     0002 R Q01062 PHIM     0011 R 000004 PHIN     0000 R 004240 PHN
0002 R 001071 PI       0003 R 000052 PIN      0000 R 004367 PLMASI   0014 R 000015 PLMASS   0000 R 004354 PRLNTL
0000 R 004320 PRO      0000 R 004255 PROB     0000 R 004321 PROMTL   0000   004627 PROTLR   0002 R 001065 P0
0010 R 000454 QIFN     0010   001274 QITB     0000   004515 QNML     0003   000314 QOUT     0002 R 001102 QREF
0002   000360 QRFN     0002   000524 QRMP     0010 R 000144 QSFN     0010 R 000764 QSTB     0010 R 001606 QTO
0000 R 001131 R        0002 R 001074 RDTWRT   0000 R 004353 REY      0026 R 000000 RHOF     0000 R 004374 RHOFLD
0002 R 001114 RHOFN    0000 R 004250 RHOFNI   0000 R 004352 RHOI     0000 R 004252 RHOMET   0000 R 004334 RHOMP
0000 R 004251 RHOMPI   0000 R 004333 RHOTB    0000 R 004243 RHOTBI   0002 R 001067 RHOO     0000 R 004331 RITB
0002 R 001073 RLIMIT   0000 R 004332 ROTB     0002 R 001100 RTEND    0000   004705 RUNOPT   0013 R 000003 R1
0013 R 000000 R2       0000 R 002261 SD       0014 R 000000 SFN      0000 R 004273 SIDE     0000 R 004351 SLOPE
0000 R 004336 SMP      0006 R 000005 SMPC     0000 R 004327 SROOT    0000 R 004245 SROOTI   0000 R 004340 SRO2
0007   003473 SS       0007   003670 SSTT     0006 R 000000 STAGX    0000 R 004326 STB      0000 R 004242 STBI
0000 R 004330 STIP     0000 R 004247 STIPI    0014 R 000017 STR      0006 R 000006 ST4      0000   004410 SYSTEM
0013 R 000001 T        0005 R 000000 TA       0000 R 004254 TAU      0000 R 004357 TAVG     0003   000217 TB
0000 R 004312 TBM      0000 R 004366 TBMASI   0014 R 000014 TBMASS   0000 R 004313 TBMTL    0002 R 000132 TEMP
0000 R 004267 TEND     0000 R 004373 TFLD     0003 R 000026 TH       0031 R 000000 THCF     0035 R 000000 THCMP
0034 R 000000 THCT3    0000 R 004262 THETA    0002 R 001077 TI       0015 R 000146 TIFLD    0000 R 004400 TIME
0003 R 000040 TIN      0002 R 001076 TINTL    0025 R 000000 TK       0003   000270 TL       0010 R 000000 TM
0015 R 000002 TMEFLD   0002 R 000276 TMP      0000 R 004335 TNN      0014 R 000013 TNXL     0011 R 000002 TO
0000 R 004346 TOL      0000 R 004370 TOTMSI   0000 R 004363 TOTMSS   0003 R 000340 TOUT     0005 R 000144 TR
0002 R 001075 TREF     0007   000000 TRMTX    0003 R 000077 TSTAR    0000 R 004303 TSTARM   0000   004536 TUBE
0000   004426 TUBEA    0002 R 000050 TW       0010   001607 TX       0002 R 001064 T0       0005 R 000620 VELA
0000 R 004253 VELM     0005 R 000764 VELR     0006 R 000001 VERTX    0027 R 000000 VISC     0003   000135 VSC
0000 R 006020 W        0015 R 000312 WIFLD    0016 R 000000 WRAT     0013 R 000006 WWA      0013 R 000007 WWB
0000 R 004337 WWC      0000 R 004343 WWD      0000 R 004341 WWR1     0000 R 004342 WWR2     0002 R 001066 W0
0000 R 006020 W1       0000 R 006033 W2       0000 R 004375 XFNU     0002 R 000536 XIFN     0002 R 000005 XIMP
0002 R 000000 XITB     0002 R 001106 XL       0000 R 004360 XNUSLT   0002 R 001054 XRE      0013 R 000005 XSMP
0013 R 000004 XSPM     0002 R 001057 XX10     0002 R 001060 XX11     0002 R 001061 XX12     0000 R 004377 XX13
0007 R 003446 XX2      0004 R 000000 XX20     0002 R 001055 XX3      0002 R 001056 XX4      0004 R 000001 XX48
0000 R 000001 Y        0000 R 002571 YS       0000 R 003721 YSIMP    0000 R 003411 YST      0002 R 000550 ZETA
0007 R 003453 ZZ2
```

```
00100      1*    C
00100      2*    C    THIS PROGRAM PROVIDES :
00100      3*    C      1- INPUT AND OUTPUT
00100      4*    C      2- UNIT CONVERSION
00100      5*    C      3- COMPUTATION OF DESIGN PARAMETERS
00100      6*    C      4- PREPARATION FOR PRINCIPLE INTEGRATION
00100      7*    C
00100      8*    C
00100      9*    C    INPUT DATA
00100     10*    C    **********
00100     11*    C
00100     12*    C    THE FOLLOWING CARDS DESCRIBE EACH VARIABLE IN THE NAMELISTS
00100     13*    C    WITH THEIR CORRESPONDING UNITS
00100     14*    C
00100     15*    C    NAMELIST /SYSTEM/
00100     16*    C      ISYM      = 0 SINGLE, FLAT, SYMMETRICAL PANEL WITH STRAIGHT TUBES
00100     17*    C                = 1 CURVED PANELS, STRAIGHT TUBES
00100     18*    C                = 2 FLAT PANELS, U-SHAPED TUBES
00100     19*    C                = 3 CURVED PANELS, U-SHAPED TUBES
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00100     C              = 4 FLAT PANELS, STRAIGHT TUBES, NON-SYMMETRICAL LOADING
00100     C     NSRD     NUMBER OF RADIATING SIDES (1 OR 2)
00100     C     NT       NUMBER OF FLAT, SYMMETRICAL PANELS, EACH WITH NTBS TUBES
00100     C     TSTAR    ARRAY OF SINK TEMPERATURES FOR CARD INPUT
00100     C
00100     C   NAMELISTS TUBEA, FINA, FLUIDA, AND MRI ARE USED ONLY FOR THE
00100     C   NON-SYMMETRICAL CASE (ISYM>0)
00100     C
00100     C   NAMELIST /TUBEA/
00100     C     D        INNER DIAMETER OF TUBE [IN]
00100     C     AL       TUBE LENGTHS FOR STRAIGHT TUBE CASE [FT]
00100     C     W1       INLET-OUTLET TUBE SPACING FOR U-SHAPE CASE [IN]
00100     C     W2       CROSSOVER TUBE SPACING FOR U-SHAPE CASE [IN]
00100     C
00100     C   NAMELIST /FINA/
00100     C     H        HALF-WIDTHS OF FINS FOR STRAIGHT TUBE CASE [IN]
00100     C     TH       FIN THICKNESSES [IN]
00100     C     ABEMF    FIN ABSORBTIVITY/EMISIVITY RATIO (USED WITH MRI INPUT)
00100     C
00100     C   NAMELIST /FLUIDA/
00100     C     TIN      ENTRANCE (AND REFERENCE) TEMPERATURES [R]
00100     C     PIN      ENTRANCE (AND REFERENCE) PRESSURES [LBF/SQ.FT]
00100     C     M        COOLANT REFERENCE MASS FLOW RATE PER PANEL [LBM/HR]
00100     C
00100     C   NAMELIST /MRI/
00100     C     ITAPE    UNIT NUMBER ATTACHED TO MRI TAPE
00100     C     ICASE    DATA CASE NUMBER ON MRI TAPE
00100     C     NTM      NUMBER OF DATA POINTS IN DATA CASE
00100     C     TO       TIME POINT IN ORBIT FROM WHICH TO TAKE DATA [MIN]
00100     C     PHIN     ANGLES OF PANELS RELATIVE TO MRI BASE DATA [DEGREES]
00100     C
00100     C   THE NAMELIST QNML IS USED ONLY IN THE SYMMETRICAL CASE (ISYM=0)
00100     C
00100     C   NAMELIST /QNML/
00100     C     ITAPE    UNIT NUMBER ATTACHED TO MRI TAPE
00100     C     ICASE    DATA CASE NUMBER ON MRI TAPE
00100     C     NTM      NUMBER OF DATA POINTS IN DATA CASE
00100     C     TO       STEADY-STATE TIME POINT AT WHICH TO TAKE DATA [MIN]
00100     C     PHN      ANGLE OF PANEL RELATIVE TO MRI BASE DATA [DEGREES]
00100     C
00100     C   NAMELIST /TUBE/
00100     C     DITBI    TUBE INNER DIAMETER FOR SYMMETRICAL CASE [IN]
00100     C     STBI     TUBE THICKNESS [IN]
00100     C     XL       TUBE LENGTH FOR SYMMETRICAL CASE [FT]
00100     C     RHOTBI   TUBE DENSITY [LBM/CU.FT]
00100     C     MZ       NUMBER OF NODAL POINTS ALONG THE TUBE LENGTH (LESS THAN OR
00100     C              EQUAL TO 10)
00100     C     NRTBI    NUMBER OF NODAL POINTS IN THE TUBE WALL RADIAL DIRECTION
00100     C              (LESS THAN OR EQUAL TO 5)
00100     C     NTBS     NUMBER OF TUBES
00100     C
00100     C   THE NAMELIST FLOW IS USED ONLY IN THE SYMMETRICAL CASE (ISYM=0)
00100     C
00100     C   NAMELIST /FLOW/
00100     C     MDOTI    TOTAL COOLANT REFERENCE MASS FLOW RATE [LBM/HR]
00100     C     TO       ENTRANCE (AND REFERENCE) TEMPERATURE [R]
00100     C     PO       ENTRANCE (AND REFERENCE) PRESSURE [LBF/SQ.FT]
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00100  C
00100  C   NAMELIST /FIN/
00100  C     NX       NUMBER OF NODAL POINTS ALONG THE FIN HEIGHT (LESS THAN
00100  C              OR EQUAL TO 10)
00100  C     SROOTI   FIN ROOT THICHNESS FOR SYMMETRICAL CASE [IN]
00100  C     HFNI     FIN HEIGHT FOR SYMMETRICAL CASE [IN]
00100  C     STIPI    FIN TIP THICKNESS FOR SYMMETRICAL CASE [IN]
00100  C     RHOFNI   FIN DENSITY [LBM/CU.FT]
00100  C     STAGX    DISTANCE FROM THE STAGNATION POINT ON THE SHUTTLE TO THE
00100  C              CENTER OF THE RADIATOR PANEL [FT]
00100  C     VERTX    OVERALL DIMENSION OF THE RADIATOR PANEL IN THE DIRECTION
00100  C              PARALLEL TO THE ACCELERATION OF GRAVITY [FT]
00100  C
00100  C   NAMELIST /PROTLR/
00100  C     NRMP     NUMBER OF NODAL POINTS IN THE PROTECTION LAYER RADIAL
00100  C              DIRECTION (LESS THAN OR EQUAL TO 5)
00100  C     RHOMPI   PROTECTION LAYER DENSITY [LBM/CU.FT]
00100  C     VELM     METEOROID VELOCITY [FT/SEC]
00100  C     TAU      TIME THAT VULNERABLE AREA IS EXPOSED TO METEOROID
00100  C              ENVIRONMENT [DAYS]
00100  C     PROB     PROBABILITY OF NO DAMAGE CAUSED BY METEOROID IMPACTS
00100  C              [DIMENSIONLESS]
00100  C     ALPHA    EXPERIMENTAL CONSTANT THAT RELATES METEOROID FLUX AND
00100  C              MASS [GM/(DAY.SQ.FT)]
00100  C     BTA      EXPERIMENTAL CONSTANT THAT RELATES METEOROID FLUX AND MASS
00100  C              [DIMENSIONLESS]
00100  C     GAMMA    EMPIRICAL CONSTANT USED TO ADJUST PREDICTED PENETRATION
00100  C              DEPTH TO ONES OBSERVED EXPERIMENTALLY [DIMENSIOLESS]
00100  C     PHI      EMPIRICAL CONSTANT [DIMENSIONLESS]
00100  C     THETA    EMPIRICAL CONSTANT [DIMENSIONLESS]
00100  C     ATK      EMPIRICAL CONSTANT USED TO ACCOUNT FOR SPALLING ON A
00100  C              TARGET OF FINITE THICKNESS [DIMENSIONLESS]
00100  C     AN       EXPERIMENTAL CONSTANT THAT DESCRIBES PENETRATION DEPTH AS
00100  C              A FUNCTION OF ANGLE OF INCIDENCE [DIMENSIONLESS]
00100  C
00100  C   NAMELIST /MANIFD/
00100  C     AMAN     TOTAL MANIFOLD AREA PROJECTED INTO THE FIN PLANE [SQ.FT]
00100  C
00100  C
00100  C   NAMELIST /RUNOPT/
00100  C     MSTOTR   = 1 TO COMPUTE STEADY STATE CONDITIONS
00100  C              = 2 TO SIMULATE TRANSIENT SYSTEM PERFORMANCE IN THE
00100  C                  SYMMETRICAL CASE ONLY
00100  C     DTWRTE   FIXED TIME INTERVAL BETWEEN DATA PRINTOUT DURING
00100  C              INTEGRATION [HR]
00100  C     TEND     TERMINATION TIME FOR TRANSIENT PERFORMANCE CALCULATIONS
00100  C              [HR]
00100  C     ALIMIT   ABSOLUTE ERROR LIMIT PER INTEGRATION STEP [DIMENSIONLESS]
00100  C     RLIMIT   RELATIVE ERROR LIMIT PER INTEGRATION STEP [DIMENSIONLESS]
00100  C     TI       INITIAL TEMPERATURE [R]
00100  C     LIMWRT   MAXIMUM NUMBER OF DATA RECORDING DURING INTEGRATION TOWARD
00100  C              STEADY STATE, EXCLUSIVE OF INITIAL CONDITIONS RECORD AND
00100  C              STEADY STATE RECORD
00100  C     NCONV    = 0 NO AERODYNAMIC HEATING
00100  C              = 1 ASCENT
00100  C              = 2 REENTRY
00100  C     LTT      = 0 OPTICAL PROPERTIES INDEPENDENT OF TEMPERATURE
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00100    134*    C              = 1 OPTICAL PROPERTIES DEPENDENT ON TEMPERATURE
00100    135*    C              = 2 QRFN AND QRMP ARE BOTH EQUAL TO ZERO BUT QINCID IS
00100    136*    C                  CALLED
00100    137*    C        LFLD  = 1 CONSTANT FLUID INLET CONDITIONS
00100    138*    C              = 2 VARIABLE FLUID INLET CONDITIONS
00100    139*    C        LTS   = 0 UNIFORM INITIAL TEMPERATURE EQUAL TO TI
00100    140*    C              = 1 INITIAL TEMPERATURE AS OBTAINED BY PREVIOUS
00100    141*    C                  COMPUTATIONS
00100    142*    C
00100    143*    C      NAMELIST/GINPT/
00100    144*    C        IT CONTAINS THE VARIABLES IN MOST OF THE PREVIOUS NAMELISTS, AND
00100    145*    C        IN ADDITION
00100    146*    C        MRSTRT  = 1 NEW VELOCITY AND ALTITUDE PROFILES
00100    147*    C                = 2 NEW IRRADIATION HISTORY
00100    148*    C                = 3 BOTH 1 AND 2
00100    149*    C                = 4 NEW COOLANT INLET CONDITIONS
00100    150*    C                = 5 BOTH 1 AND 4
00100    151*    C                = 6 BOTH 2 AND 4
00100    152*    C                = 7 ALL (1, 2, AND 4)
00100    153*    C                = 8 ONLY NEW PARAMETERS FROM GINPT
00100    154*    C        IF THIS THIS NAMELIST IS OMMITED, THE PROGRAM WILL TERMINATE
00100    155*    C
00100    156*    C
00100    157*    C      THE FOLLOWING CARDS DESCRIBE THE INPUT VARIABLES, OTHER THAN THOSE
00100    158*    C      IN THE NAMELISTS, WITH THEIR CORRESPONDING UNITS
00100    159*    C
00100    160*    C        NA      NUMBER OF ORDERED PAIRS OF ELEMENTS IN THE VELOCITY-TIME
00100    161*    C                ARRAY FOR ASCENT PROFILES
00100    162*    C        NR      NUMBER OF ORDERED PAIRS OF ELEMENTS IN THE ALTITUDE-TIME
00100    163*    C                ARRAY FOR REENTRY PROFILES
00100    164*    C
00100    165*    C        TA      ELEMENT OF TIME ARRAY (NA VALUES), SELECTED FOR ASCENT
00100    166*    C                VELOCITY AND ELEVATION PROFILES [SEC]
00100    167*    C        TR      ELEMENT OF TIME ARRAY (NR VALUES), SELECTED FOR REENTRY
00100    168*    C                VELOCITY AND ELEVATION PROFILES [SEC]
00100    169*    C
00100    170*    C        VELA    ELEMENTS OF VELOCITY ARRAY (NA VALUES), SELECTED FOR
00100    171*    C                ASCENT VELOCITY PROFILE OF ORBITER [FT/SEC]
00100    172*    C        VELR    ELEMENTS OF VELOCITY ARRAY (NR VALUES), SELECTED FOR
00100    173*    C                REENTRY VELOCITY PROFILE OF ORBITER [FT/SEC]
00100    174*    C        ALTA    ELEMENT OF ALTITUDE ARRAY (NA VALUES), SELECTED FOR
00100    175*    C                ASCENT ELEVATION PROFILE OF ORBITER [FT]
00100    176*    C        ALTR    ELEMENT OF ALTITUDE ARRAY (NR VALUES), SELECTED FOR
00100    177*    C                REENTRY ELEVATION PROFILE OF ORBITER [FT]
00100    178*    C
00100    179*    C        TBM,TBMTL  TUBE MATERIAL SPECIFICATION
00100    180*    C                (UP TO 12 ALPHANUMERIC CHARACTERS)
00100    181*    C        FNM,FNMTL  FIN MATERIAL SPECIFICATION
00100    182*    C                (UP TO 12 ALPHANUMERIC CHARACTERS)
00100    183*    C        FLU,FLUID  FLUID SPECIFICATION
00100    184*    C                (UP TO 12 ALPHANUMERIC CHARACTERS)
00100    185*    C        PRO,PROMTL PROTECTION LAYER MATERIAL SPECIFICATION
00100    186*    C                (UP TO 12 ALPHANUMERIC CHARACTERS)
00100    187*    C
00100    188*    C        TMEFLD  TIME AT WHICH FLUID INLET CONDITIONS ARE SPECIFIED [HR]
00100    189*    C        TIFLD   INSTANTANEOUS FLUID INLET TEMPERATURE [R]
00100    190*    C        WIFLD   INSTANTANEOUS FLUID MASS FLOW RATE [LBM/HR]
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```
00100  C     NFLDTA  NUMBER OF DATA POINTS DEFINING INLET CONDITIONS
00100  C             (LESS THAN OR EQUAL TO 100)
00100  C
00100  C *****************************************************************
00100  C
00100  C     DECLARATION
00100  C
00101        PARAMETER NTP = 10
00103        PARAMETER NTP1 = NTP+1
00104        REAL MDOT,MDOTI,M
00105        EXTERNAL DERIVM,CNTLM
00106        DIMENSION Y(200),DY(200),A(200),R(200),DELY(200),PD(200),SD(200),
00106       1   YS(200),DYST(200),YST(200),YSIMP(200),HDG(6),W1(NTP1),W2(NTP1),
00106       2    W(NTP1,2)
00107        COMMON XITB(5),XIMP(5),FP(10),FW(10),FT(10),TW(10,5),TEMP(10,10),
00107       1         TMP(10,5),QRFN(10,10),QRMP(10),XIFN(10),ZETA(10),AUX2(10),
00107       2         CONFN(10,10),CONMP(10),COB(10),DOB(10)
00110        COMMON NX,MZ,NRTB,NRMP,NCTL,IFLOW,LT,LTB,LMP,LTBMZ,LTB2MZ,LL1,
00110       1       LL2,LL3,LL4,LL5,LL6,LL7,NRMP1,NRTB1,NRMP2,NEQUS,LC,MSTOTR,
00110       2       NCTM,NM1,MM1,LIMWRT,LIM,MODA,NCCZ,NCONV
00111        COMMON FRE,FR,FNU,FMACH,FPR,FRL,FRM,FFO,FOF,FZ,FRAD,DZ,DXITB,DXIMP
00111       1        ,XRE,XX3,XX4,XX10,XX11,XX12,PHIM,PHIF,TO,PO,WO,RHOO,CPO,PI
00111       2        ,DELTA,RLIMIT,RDTWRT,TREF,TINTL,TI,RTEND,FLUX,QREF,FENTH,
00111       3        FREJ,HFN,XL,COH,DXI,FRO,FXOH,FXHW,RHOFN
00112        COMMON /ADBH/ D,AL(NTP),H(NTP1),TH(NTP),TIN(NTP),PIN(NTP),
00112       1              M(NTP),NT,TSTAR(NTP,3),VSC(NTP),CP(NTP),CONFL(NTP),
00112       2              CONFNA(NTP),EMIS(NTP),TB(NTP),HAB(NTP1),EFF(NTP,2),
00112       3              TL(NTP,2),QOUT(NTP),DTL(NTP),TOUT(NTP)
00113        COMMON/DVM/XX20,XX48
00114        COMMON/VELALT/TA(100),TR(100),ALTA(100),ALTR(100),VELA(100),
00114       1              VELR(100),NA,NR
00115        COMMON/CNV/STAGX,VERTX,IOPTN,DX,NSRAD,SMPC,ST4,COEFF
00116        COMMON /QRD/ TRMTX(30,60),EBFN(5,5),EBMP(5),XX2(5),ZZ2(5),
00116       1             MCVRD,LCT,LTT,DZMFN,
00116       2             DXX2,CSF,EXTSFN,EXTIFN,EXTSMP,EXTIMP,DXX21,SS(5,5,5)
00116       3             ,SSTT(5,5)
00117        COMMON /QIN/TM(100), QSFN(100,2), QIFN(100,2), QSTB(100,2),
00117       1            QITB(100,2), NTM, NSRD, QTO, TX
00120        COMMON /TC/ ITAPE,ICASE,TO,ABEMF,PHIN(NTP,3)
00121        COMMON /ABSRST/ALPHFN(5,5,6),ALPHMP(5,31),EMITFN(5,5),EMITMP(5),
00121       1               EXTVCT(50)
00122        COMMON /SSF/R2, T, ALPFN,R1,XSPM,XSMP,WWA,WWB
00123        COMMON /GEOM/ SFN(10),NTBS,TNXL,TBMASS,PLMASS,FLMASS,STR
00124        COMMON /FLDINL/ NFLDTA,LFLD,TMEFLD(100),TIFLD(100),WIFLD(100),
00124       1                FLDINT
00125        COMMON /DVCMFL/ WRAT,FLUXI
00126        EQUIVALENCE (MDOT,FLUX),(ALPFN,CTA),(W(1,1),W1(1)),(W(1,2),W2(1))
00126  C
00127        NAMELIST /SYSTEM/ ISYM,NSRD,NT,TSTAR
00130        NAMELIST /TUBEA/ D,AL,W1,W2
00131        NAMELIST /FINA/ H,TH,ABEMF
00132        NAMELIST /FLUIDA/ TIN,PIN,M
00133        NAMELIST /MRI/ ITAPE,ICASE,NTM,TO,PHIN
00134        NAMELIST /QNML/ ITAPE,ICASE,NTM,TO,PHN
00135        NAMELIST/TUBE/ DITBI,STBI,XL,RHOTBI,MZ,NRTBI,NTBS
00136        NAMELIST/FLOW/MDOTI,TO,PO
00137        NAMELIST/FIN/NX,SROOTI,HFNI,STIPI,RHOFNI,STAGX,VERTX
```

```
      NAMELIST/PROTLR/NRMP,RHOMPI,RHOMET,VELM,TAU,PROB,ALPHA,BTA,GAMMA,
     1                PHI,THETA,ATK,AN
      NAMELIST/MANIFD/ AMAN
      NAMELIST/RUNOPT/MSTOTR,DTWRTE,TEND,ALIMIT,RLIMIT,TI,LIMWRT,NCONV,
     1                 LTT,LFLD,LTS
      NAMELIST/GINPT/DITBI,STBI,XL,RHOTBI,MZ,NRTBI,NTBS,MDOTI,TO,PO,NX,
     1          SROOTI,HFNI,STIPI,RHOFNI,NRMP,RHOMPI,RHOMET,VELM,TAU,
     2          PROB,ALPHA,BTA,GAMMA,PHI,THETA,ATK,AN,AMAN,MSTOTR,
     3          DTWRTE,TEND,ALIMIT,RLIMIT,TI,LIMWRT,NCONV,STAGX,VERTX,
     4          LTT,MRSTRT,NSRD,ITAPE,ICASE,NTM,TO,PHN
C
C
  155 FORMAT(1H1,//,59X,A6,' SURFACE',/,54X,I2,1X,A6,A2,'-TUBE PANELS',
     1    /,58X,I1,' RADIATING ',A5,/)
  255 FORMAT(//,' MRI TAPE PARAMETERS:',7X,'UNIT',I3,4X,' CASE',
     1    I3,3X,I4,' DATA POINTS',3X,F8.3,' MINUTES INTO ORBIT',//,
     2    ' FIN ABSORBTIVITY/EMISSIVITY RATIO:',F8.4)
  355 FORMAT(/,' FIN ANGLES RELATIVE TO MRI TAPE DATA (DEGREES)',
     1    /,10(2X,1PE10.4))
  455 FORMAT(/,' FIN ANGLES AT OUTLET TUBES (MRI RELATIVE DEGREES)',
     1    /,10(2X,1PE10.4))
  555 FORMAT(//,' TUBE SPECIFICATIONS',6X,1PE10.4,
     1    ' INCHES INSIDE DIAMETER')
  655 FORMAT(/,' TUBE LENGTH (FEET)',/,10(2X,1PE10.4))
  755 FORMAT(/,' INLET-OUTLET TUBE SPACING (INCHES)',/,11(2X,1PE10.4))
  855 FORMAT(/,' CROSSOVER TUBE SPACING (INCHES)',/,11(2X,1PE10.4))
  955 FORMAT(//,' FIN SPECIFICATIONS',//,' FIN THICKNESS (INCHES)',
     1    /,10(2X,1PE10.4))
 1055 FORMAT(/,' FIN HALF-WIDTH (INCHES)',/,11(2X,1PE10.4))
 1155 FORMAT(/,' SINK TEMPERATURE (DEGREES R)',/,10(2X,1PE10.4))
 1255 FORMAT(10(2X,1PE10.4))
 1355 FORMAT(//,' FLUID SPECIFICATIONS',//,
     1    ' INLET TEMPERATURE (DEGREES R)',/,10(2X,1PE10.4))
 1455 FORMAT(/,' INLET PRESSURE (LBF/SQ.FT.)',/,10(2X,1PE10.4))
 1555 FORMAT(/,' MASS FLOW RATE (LBM/HR)',/,10(2X,1PE10.4))
C
C
      DATA PI/3.1415927/,SIDE/'SIDE'/,HDG/' FLAT','CURVED','STRAIGHT',
     1    'U-SHAPED'/
C
      MRSTRT = 15
      READ(5,SYSTEM)
      NSRD = MAX(MIN(NSRD,2-AND(ISYM,1)),1)
      NSRAD = NSRD
      IF (ISYM.NE.0) GO TO 2000
      NT = 1
      GO TO 8
 2000 READ(5,TUBEA)
      READ(5,FINA)
      READ(5,FLUIDA)
      READ(5,MRI)
      NTF = (NT-1)*AND(ISYM,1)+1
      NT1 = NT+1
      IF (ITAPE.LE.0) GO TO 300
      IF (ISYM.NE.3) GO TO 200
      IU = (NT+1)/2
      IW = NT/2+1
```

```
00225              ANGINC = (PHIN(IU,2)+PHIN(IW,2)-PHIN(IU,1)-PHIN(IW,1))/(NT-1)
00226              DO 100 I = 1,NT
00231          100 PHIN(I,3) = (PHIN(IU,1)+PHIN(IW,1)+ANGINC*(I-1))/2 .
00233          200 CALL TCALC(NTF)
00234          300 IF (NTF.EQ.NT) GO TO 500
00236              DO 400 J = 1,NSRD
00241              DO 400 I = 2,NT
00244          400 TSTAR(I,J) = TSTAR(1,J)
00247          500 IF (ISYM.NE.3.OR.ITAPE.LE.0) GO TO 800
00251              PHN = (PHIN(IU,3)+PHIN(IW,3))/2
00252              TSTARM = 0
00253              DO 600 I = 1,NT
00256              PHIN(I,3) = PHN
00257          600 TSTARM = TSTARM+TSTAR(I,3)
00261              TSTARM = TSTARM/NT
00262              DO 700 I = 1,NT
00265          700 TSTAR(I,3) = TSTARM
00267          800 IF (NSRD.EQ.2) SIDE = 'SIDES'
00271              IH1 = AND(ISYM,1)+1
00272              IH2 = AND(ISYM,2)+3
00273              WRITE(6,155) HDG(IH1),NT,HDG(IH2),HDG(IH2+1),NSRD,SIDE
00303              IF (ITAPE.GT.0) WRITE(6,255) ITAPE,ICASE,NTM,TO,ABEMF
00313              IF (ITAPE.GT.0) WRITE(6,355) (PHIN(I,1),I=1,NTF)
00322              IF (ISYM.EQ.3.AND.ITAPE.GT.0) WRITE(6,455) (PHIN(I,2),I=1,NTF)
00331              WRITE(6,555) D
00334              IF (AND(ISYM,2).EQ.0) WRITE(6,655) (AL(I),I=1,NT)
00343              IF (AND(ISYM,2).NE.0) WRITE(6,755) (W1(I),I=1,NT1)
00352              IF (AND(ISYM,2).NE.0) WRITE(6,855) (W2(I),I=1,NT1)
00361              WRITE(6,955) (TH(I),I=1,NT)
00367              IF (AND(ISYM,2).EQ.0) WRITE(5,1055) (H(I),I=1,NT1)
00376              WRITE(6,1155) (TSTAR(I,1),I=1,NT)
00404              IF (ISYM.EQ.3) WRITE(6,1255) (TSTAR(I,3),I=1,NT)
00413              IF (NSRD.EQ.2.OR.ISYM.EQ.3) WRITE(6,1255) (TSTAR(I,2),I=1,NT)
00422              WRITE(6,1355) (TIN(I),I=1,NT)
00430              WRITE(6,1455) (PIN(I),I=1,NT)
00436              WRITE(6,1555) (M(I),I=1,NT)
00436       C
00436       C      ASCENT AND REENTRY PROFILE SPECIFICATIONS READ IN
00436       C
00444            8 IF (AND(MRSTRT,1).EQ.0) GO TO 12
00446              READ(5,2) NA,NR
00452            2 FORMAT (2I10)
00453              READ (5,3) (TA(I), I = 1,NA)
00461              READ (5,3) (TR(I), I = 1,NR)
00467            3 FORMAT (10F8.3)
00470              READ (5,4) (VELA(I),I=1,NA)
00476              READ (5,4) (VELR(I),I=1,NR)
00504              READ (5,4) (ALTA(I),I=1,NA)
00512              READ (5,4) (ALTR(I),I=1,NR)
00520            4 FORMAT ( 8E10.1)
00520       C
00521           12 IF (AND(MRSTRT,2).EQ.0) GO TO 24
00523              IF (MRSTRT+ISYM.EQ.15) READ(5,QNML)
00527              IF (ITAPE.GT.0) GO TO 24
00531              PHN = 0.0
00532              ICASE = 0
00533              NS = 6
```

```
00534              DO 20 J = 1,NSRD
00537              IU = J+2
00540              K1 = J*3-2
00541              K2 = K1+2
00542              DO 14 I = 1,NTM
00545              READ(5,3) TM(1),(QSFN(K,1),K=K1,K2),(QIFN(K,1),K=K1,K2),
00545             1          (QSTB(K,1),K=K1,K2)
00564              IF (J.EQ.2) READ(3) NS,TM(1),(QSFN(K,1),QIFN(K,1),QSTB(K,1),K=1,3)
00577           14 WRITE(IU) NS,TM(1),(QSFN(K,1),QIFN(K,1),QSTB(K,1),K=1,6)
00612           20 CALL CLOSE(J+2,1)
00612         C
00612         C    MATERIAL SPECIFICATIONS READ IN
00614           24 IF (MRSTRT.NE.15) GO TO 28
00616              READ(5,16) TBM,TBMTL,FNM,FNMTL,FLU,FLUID,PRO,PROMTL
00616         C
00616         C    SYSTEM SPECIFICATIONS READ IN
00616         C
00630           15 READ(5,TUBE)
00633              IF (ISYM.EQ.0) READ(5,FLOW)
00637              READ(5,FIN)
00642              READ(5,PROTLR)
00645              READ(5,MANIFD)
00645         C
00645         C    PROGRAM CONTROL PARAMETERS READ IN
00645         C
00650              READ(5,RUNOPT)
00653           16 FORMAT(2A6)
00653         C
00653         C    FLUID INLET CONDITIONS READ IN
00653         C
00654              IF (LFLD .EQ. 1) GO TO 30
00656           28 IF (AND(MRSTRT,4).EQ.0) GO TO 30
00660              READ(5,2) NFLDTA
00663              READ (5,22) (TMEFLD(I),TIFLD(I),WIFLD(I),I=1,NFLDTA)
00673           22 FORMAT (3F20.6)
00673         C
00674           30 IUL = AND(ISYM,2)+1
00675              DO 840 I = 1,NT
00700          840 M(I) = M(I)/(32.174*NTBS)
00702              DO 9997 IU = 1,IUL
00705              IF (AND(ISYM,2).EQ.0) GO TO 2100
00707              IW = AND(IU,1)
00710              H(1) = W(1,2-IW)
00711              H(NT+1) = MIN(W1(NT+1),W2(NT+1))
00712              IF (NT.EQ.1) GO TO 1100
00714              DO 1000 IT = 2,NT
00717         1000 H(IT) = W(1,2-IW)/2
00721         1100 DO 1300 IT = 1,NT
00724              AL(IT) = 0
00725              I1 = IT+1
00726              DO 1200 I = I1,NT1
00731         1200 AL(IT) = W(1,1+IW)+AL(IT)
00733         1300 AL(IT) = (2-AND(IU,1))*AL(IT)/12
00735         2100 IF (ISYM.GT.0) CALL ADIABH(BOOL(AND(ISYM,3).EQ.3)*MOD(4-IU,3)+1)
00737              DO 9997 IT = 1,NT
00742              IF (ISYM.EQ.0) GO TO 34
00744              MSTOTR = 1
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00745          IF (ITAPE.GT.0) PHN = PHIN(IT,IU)
00747          DITBI = D
00750          XL = AL(IT)
00751          MDOTI = M(IT)*32.174*NTBS
00752          TO = TIN(IT)
00753          TIN(IT) = TOUT(IT)
00754          PO = PIN(IT)
00755          SROOTI = TH(IT)
00756          STIPI = TH(IT)
00757          HFNI = (HAB(IT)*EFF(IT,1)+(2*H(IT+1)-HAB(IT+1))*EFF(IT,2))/
00757         1     (EFF(IT,1)+EFF(IT,2))-D/2-STBI
00760       34 IF (AND(MRSTRT,2).NE.0) CALL QINCID (MSTOTR,PHN)
00760    C     LISTING OF SYSTEM SPECIFICATIONS AND CONTROL PARAMETERS
00760    C
00762          WRITE(6,9998)
00764          WRITE(6,QNML)
00767          WRITE(6,TUBE)
00772          WRITE(6,FLOW)
00775          WRITE(6,FIN)
01000          WRITE(6,PROTLR)
01003          WRITE(6,MANIFD)
01006          WRITE(6,RUNOPT)
01006    C
01006    C     UNIT CONVERSION ON INPUT DATA
01006    C
01011          DITB    = DITBI/12.0
01012          STB     = STBI /12.0
01013          SROOT   = SROOTI/12.0
01014          STIP    = STIPI/12.0
01015          HFN     = HFNI /12.0
01016          RITB    = DITB/2.0
01017          MDOT    = MDOTI/32.174
01020          ROTB    = (RITB+STB)*12.0
01021          RHOTB   = RHOTBI/32.174
01022          RHOFN   = RHOFNI/32.174
01023          RHOMP   = RHOMPI/32.174
01023    C
01024          TNN     = FLOAT(NTBS)
01024    C
01024    C     METEOROID PROTECTION LAYER THICKNESS
01024    C
01025          SMPC    = TK(GAMMA,ATK,BTA,RHOMET,THETA,PHI,AN,ALPHA,VELM,PROB,
01025         1            TAU,RHOMPI,XL,TNN,AMAN,TO,ROTB)
01026          SMP     = SMPC/12.0
01026    C
01026    C     INTERSECTION BETWEEN OUTER TUBE CIRCLE AND UPPER FIN PLANE
01026    C
01027          WWA     = (STIP-SROOT)/(2.0*HFN)
01030          WWC     = WWA**2+1.0
01031          SRO2    = SROOT/2.0
01032          WWR1    = RITB+STB
01033          WWR2    = WWR1+SMP
01034          WWB     = SRO2-WWA*WWR1
01035          WWD     = SQRT(WWC*WWR2**2-WWB**2)
01036          XSMP    = ((-WWA*WWB+WWD)/WWC-WWR1)/HFN
01036    C
01036    C     CONTROL INTEGERS
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```
01036   476*   C
01037   477*         NRTB    = NRTBI
01040   478*         NM1     = NX-1
01041   479*         MM1     = MZ-1
01042   480*         NRMP1   = NRMP-1
01043   481*         NRMP2   = NRMP-2
01044   482*         NRTB1   = NRTB-1
01045   483*         LT      = MZ*NM1
01046   484*         LTB     = LT+MZ
01047   485*         LMP     = LTB+MZ*NRTB
01050   486*         LTBMZ   = LTB+MZ
01051   487*         LTB2MZ  = LTBMZ+MZ
01052   488*         LL1     = LTB+(NRTB-2)*MZ
01053   489*         LL2     = LL1-MZ
01054   490*         LL3     = LMP+MZ
01055   491*         LL4     = LL1+MZ
01056   492*         LL5     = LMP+NRMP2*MZ
01057   493*         LL6     = LL5-MZ
01060   494*         LL7     = LL6-MZ
01061   495*         LC      = MZ/2
01062   496*         IF(NCONV.EQ.1) IOPTN = 0
01064   497*         IF(NCONV.EQ.2) IOPTN = 1
01064   498*   C
01064   499*   C     GRID INTERVALS
01064   500*   C
01066   501*         DZ      = 1.0/FLOAT(MM1)
01067   502*         DXI     = 1.0/FLOAT(NM1)
01070   503*         DXITB   = STB/(RITB*FLOAT(NRTB1))
01071   504*         DXIFN   = HFN/RITB*DXI
01072   505*         DXIMP   = SMP/(RITB*FLOAT(NRMP1))
01073   506*         DELTA   = DITB/XL
01073   507*   C
01073   508*   C     GRID SPACINGS
01073   509*   C
01074   510*         XITB(1) = 1.0
01075   511*         DO 50 I = 2,NRTB
01100   512*      50 XITB(I) = XITB(I-1)+DXITB
01102   513*         XIMP(1) = XITB(NRTB)
01103   514*         DO 55 I = 2,NRMP
01106   515*      55 XIMP(I) = XIMP(I-1)+DXIMP
01110   516*         ZETA(1) = 0.0
01111   517*         DO 60 J = 2,MZ
01114   518*      60 ZETA(J) = ZETA(J-1)+DZ
01116   519*         XIFN(1) = 0.0
01117   520*         DO 65 J = 2,NX
01122   521*      65 XIFN(J) = XIFN(J-1)+DXI
01122   522*   C
01124   523*         MMEP    = (INT(2.0*XSMP/DXI)+1)/2
01125   524*         MCVRD   = MMEP
01126   525*         IF(XSMP.GE.XIFN(MMEP+1)) MMEP = MMEP+1
01126   526*   C
01130   527*         DXX2    = (1.0-XSMP)/4.5
01131   528*         DXX21   = 2.0
01132   529*         XX2(1)  = XSMP+DXX2/2.0
01133   530*         XSPM    = ((0.5+FLOAT(MCVRD))*DXI-XSMP)/DXI
01134   531*         IF(MCVRD.EQ.0) XSPM = (DXI-2.0*XSMP)/DXI
01136   532*         ZZ2(1)  = 0.0
```

```
01137              DO 66 I = 2,5
01142              ZZ2(I)  =  ZZ2(I-1)+0.25
01143           66 XX2(I)  = XX2(I-1)+DXX2
01143        C
01143        C     GENERAL CONSTANTS
01143        C
01145              TOL     = SROOT/(2.0*HFN)
01146              CTA     = TOL-STIP/(2.0*HFN)
01147              DTA     = SQRT(1.0+CTA**2)
01150              DO 70 I=2,NM1
01153              BOL     = TOL-CTA*XIFN(I)
01154              DOB(I)  = DTA/(2.0*BOL)
01155           70 COB(I)  = CTA/BOL
01155        C
01157              SLOPE   = (SROOT-STIP)/(2.0*HFN)
01160              SFN(1)  = SROOT
01161              SFN(NX) = STIP
01162              DO 80 I = 2,NM1
01165           80 SFN(I)  = STIP+2.0*HFN*SLOPE*(1.0-XIFN(I))
01165        C
01165        C
01167              RHOO    = RHOF(P0,T0)
01170              RHOI    = RHOF(P0,TI)
01171              XRE     = 2.0*MDOT/(PI*TNN*RITB)
01172              FRL     = (DELTA/2.0)**2
01173              FFO     = 4.0/(XRE*DELTA)*RHOO/RHOTB
01174              FOF     = FFO*RHOTB/RHOMP
01175              REY     = XRE/VISC(RHOI,TI)
01176              FRE     = RHOO*DELTA/XRE
01177              FRM     = ((RITB+STB)/XL)**2
01200              FRD     = 1.714E-09*T0**3
01201              FRAD    = FRD*RITB
01202              FRD     = FRD*HFN
01203              PRLNTL  = (VISC(RHOI,TI)*CPF(RHOI,TI))/THCF(RHOI,TI)
01204              QREF    = FRD*T0*TNN*2.0
01205              AITB    = TNN*PI*RITB**2
01206              W0      = XRE/(DITB*3600.0*RHOO)
01207              CP0     = CPF(RHOO,T0)
01210              HFL0    = HFL(RHOO,T0)
01211              FENTH   = FLUX*(HFL0+W0**2/1556.36)
01212              FREJ    = PI*T0
01213              FXOH    = (HFN/XL)**2
01214              FXHW    = XL/(W0*3600.0*HFN**2)
01214        C
01215              T       = SRO2/HFN
01216              R1      = WWR1/HFN
01217              R2      = WWR2/HFN
01220              DZMFN   = XL/(HFN*4.0)
01220        C
01221              TREF    = XL*DITB/XRE*RHOO
01222              RDTWRT  = DTWRTE/TREF
01223              RTEND   = TEND/TREF
01224              STR     = T0*HFN*(SROOT+STIP)*TNN*SQRT(RHOFN/(PI*TREF))
01224        C
01225              XX3     = DXITB/DXIMP
01226              XX4     = DXITB/DXIFN
01227              XX10    = 1.0/(4.0*XIMP(NRMP)-DXIMP)
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01230           XX11    = 4.0*XX10*(2.0*XIMP(NRMP)-DXIMP)/(DXIMP**2)
01231           XX12    = 8.0*XX10*XIMP(NRMP)/DXIMP
01231     C
01232           PHIF    = 4.0*ASIN(SROOT/(2.0*WWR1+SMP))
01233           PHIM    = 2.0*PI-4.0*ASIN(SROOT/(2.0*WWR2))
01234           PHIF    = PHIF*RITB/HFN
01235           COH     = PHIM*WWR2/(2.0*HFN)
01235     C
01235     C
01236           COEFF  =  3600./STAGX
01237           ST4     = 0.1714E-08*T0**4.0
01240           QTO     = ST4
01241           DX     =  HFN*DXI*12.0
01241     C
01241     C     INITIAL TEMPERATURE PROFILES
01241     C
01242           IF (MRSTRT-LTS*8.LE.0) GO TO 312
01244           TINTL   = TI/TO
01245           DO 310 J=1,MZ
01250           DO 302 I=1,NRTB
01253       302 TW(J,I) = TINTL
01255           DO 305 I=1,NRMP
01260       305 TMP(J,I)= TINTL
01262           CONMP(J)    = 0.0
01263           DO 310 I=1,NX
01266           CONFN(J,I) = 0.0
01267       310 TEMP(J,I) = TINTL
01267     C
01267     C     INITIAL FLOW CONDITIONS
01267     C
01272       312 IFLOW   = 1
01273           FT(1)   = TW(1,1)
01274           IF (LFLD .EQ. 2) FT(1) = TIFLD(1)/TO
01276           WRAT    = 1.0
01277           FLUXI = MDOTI
01300           IF (LFLD .EQ. 2) WRAT = WIFLD(1)/FLUXI
01302           CALL FLSTRT(REY,PRLNTL,DELTA)
01302     C
01302     C     CRITERIA FOR LUMPED-PARAMETER TREATMENT OF TUBE PLUS
01302     C     PROTECTION LAYER
01302     C
01303           TAVG    = 0.5*(TI+TO)
01304           XNUSLT  = FNU*DELTA*REY*PRLNTL/4.0
01305           BIOTNO  = XNUSLT/DITB*THCF(RHO0,T0)*(STB/THCTB(TAVG)+SMP/THCMP
01305          1          (TAVG))
01306           WRITE(6,313) XNUSLT,BIOTNO
01312       313 FORMAT(1H ,5X,25HINIT. NUSSELT NO. NU  =  ,E20.6,/,
01312          1          6X,25HWALL BIOT NO.      BI  =  ,E20.6,/)
01313           IF(BIOTNO.GT.0.05) GO TO 314
01315           NRTB    = 0
01316           LL4     = MZ*NX
01317           LL5     = LL4
01320           LL6     = MZ-2
01321           LTB     = LL4
01322           NEQUS   = MZ*(NX+1)
01322     C
01322     C
```

```
01322     C     MASS CALCULATIONS
01322     C
01323       314 DO 315 J=1,MZ
01326       315 Y(J)     = 1.0/FW(J)
01330           TNXL     = TNN*XL
01331           FLMASS   = TNXL*AITB*RHOO0*DEFINT(Y,DZ,MZ)
01332           FNMASS   = TNXL*HFN*RHOFN*(SROOT+STIP)
01333           TBMASS   = TNXL*PI*STB*(DITB+STB)*RHOTB
01334           PLMASS   = TNXL*SMP*RHOMP*(DITB+2.0*STB+SMP)*PHIM/2.0
01335           TOTMSS   = FLMASS+FNMASS+PLMASS+TBMASS
01336           FLMASI   = FLMASS*32.174
01337           FNMASI   = FNMASS*32.174
01340           TBMASI   = TBMASS*32.174
01341           PLMASI   = PLMASS*32.174
01342           TOTMSI   = TOTMSS*32.174
01342     C
01343           ATOT     = TNXL*(2.0*(HFN+STB)+DITB)
01344           WRITE(6,320) XL,DITBI,STBI,TBM,TBMTL,TBMASI,NTBS,
01344          1              HFNI,SROOTI,STIPI,FNM,FNMTL,FNMASI,NSRAD,
01344          2              FLU,FLUID,FLMASI
01367           WRITE (6,321) SMPC,PLMASI,PRO,PROMTL,
01367          1              TOTMSI,ATOT
01377       320 FORMAT(1H0,15X,17HSYSTEM PARAMETERS,/,16X,17H*****************,//,
01377          2 6X,35HTUBE LENGTH ,                   XL = ,F10.3,11H FT        ,/,
01377          3 6X,35H      INTERNAL DIAMETER ,     DITB = ,F10.3,11H IN        ,/,
01377          4 6X,35H      WALL THICKNESS ,         STB = ,F10.3,11H IN        ,/,
01377          5 6X,35H      MATERIAL                      ,2A6                  ,/,
01377          6 6X,35H      MASS   (ALL TUBES) ,     MTB = ,F10.4,11H LBM       ,/,
01377          1 6X,35H      NUMBER OF TUBES,        NTBS = ,I10                 ,//
01377          7 6X,35HFIN   HEIGHT ,                 HFN = ,F10.3,11H IN        ,/,
01377          8 6X,35H      THICKNESS AT ROOT ,    SROOT = ,F10.3,11H IN        ,/,
01377          9 6X,35H      THICKNESS AT TIP ,      STIP = ,F10.3,11H IN        ,/,
01377          1 6X,35H      MATERIAL                      ,2A6                  ,/,
01377          2 6X,35H      MASS (ALL FINS) ,        MFN = ,F10.4,11H LBM       ,/,
01377          3 6X,35H      NO. OF FIN SIDES RADIATING  = ,I10                  ,//
01377          3 6X,35HCOOLANT FLUID IS                    ,2A6                  ,/,
01377          3 6X,35H      MASS (IN ALL TUBES) ,    MFL = ,F10.4,11H LBM       ,/)
01400       321 FORMAT (1H0,6X,35HPROTECTION LAYER THICKNESS,  SMP = ,F10.3,11H IN
01400          1        ,/,
01400          6 6X,35H      MASS,                    MMP = ,F10.3,11H LBM       ,/,
01400          7 6X,35H      MATERIAL IS                   ,2A6                  ,//
01400          8 6X,35HTOTAL MASS (EXCL. MANIFLD.) MTOT = ,F10.4,11H LBM         ,/,
01400          9 6X,39HTOTAL AREA (SINGLE NORMAL PROJECTION) ,,/,
01400          1 6X,35H                              ATOT = ,F10.4,11H SQ FT     ,/)
01400     C
01400     C     INITIALIZATION
01400     C
01400     C
01400     C     TUBE
01400     C
01401           IF(NRTB.EQ.0) GO TO 341
01401     C
01403           PFLD     = PO*FP(LC)
01404           TFLD     = TO*FT(LC)
01405           RHOFLD   = RHOF(PFLD,TFLD)
01406           XFNU     = THCF(RHOFLD,TFLD)/(4.0*THCTB(TINTL))*FNU*REY*PRLNTL
01406          1              *DELTA*DXITB
```

```
01407              DO 330 J=1,MZ
01412              DO 325 I=2,NRTB1
01415              K        = LTB+MZ*(I-1)+J
01416          325 Y(K)     = TW(J,I)
01420              LTBJ     = LTB+J
01421          330 Y(LTBJ) = (XFNU*FT(J)+4.0*TW(J,2)-TW(J,3))/(XFNU+3.0)
01421        C
01421        C     PROTECTION LAYER
01421        C
01421        C
01423              DO 340 J=1,MZ
01426              DO 335 I=2,NRMP1
01431              K        = LMP+MZ*(I-2)+J
01432          335 Y(K)     = TMP(J,I)
01434              Y(LL4+J)= TMP(J,1)
01435          340 Y(LL5+J)= TMP(J,NRMP)
01435        C
01435        C     FIN
01435        C
01437          341 DO 350 I=2,NX
01437        C
01442              DO 350 J=1,MZ
01445              K        = MZ*(I-2)+J
01446          350 Y(K)     = TEMP(J,I)
01446        C
01446        C     FLUID
01446        C
01451              DO 360 J=1,MZ
01454          360 Y(LT+J) = FT(J)
01454        C
01456              IF(NRTB.NE.0) GO TO 364
01460              DO 361 J=1,MZ
01463              K        = LL4+J
01464          361 Y(K)     = TW(J,1)
01464        C
01466              XX3      = (2.0-PHIM/PI)*(RITB+STB+SMP)
01467              XX4      = 2.0*(SROOT-DXI/2.0*(SROOT-STIP))/(PI*HFN)
01470              XX10     = RHOTB*STB*(DITB+STB)/TREF
01471              XX11     = RHOMP*SMP*(DITB+2.0*STB+SMP)*PHIM/(2.0*PI*TREF)
01472              XX12     = RHOFN*DXI*HFN/PI*(SROOT-DXI/4.0*(SROOT-STIP))/TREF
01473              XX13     = PHIM*(RITB+STB+SMP)
01474              XX20     = DXI*HFN/XX13
01475              XX48     = DXI*12.0
01476              FRAD     = FRD*XX13/(HFN*PI)
01476        C
01477          364 DO 365 I=1,NEQUS
01502              A(I)     = ALIMIT
01503          365 R(I)     = RLIMIT
01505              RLIMIT   = RLIMIT*5.0
01505        C
01505        C
01506              IF (OR(MRSTRT,2-LTT).GT.8) CALL SHAPEF
01506        C
01506        C
01506        C
01510              TIME     = 0.0
01511              DTME     = 0.001
```

```
01511     761*     C
01512     762*              LCT      = 1
01513     763*              NCTM     = 0
01514     764*              LIM      = 0
01515     765*              MODA     = 0
01516     766*              NCCZ     = 0
01516     767*     C
01517     768*              NTRY     = 1
01520     769*              IFVD     = 0
01521     770*              IBKP     = 1
01522     771*              IERR     = 0
01522     772*     C
01522     773*     C        PRINCIPLE INTEGRATION
01522     774*     C
01523     775*              CALL RKS(DERIVM,CNTLM,Y,DY,A,R,TIME,DTME,NEQUS,IFVD,IBKP,NTRY,IERR
01523     776*            1          ,DELY,PD,SD,YS,YST,DYST,YSIMP)
01524     777*        9997 RLIMIT  = R(1)
01527     778*              IF (ISYM.NE.0) GO TO 9999
01531     779*              READ (5,GINPT, END = 9999)
01534     780*              MRSTRT = AND(MRSTRT,7)
01535     781*              GO TO 8
01536     782*        9998 FORMAT(1H1)
01537     783*        9999 STOP
01540     784*              END

      END OF COMPILATION:        NO  DIAGNOSTICS.


@HDG,P  ******  MTXINV  ******
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QFOR,S ME*NASA5.MTXINV,ME*NASA5.MTXINV
FOR S9A-07/13/72-20:57:03 (0,)

   SUBROUTINE MTXINV    ENTRY POINT 000166

   STORAGE USED: CODE(1) 000206; DATA(0) 000037; BLANK COMMON(2) 000000

    COMMON BLOCKS:

    0003   QRD    003670

   EXTERNAL REFERENCES (BLOCK, NAME)

    0004   NERR3$

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

    0001   000016 105G      0001   000076 11L       0001   000031 111G      0001   000052 121G      0001   000055 125G
    0001   000117 136G      0001   000122 142G      0001   000137 20L       0000 R 000001 AA        0000 R 000005 B
    0003   003465 CSF       0003   003464 DXX2      0003   003472 DXX21     0003   003463 DZMFN     0003   003410 EBFN
    0003   003441 EBMP      0003   003467 EXTIFN    0003   003471 EXTIMP    0003   003466 EXTSFN    0003   003470 EXTSMP
    0000 I 000000 I         0000   000011 INJP$     0000 I 000003 I1        0000 I 000006 I2        0000 I 000002 J
    0000 I 000004 K         0003   003461 LCT       0003   003462 LTT       0003   003460 MCVRD     0003   003473 SS
    0003 R 000000 TRMTX     0003   003446 XX2       0003   003453 ZZ2


00101              SUBROUTINE MTXINV(N,M)
00101        C
00101        C   THIS SUBROUTINE SOLVES A SYSTEM OF LINEAR ALGEBRIC EQUATIONS BY
00101        C   MATRIX INVERSION
00101        C
00103              COMMON /QRD/ TRMTX(30,60),EBFN(5,5),EBMP(5),XX2(5),ZZ2(5),
00103             1             MCVRD,LCT,LTT,DZMFN,
00103             2             DXX2,CSF,EXTSFN,EXTIFN,EXTSMP,EXTIMP,DXX21,SS(5,5,5)
00104             DO 20 I   =1,N
00107             AA        =TRMTX(I,I)
00110             DO 9 J    =1,M
00113           9 TRMTX(I,J)=TRMTX(I,J)/AA
00115             IF (I.EQ.1) GO TO 11
00117             I1        = I-1
00120             DO 10 K   =1,I1
00123             B         =TRMTX(K,I)
00124             DO 10 J   =1,M
00127          10 TRMTX(K,J)=TRMTX(K,J) -TRMTX(I,J) * B
00132             IF (I.EQ.N) GO TO 20
00134          11 I2        = I+1
00135             DO 15 K   =I2,N
00140             B         =TRMTX(K,I)
00141             DO 15 J   =1,M
00144          15 TRMTX(K,J)=TRMTX(K,J) -TRMTX(I,J) * B
00147          20 CONTINUE
```

23

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00151     26*          RETURN
00152     27*          END
        END OF COMPILATION:     NO  DIAGNOSTICS.

@HDG,P  ******  NUS  ******
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QFOR,S ME*NASA5.NUS,ME*NASA5.NUS
FOR S9A-07/13/72-20:57:08 (0,)

   SUBROUTINE NUS       ENTRY POINT 000573

   STORAGE USED: CODE(1) 000642; DATA(0) 000114; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   YINT
    0004   NEXP6$
    0005   NERR3$

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

    0001   000550 100L     0001   000354 150G     0001   000374 161G     0001   000407 166G     0001   000443 175G
    0001   000243 20L      0001   000456 202G     0001   000513 211G     0001   000526 216G     0001   000324 30L
    0001   000431 40L      0001   000501 50L      0000 R 000015 BETA     0000 R 000021 FORCE    0000 R 000020 FREE
    0000 R 000017 GP       0000 R 000016 GRASH    0000 I 000023 I        0000   000066 INJP$    0000 R 000000 MACH
    0000 R 000004 NUS      0000 R 000010 REY      0000 R 000014 REYNO    0000 R 000022 X        0003 R 000000 YINT


00101          SUBROUTINE NUS(MACHNO,TATM,CATM,TIN,PRATM,VISATM,RHOATM,
00101         1          STAGX,VERTX,NSRAD,NUS1)
00101    C
00101    C   THIS SUBROUTINE COMPUTES :
00101    C     A SINGLE NUSSELT NUMBER FOR THE CALCULATION OF THE AERODYNAMIC
00101    C     HEATING OF THE ORBITER RADIATOR SYSTEM AT THE CURRENT TIME
00101    C
00103          REAL MACHNO,NUS1,MACH(4),NUS(4)
00104          DIMENSION REY(4)
00105          REYNO   =  MACHNO*STAGX*CATM*RHOATM/VISATM
00106          IF (MACHNO .GT. 1.0)  GO TO 20
00110          IF (MACHNO .LE. 1.0 .AND. MACHNO .GE. 0.5)  GO TO 30
00110    C
00110    C FREE CONVECTION NUSSELT NUMBER
00110    C
00112          BETA    =  2.0/(TIN+TATM)
00113          GRASH   =  32.174*BETA*(RHOATM/VISATM)**2*VERTX**3.*(TIN-TATM)
00114          GP      =  GRASH*PRATM
00115          IF (GP .GT. 1.0E-01 .AND. GP .LE. 1.0E+04)  FREE  =  1.585*(GP)
00115         1                **0.195
00117          IF (GP .GT. 1.0E+04 .AND. GP .LE. 1.0E+09)  FREE  =  0.59*(GP)**
00117         1          0.25
00121          IF (GP .GT. 1.0E+09)  FREE  =  0.13*(GP)**0.33333
00121    C
00121    C LOW SPEED NUSSELT NUMBERS FOR LAMINAR, TURBULENT AND TRANSITION FLOWS
00121    C
00123          IF (REYNO .LT. 1.0E+05)
00123         1 FORCE  =  0.332*REYNO**0.5*PRATM**0.33333
00125          IF (REYNO .GT. 1.0E+06)
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00125          1 FORCE  =  0.0288*REYNO**0.8*PRATM**0.33333
00127           IF (REYNO .LE. 1.0E+06 .AND. REYNO .GE. 1.0E+05)
00127          1 FORCE  =  6.78E-05*PRATM**0.33333*REYNO**1.238
00131           NUS1    =  FREE*STAGX/VERTX+FORCE
00132           GO TO 100
00132     C
00132     C HIGH SPEED NUSSELT NUMBERS FOR LAMINAR, TURBULENT AND TRANSITION FLOWS
00132     C
00133        20 IF (REYNO .LT. 1.0E+05)
00133          1 NUS1   =  0.3751*PRATM*REYNO**0.5014
00135           IF (REYNO .GT. 1.0E+06)
00135          1 NUS1   =  0.0346*PRATM*REYNO**0.7746
00137           IF (REYNO .LE. 1.0E+06 .AND. REYNO .GE. 1.0E+05)
00137          1 NUS1   =  3.339E-04*PRATM*REYNO**1.1111
00141           GO TO 100
00141     C
00141     C LAMINAR, TRANSITION AND TURBULENT NUSSELT NUMBERS FOR FLOWS THAT LIE
00141     C BETWEEN LOW AND HIGH SPEED MODELS
00141     C
00142        30 MACH(1)  =  0.4000
00143           MACH(2)  =  0.6333
00144           MACH(3)  =  0.8666
00145           MACH(4)  =  1.1000
00146           X        =  STAGX*CATM*RHOATM/VISATM
00147           DO 34 I = 1,4
00152        34 REY(I)   =  MACH(I)*X
00154           IF (REYNO .GT. 1.0E+06)  GO TO 40
00156           IF (REYNO .LT. 1.0E+05)  GO TO 50
00160           DO 36 I = 3,4
00163        36 NUS(I)  =  3.339E-04*PRATM*REY(I)**1.1111
00165           DO 38 I = 1,2
00170        38 NUS(I)  =  6.78E-05*PRATM**0.33333*REY(I)**1.238
00172           NUS1     =  YINT(MACH,NUS,4,4,MACHNO)
00173           GO TO 100
00174        40 DO 44 I = 3,4
00177        44 NUS(I)  =  0.0346*PRATM*REY(I)**0.7746
00201           DO 48 I = 1,2
00204        48 NUS(I)   =  0.0288*REY(I)**0.8*PRATM**0.33333
00206           NUS1     =  YINT(MACH,NUS,4,4,MACHNO)
00207           GO TO 100
00210        50 DO 54 I = 3,4
00213        54 NUS(I)  =  0.3751*PRATM*REY(I)**0.5014
00215           DO 58 I = 1,2
00220        58 NUS(I)   =  0.322*REY(I)**0.5*PRATM**0.33333
00222           NUS1     =  YINT(MACH,NUS,4,4,MACHNO)
00223       100 IF (NSRAD .EQ. 2) NUS1  =  2.0*NUS1
00225           RETURN
00226           END

     END OF COMPILATION:        NO  DIAGNOSTICS.


QHDG,P  ******  NUSA  ******
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****** NUSA ******                                                                DATE 071372        PAGE    1

@FOR,S ME*NASA5.NUSA,ME*NASA5.NUSA
FOR S9A-07/13/72-20:57:12 (0,)

   FUNCTION NUSA          ENTRY POINT 000067

   STORAGE USED: CODE(1) 000103; DATA(0) 000024; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   NEXP6$
    0004   NERR3$

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

    0001   000024 2L      0001   000043 4L      0001   000057 5L      0000   000016 INJP$     0000 R 000000 NUSA
    0000 R 000001 RPD


00101      1*              FUNCTION NUSA(REY,PR,DOL)
00103      2*              REAL NUSA
00104      3*              IF(REY-2300)1,1,2
00107      4*       1      RPD=REY*PR*DOL
00110      5*              NUSA=3.65+0.0668*RPD/(1+.045*RPD**.6667)
00111      6*              GO TO 5
00112      7*       2      IF(PR-.1)3,3,4
00115      8*       3      NUSA=5+.025*(REY*PR)**.8
00116      9*              GO TO 5
00117     10*       4      NUSA=.023*(REY**.8)*(PR**.3)
00120     11*       5      RETURN
00121     12*              END
      END OF COMPILATION:       NO  DIAGNOSTICS.


@HDG,P  ******  PDERIV  ******
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****** PDERIV ******                                                          DATE 071372        PAGE    1

QFOR,S ME*NASA5.PDERIV,ME*NASA5.PDERIV
FOR S9A-07/13/72-20:57:13 (0,)

   FUNCTION PDERIV      ENTRY POINT 000160

   STORAGE USED: CODE(1) 000204; DATA(0) 000020; BLANK COMMON(2) 000000

    COMMON BLOCKS:

    0003   ADBH   000352

   EXTERNAL REFERENCES (BLOCK, NAME)

    0004   TTIPS
    0005   NERR3$

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

    0001     000036 2L      0001     000114 3L       0003     000001 AL     0003     000161 CONFL    0003     000173 CONFNA
    0003     000147 CP      0003     000000 D        0000 R 000001 DM     0003 R 000326 DTL      0003     000244 EFF
    0003     000205 EMIS    0003 R 000013 H        0003 R 000231 HAB    0000     000007 INJP$    0003 R 000064 M
    0003     000076 NT      0000 R 000000 PDERIV   0003     000052 PIN    0003     000314 QOUT     0003     000217 TB
    0003     000026 TH      0003     000040 TIN      0003 R 000270 TL     0003     000340 TOUT     0003     000077 TSTAR
    0000 R 000003 T1      0000 R 000002 T2       0003     000135 VSC


00101      1*           FUNCTION  PDERIV(J,IT,ITST)
00103      2*              PARAMETER NTP = 10
00104      3*              PARAMETER NTP1 = NTP+1
00105      4*              REAL M
00106      5*              COMMON /ADBH/ D,AL(NTP),H(NTP1),TH(NTP),TIN(NTP),PIN(NTP),
00106      6*          1   M(NTP),NT,TSTAR(NTP,3),VSC(NTP),CP(NTP),CONFL(NTP),
00106      7*          2   CONFNA(NTP),EMIS(NTP),TB(NTP),HAB(NTP1),EFF(NTP,2),TL(NTP,2),
00106      8*          3   QOUT(NTP),DTL(NTP),TOUT(NTP)
00107      9*           IF(J) ,2,3
00112     10*              CALL TTIPS(IT,ITST,1.01*HAB(IT),2*H(IT+1)-HAB(IT+1),DM,T2)
00113     11*           PDERIV=(T2-TL(IT+1,1)-DTL(IT))/(.01*HAB(IT))
00114     12*           RETURN
00115     13*     2        CALL TTIPS(IT,ITST,HAB(IT),2.0*H(IT+1)-1.01*HAB(IT+1),DM,T2)
00116     14*              CALL TTIPS(IT+1,ITST,1.01*HAB(IT+1),2*H(IT+2)-HAB(IT+2),T1,DM)
00117     15*           PDERIV=(T2-T1-DTL(IT))/(.01*HAB(IT+1))
00120     16*           RETURN
00121     17*     3        CALL TTIPS(IT+1,ITST,HAB(IT+1),2*H(IT+2)-1.01*HAB(IT+2),T1,DM)
00122     18*           PDERIV=(TL(IT,2)-T1-DTL(IT))/(.01*HAB(IT+2))
00123     19*           RETURN
00124     20*           END

      END OF COMPILATION:        NO  DIAGNOSTICS.
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QHOG,P ****** PF/CFHE ******

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@FOR,S ME*NASA5.PF/CFHE,ME*NASA5.PF/CFHE
FOR S9A-07/13/72-20:57:16 (0,)

   FUNCTION PF          ENTRY POINT 000047

   STORAGE USED: CODE(1) 000052; DATA(0) 000026; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   NERR3$

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

    0000 R 000005 A         0000 R 000012 ALPHA     0000 R 000002 A1        0000 R 000003 B1        0000 R 000004 C
    0000   000017 INJP$     0000 R 000000 PF        0000 R 000001 R         0000 R 000006 RHOX      0000 R 000007 TX
    0000 R 000010 V         0000 R 000011 VM2


00101             FUNCTION PF(RHO,T)
00101        C
00101        C       THIS FUNCTION SUBPROGRAM COMPUTES :
00101        C       PRESSURE AS A FUNCTION OF DENSITY (SLUG/CU.FT) AND
00101        C            TEMPERATURE (R) OF HELIUM
00101        C                                           UNITS LBF/SQ.FT
00101        C
00103             DATA R,A1,B1,C,A /2077.02,136.9595,3.5002295E-03,10.000658,1.49610
00103            13E-02/
00111             RHOX  = RHO*515.4275
00112             TX    = T/1.8
00113             V     = 1.0/RHOX
00114             VM2   = RHOX*RHOX
00115             ALPHA = C*RHOX/(TX**3)
00116             PF    = (R*TX*(1.0-ALPHA)*(V+B1)-A1*(1.0-A*RHOX))*VM2*2.08846E-02
00117             RETURN
00120             END

      END OF COMPILATION:       NO  DIAGNOSTICS.


@HDG,P  ******  PF/CFNAK  ******
```

```
@FOR,S ME*NASA5.PF/CFNAK,ME*NASA5.PF/CFNAK
FOR S9A-07/13/72-20:57:18 (0,)

   FUNCTION PF          ENTRY POINT 000030

   STORAGE USED: CODE(1) 000040; DATA(0) 000015; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   CAPPA
    0004   NERR3$

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

    0000 R 000004 C        0003 R 000000 CAPPA     0000   000010 INJP$     0000 R 000000 PF        0000 R 000003 P0
    0000 R 000005 TK       0000 R 000001 X1        0000 R 000002 X2


00101      1*            FUNCTION PF(RHO,T)
00101      2*      C
00101      3*      C        THIS FUNCTION SUBPROGRAM COMPUTES :
00101      4*      C        PRESSURE AS A FUNCTION OF DENSITY (SLUG/CU.FT) AND
00101      5*      C             TEMPERATURE (R) OF NAK 78.6
00101      6*      C                                       UNITS LBF/SQ.FT
00101      7*      C
00103      8*            DATA X1,X2 /58.773064,-0.008433/,P0 /2116.224/
00107      9*            C  = (X1+X2*T)/32.174
00110     10*            TK   = CAPPA(RHO,T)
00111     11*            PF = (RHO/C-1.0)/TK+P0
00112     12*            RETURN
00113     13*            END

       END OF COMPILATION:        NO  DIAGNOSTICS.


@HDG,P  ******  PF/CFSIL  ******
```

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****** PF/CFSIL ******                                                          DATE 071372      PAGE    1

@FOR,S ME*NASA5.PF/CFSIL,ME*NASA5.PF/CFSIL
FOR S9A-07/13/72-20:57:20 (0,)

   FUNCTION PF           ENTRY POINT 000155

   STORAGE USED: CODE(1) 000162; DATA(0) 000072; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   ALOG
    0004   SQRT
    0005   NWDU$
    0006   NIO2$
    0007   NERR3$

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

    0000   000030 1F       0000 R 000022 A       0000 R 000001 A1      0000 R 000002 A2     0000 R 000003 A3
    0000 R 000004 A4       0000 R 000005 A5      0000 R 000023 B       0000 R 000006 B1     0000 R 000007 B2
    0000 R 000010 B3       0000 R 000011 B4      0000 R 000012 B5      0000 R 000024 C      0000 R 000013 C1
    0000 R 000014 C2       0000 R 000017 DT      0000   000061 INJP$   0000 R 000027 P      0000 R 000000 PF
    0000 R 000025 RHO1     0000 R 000020 THETA   0000 R 000021 THETA1  0000 R 000015 T0     0000 R 000016 T01
    0000 R 000026 Z


 00101      1*          FUNCTION PF(RHO,T)
 00101      2*      C
 00101      3*      C      THIS FUNCTION SUBPROGRAM COMPUTES :
 00101      4*      C      PRESSURE AS A FUNCTION OF DENSITY (SLUG/CU.FT) AND TEMPERATURE
 00101      5*      C           (R) OF DOW CORNING 200 SILICON OIL (1 CS)
 00101      6*      C                                     UNITS LBF/SQ.FT
 00101      7*      C           TEMPERATURE .GE. 359.67 AND .LE. 859.67
 00101      8*      C           TEMP. GE. 360.67 AND LE. 860.67
 00103      9*          DATA A1,A2,A3,A4,A5 /12.35,2.98333,1.1,-0.48333,0.1/,B1,B2,B3,B4,
 00103     10*         1B5 /-1.5,-0.01333,-1.18,0.57333,-0.1/,C1,C2 /0.7767,-0.0288/,
 00103     11*         2T0,T01,DT /559.67,609.67,50.0/
 00123     12*          THETA  = (T-T0)/DT
 00124     13*          THETA1 = (T-T01)/DT
 00125     14*          A  = ((((A5*THETA+A4)*THETA+A3)*THETA+A2)*THETA+A1)
 00126     15*          B  = ((((B5*THETA+B4)*THETA+B3)*THETA+B2)*THETA+B1)
 00127     16*          C  = C1+C2*THETA1
 00130     17*          RHO1 = RHO*32.174/62.42
 00131     18*          Z  = A*A+2.0*B*ALOG(RHO1/C)*1000.0
 00132     19*          P  = (-A+SQRT(Z))*1000.0/B
 00133     20*          PF = (P+14.696)*144.0
 00134     21*          IF (T.LT.360.67.OR.T.GT.860.67.OR.PF.GT.146116.224.OR.PF.GT.110116
 00134     22*         1.224.AND.T.LT.460.67) WRITE(6,1) T,PF
 00141     23*        1 FORMAT (1H0,43HPRESSURE OF SILICON OIL, OUT OF RANGE, T = ,F10.5,
 00141     24*         16H, P = ,F15.5,/)
 00142     25*          RETURN
 00143     26*          END
```

```
END OF COMPILATION:      NO DIAGNOSTICS.

@HDG,P ****** POLY ******
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```
****** POLY ******                                                                              DATE 071372        PAGE      1

@FOR,S ME*NASA5.POLY,ME*NASA5.POLY
FOR S9A-07/13/72-20:57:23 (0,)

   FUNCTION POLY        ENTRY POINT 000036

   STORAGE USED: CODE(1) 000044; DATA(0) 000015; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   NERR3$

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

    0001   000012 107G      0000   000003 INJP$     0000 I 000002 K        0000 I 000001 L        0000 R 000000 POLY


00101      1*          FUNCTION POLY(N,A,X)
00101      2*     C
00101      3*     C   THIS SUBROUTINE EVALUATES POLYNOMIAL
00101      4*     C     POLY = A(1)+A(2)*X+A(3)*X**2+.....+A(N)*X**(N-1)
00101      5*     C
00103      6*          DIMENSION A(N).
00104      7*          POLY = 0.
00105      8*          L = N
00106      9*          DO 1 K=1,N
00111     10*          POLY = POLY*X+A(L)
00112     11*        1 L = L-1
00114     12*          RETURN
00115     13*          END

      END OF COMPILATION:        NO  DIAGNOSTICS.


@HDG,P  ******  @INCID  ******
```

```
QFOR,S ME*NASA5.QINCID,ME*NASA5.QINCID
FOR S9A-07/13/72-20:57:27 (0,)

   SUBROUTINE QINCID    ENTRY POINT 001001

   STORAGE USED: CODE(1) 001027; DATA(0) 000665; BLANK COMMON(2) 000000

    COMMON BLOCKS:

    0003   QIN    001610
    0004   TC     000042

   EXTERNAL REFERENCES (BLOCK, NAME)

    0005   YINT
    0006   SHADE
    0007   DEFINT
    0010   NRBU$
    0011   NIO2$
    0012   N3SP$
    0013   NIO1$
    0014   NREW$
    0015   NERR3$

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

    0001     000036 10L      0001     000036 123G     0001     000064 142G     0001     000124 160G     0001     000132 165G
    0001     000151 173G     0001     000057 20L      0001     000166 203G     0001     000073 22L      0001     000273 225G
    0001     000337 240G     0001     000354 247G     0001     000404 263G     0001     000230 30L      0001     000547 301G
    0001     000255 32L      0001     000730 324G     0001     000741 330G     0001     000313 36L      0001     000325 38L
    0001     000507 58L      0001     000633 70L      0001     000643 80L      0004     000003 ABEMF    0000 R 000000 ANG
    0007 R 000000 DEFINT   0000 I 000605 I        0004 I 000001 ICASE    0000 I 000603 IFILE    0000     000633 INJP$
    0000 I 000604 IP       0004 I 000000 ITAPE    0000 I 000617 J        0000 I 000610 K        0000 I 000614 KO
    0000 I 000615 K1       0000 I 000612 M1       0000 I 000613 M2       0000 I 000611 NP       0000 I 000606 NS
    0003 I 001605 NSRD     0003 I 001604 NTM      0000 I 000607 N1       0000 R 000616 PANG     0004     000004 PHIN
    0000 R 000343 QA       0000 R 000077 QALB     0003 R 000454 QIFN     0003 R 001274 QITB     0000 R 000463 QP
    0000 R 000151 QPLN     0000 R 000223 QS       0003 R 000144 QSFN     0003 R 000764 QSTB     0000 R 000025 QSUN
    0003     001606 QTO      0003 R 000000 TM       0004 R 000002 TO       0003     001607 TX       0005 R 000000 YINT


00101      1*              SUBROUTINE QINCID(MSTOTR,PHN)
00101      2*       C
00101      3*       C   THIS SUBROUTINE PROVIDES :
00101      4*       C     1- DATA TRANSFER FROM THE SRI INCIDENT RADIATION COMPUTER PROGRAM
00101      5*       C     2- AVERAGING OF RADIANT FLUX OVER CIRCUMFERENCE OF TUBE CROSS-
00101      6*       C     SECTION
00101      7*       C
00103      8*              PARAMETER NTP = 10
00104      9*              PARAMETER MAXSID = 20
00105     10*              PARAMETER MAXSD1 = MAXSID+1
00106     11*              COMMON /QIN/ TM(100),QSFN(100,2),QIFN(100,2),QSTB(100,2),
```

```
00106            1   QITB(100,2),NTM,NSRD,QTO,TX
00107                COMMON /TC/ ITAPE,ICASE,TO,ABEMF,PHIN(NTP,3)
00110                DIMENSION ANG(MAXSD1),QSUN(MAXSD1,2),QALB(MAXSD1,2),
00110            1   QPLN(MAXSD1,2),QS(4,MAXSID),QA(4,MAXSID),QP(4,MAXSID)
00111                IFILE = ITAPE
00112                IF (ITAPE.LE.0) IFILE = NSRD+2
00114                IP = 1
00115                IF (ABS(PHN).GT.0.0) IP = 2
00117                IF (ICASE.LE.1) GO TO 20
00121                TM(I) = -(10.0**30)
00122                DO 16 I = 2,ICASE
00125      10        TM(2) = TM(1)
00126                READ (IFILE) NS,TM(1)
00132                IF (TM(1).GT.TM(2)) GO TO 10
00134      16        CONTINUE
00136                BACKSPACE IFILE
00137      20        IF (MSTOTR.EQ.2) GO TO 30
00141                DO 21 I = 1,2
00144      21        READ (IFILE)
00147                N1 = 2
00150      22        READ (IFILE) NS,TM(1)
00154                N1 = N1+1
00155                IF (TM(1).LT.TO.AND.N1.LT.NTM-1) GO TO 22
00157                DO 24 I = 1,3
00162      24        BACKSPACE IFILE
00164                DO 26 I = 1,4
00167      26        READ (IFILE) NS,TM(I),(QS(I,K),QA(I,K),QP(I,K),K=1,NS)
00202                DO 28 K = 1,NS
00205                QSUN(K,1) = YINT(TM,QS(1,K),4,4,TO)
00206                QALB(K,1) = YINT(TM,QA(1,K),4,4,TO)
00207      28        QPLN(K,1) = YINT(TM,QP(1,K),4,4,TO)
00211                TM(1) = 0.0
00212                NTM = 1
00213      30        IF (ICASE.GT.1.OR.MSTOTR.EQ.1) GO TO 32
00215                READ (IFILE) NS
00220                BACKSPACE IFILE
00221      32        NP = NS/2
00222                M1 = (NP-1)/2
00223                M2 = NP/2
00224                DO 34 I = 0,NS
00227      34        ANG(I+1) = FLOAT(I*360+180)/NS
00231                IF (IP.EQ.1) GO TO 38
00233                KO = 0
00234      36        KO = KO+1
00235                IF (ANG(KO)+ANG(1).LE.PHN) GO TO 36
00237      38        DO 90 I = 1,NTM
00242                IF (MSTOTR.EQ.2) READ (IFILE) NS,TM(I),(QSUN(K,1),QALB(K,1),
00242            1   QPLN(K,1),K=1,NS)
00255                IF (IP.EQ.1) GO TO 58
00257                QSUN(NS+1,1) = QSUN(1,1)
00260                QALB(NS+1,1) = QALB(1,1)
00261                QPLN(NS+1,1) = QPLN(1,1)
00262                DO 54 K = 1,NS
00265                K1 = MIN(MAX(MOD(K+KO-2,NS),1),NS-2)
00266                PANG = ANG(K)+PHN
00267                IF (PANG.GE.ANG(NS+1)) PANG = PANG-360.0
00271                QSUN(K,2) = YINT(ANG(K1),QSUN(K1,1),4,4,PANG)
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00272     69*                 QALB(K,2) = YINT(ANG(K1),QALB(K1,1),4,4,PANG)
00273     70*     54          QPLN(K,2) = YINT(ANG(K1),QPLN(K1,1),4,4,PANG)
00275     71*     58          CALL SHADE(QSUN(1,IP),NS)
00276     72*                 CALL SHADE(QALB(1,IP),NS)
00277     73*                 CALL SHADE(QPLN(1,IP),NS)
00300     74*                 DO 90 J = 1,NSRD
00303     75*                 N1 = NP*(J-1)+1
00304     76*                 IF (M1.EQ.M2) GO TO 70
00306     77*                 QSFN(I,J) = YINT(ANG(M1),QSUN(N1+M1-1,IP),4,4,90.0)
00307     78*                 QIFN(I,J) = YINT(ANG(M1),QALB(N1+M1-1,IP),4,4,90.0)+
00307     79*          1      YINT(ANG(M1),QPLN(N1+M1-1,IP),4,4,90.0)
00310     80*                 GO TO 80
00311     81*     70          QSFN(I,J) = QSUN(N1+M1,IP)
00312     82*                 QIFN(I,J) = QALB(N1+M1,IP)+QPLN(N1+M1,IP)
00313     83*     80          QSTB(I,J) = DEFINT(QSUN(N1,IP),0.5,NP)
00314     84*     90          QITB(I,J) = DEFINT(QALB(N1,IP),0.5,NP)+
00314     85*          1      DEFINT(QPLN(N1,IP),0.5,NP)
00317     86*                 REWIND IFILE
00320     87*                 IF (MSTOTR.EQ.2) RETURN
00322     88*                 NTM = 4
00323     89*                 DO 100 I = 2,4
00326     90*                 TM(I) = 20*(I-1)
00327     91*                 DO 100 J = 1,NSRD
00332     92*                 QSFN(I,J) = QSFN(1,J)
00333     93*                 QIFN(I,J) = QIFN(1,J)
00334     94*                 QSTB(I,J) = QSTB(1,J)
00335     95*     100         QITB(I,J) = QITB(1,J)
00340     96*                 RETURN
00341     97*                 END

       END OF COMPILATION:        NO  DIAGNOSTICS.


QHDG,P  ******  QRAD  ******
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QFOR,S ME*NASA5.QRAD,ME*NASA5.QRAD
FOR S9A-07/13/72-20:57:31 (0,)

   SUBROUTINE QRAD      ENTRY POINT 000772

   STORAGE USED: CODE(1) 001013; DATA(0) 001077; BLANK COMMON(2) 001115

    COMMON BLOCKS:

    0003   QRD     003721
    0004   QIN     001610
    0005   ABSRST  000601
    0006   SSF     000010
    0007   AVGABS  000251

   EXTERNAL REFERENCES (BLOCK, NAME)

    0010   INTERP
    0011   YINT
    0012   EMIT
    0013   AVGEMT
    0014   ABSORB
    0015   TRMATX
    0016   MTXINV
    0017   EXITAV
    0020   DEFNT
    0021   NERR2$
    0022   NERR3$

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

    0001     000245 100L      0001     000010 122G      0001     000012 126G      0001     000046 135G      0001     000055 142G
    0001     000073 147G      0001     000123 156G      0001     000112 2L        0001     000304 206G      0001     000306 211G
    0001     000346 225G      0001     000362 235G      0001     000366 241G      0001     000422 252G      0001     000434 256G
    0001     000443 261G      0001     000524 273G      0001     000536 277G      0001     000632 313G      0001     000633 316G
    0001     000645 324G      0001     000702 337G      0001     000733 346G      0001     000735 352G      0001     000332 500L
    0001     000344 550L      0001     000360 600L      0001     000407 700L      0001     000641 810L      0001     000673 820L
    0001     000717 910L      0006     000002 ALPFN     0005     000000 ALPHFN    0005     000226 ALPHMP    0002     000562 AUX2
    0000 R 000163 AX1         0000 R 000327 AX2         0000 R 000473 AX3         0000 R 000637 AX4         0002     000752 COB
    0002     001107 COH       0002     000574 CONFN     0002     000740 CONMP     0002     001070 CPO       0003 R 003465 CSF
    0020 R 000000 DEFNT       0002     001072 DELTA     0002     000764 DOB       0002     001110 DXI       0002     001053 DXIMP
    0002     001052 DXITB     0003 R 003464 DXX2        0003     003472 DXX21     0002     001051 DZ        0003     003463 DZMFN
    0003 R 003410 EBFN        0003 R 003441 EBMP        0012 R 000000 EMIT        0005     000461 EMITFN    0005     000512 EMITMP
    0003 R 003467 EXTIFN      0003 R 003471 EXTIMP      0003 R 003466 EXTSFN      0003 R 003470 EXTSMP      0005 R 000517 EXTVCT
    0002     001103 FENTH     0002     001045 FFO       0002     001101 FLUX      0002     001041 FMACH     0002     001040 FNU
    0002     001046 FOF       0002     000012 FP        0002     001042 FPR       0002     001037 FR        0002     001050 FRAD
    0002     001111 FRD       0002     001036 FRE       0002     001104 FREJ      0002     001043 FRL       0002     001044 FRM
    0002     000036 FT        0002     000024 FW        0002     001113 FXHW      0002     001112 FXOH      0002     001047 FZ
    0002     001105 HFN       0000 I 001006 I           0002     001003 IFLOW     0000 I 001007 III         0000 I 001024 IJK
    0000 I 001022 IL          0000     001046 INJP$     0000 I 001005 J           0000 I 001023 JL          0000 I 001016 K
    0000 I 001025 KJL         0000 I 001021 KL          0000 I 001017 L           0002     001024 LC        0003 I 003461 LCT
    0002     001032 LIM       0002     001031 LIMWRT    0002     001011 LL1       0002     001012 LL2       0002     001013 LL3
    0002     001014 LL4       0002     001015 LL5       0002     001016 LL6       0002     001017 LL7       0002     001006 LMP
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0002   001004 LT       0002   001005 LTB      0002   001007 LTBMZ    0002   001010 LTB2MZ   0003 I 003462 LTT
0003 I 003460 MCVRD    0002   001030 MM1      0002   001033 MOD      0002   001025 MSTOTR   0002 I 000777 MZ
0002   001034 NCCZ     0002   001035 NCONV    0002   001002 NCTL     0002   001026 NCTM     0002   001023 NEQUS
0002   001027 NM1      0002 I 001001 NRMP     0002   001020 NRMP1    0002   001022 NRMP2    0002   001000 NRTB
0002   001021 NRTB1    0004 I 001605 NSRD     0004 I 001604 NTM      0002 I 000776 NX       0002   001063 PHIF
0002   001062 PHIM     0002   001071 PI       0002   001065 P0       0000 R 000017 QFN      0004 R 000454 QIFN
0004 R 001274 QITB     0000 R 000012 QMP      0002   001102 QREF     0002 R 000360 QRFN     0002 R 000524 QRMP
0004 R 000144 QSFN     0004 R 000764 QSTB     0004 R 001606 QTO      0002   001074 RDTWRT   0002   001114 RHOFN
0002   001067 RHO0     0002   001073 RLIMIT   0002   001100 RTEND    0006   000003 R1       0006   000000 R2
0003 R 003473 SS       0003 R 003670 SSTT     0006   000001 T        0000 R 001004 TALB     0002 R 000132 TEMP
0007 R 000100 TFIN     0002   001077 TI       0002   001076 TINTL    0004 R 000000 TM       0002 R 000276 TMP
0000 R 000000 TMPP     0007 R 000244 TPR      0002   001075 TREF     0003 R 000000 TRMTX    0000 R 001003 TSOL
0002   000050 TW       0004 R 001607 TX       0002 R 001064 T0       0006   000006 WWA      0006   000007 WWB
0002   001066 W0       0000 R 001012 XCFN     0000 R 001013 XCMP     0002 R 000536 XIFN     0002   000005 XIMP
0002   000000 XITB     0002   001106 XL       0002   001054 XRE      0006   000005 XSMP     0006 R 000004 XSPM
0000 R 001014 XXCFN    0000 R 001015 XXCMP    0007 R 000062 XXFN     0007   000000 XXMP     0007   000071 XXXFN
0007   000031 XXXMP    0002   001057 XX10     0002   001060 XX11     0002   001061 XX12     0003 R 003446 XX2
0002   001055 XX3      0002   001056 XX4      0011 R 000000 YINT     0000 R 001020 Z        0002 R 000550 ZETA
0000 R 001010 ZFN      0000 R 001011 ZMP      0003 R 003453 ZZ2
```

```
00101            SUBROUTINE QRAD
00101      C
00101      C   THIS SUBROUTINE COMPUTES :
00101      C     1- INVERSION OF TRANSFER MATRIX
00101      C     2- SOLUTION OF RADIOSITY EQUATION
00101      C     3- GRID MAPPING
00101      C
00101      C
00101      C     NET RADIANT HEAT LOSS, AVERAGED OVER REPRESENTATIVE AREA ELEMENT
00101      C        (OVER BOTH SIDES OF THE FIN, BOTH HALVES OF THE TUBE)
00101      C
00103            COMMON XITB(5),XIMP(5),FP(10),FW(10),FT(10),TW(10,5),TEMP(10,10),
00103           1        TMP(10,5),QRFN(10,10),QRMP(10),XIFN(10),ZETA(10),AUX2(10),
00103           2        CONFN(10,10),CONMP(10),COB(10),DOB(10)
00104            COMMON NX,MZ,NRTB,NRMP,NCTL,IFLOW,LT,LTB,LMP,LTBMZ,LTB2MZ,LL1,
00104           1       LL2,LL3,LL4,LL5,LL6,LL7,NRMP1,NRTB1,NRMP2,NEQUS,LC,MSTOTR,
00104           2       NCTM,NM1,MM1,LIMWRT,LIM,MOD,NCCZ,NCONV
00105            COMMON FRE,FR,FNU,FMACH,FPR,FRL,FRM,FFO,FOF,FZ,FRAD,DZ,DXITB,DXIMP
00105           1        ,XRE,XX3,XX4,XX10,XX11,XX12,PHIM,PHIF,T0,P0,W0,RHO0,CP0,PI
00105           2        ,DELTA,RLIMIT,RDTWRT,TREF,TINTL,TI,RTEND,FLUX,QREF,FENTH,
00105           3        FREJ,HFN,XL,COH,DXI,FRD,FXOH,FXHW,RHOFN
00106            COMMON /QRD/ TRMTX(30,60),EBFN(5,5),EBMP(5),XX2(5),ZZ2(5),
00106           1             MCVRD,LCT,LTT,DZMFN,
00106           2             DXX2,CSF,EXTSFN,EXTIFN,EXTSMP,EXTIMP,DXX21,SS(5,5,5)
00106           3             ,SSTT(5,5)
00107            COMMON /QIN/TM(100), QSFN(100,2), QIFN(100,2), QSTB(100,2),
00107           1             QITB(100,2), NTM, NSRD, QTO, TX
00110            COMMON /ABSRST/ALPHFN(5,5,6),ALPHMP(5,31),EMITFN(5,5),EMITMP(5),
00110           1                EXTVCT(50)
00111            COMMON /SSF/R2, T, ALPFN,R1,XSPM,XSMP,WWA,WWB
00112            COMMON/AVGABS/XXMP(5,5),XXXMP(5,5),XXFN(7),XXXFN(7),
00112           1                 TFIN(10,10),TPR(5)
00113            DIMENSION TMPP(10),QMP(5),QFN(10,10),
00113           1          AX1(100),AX2(100),AX3(100),AX4(100)
```

```
00114          DATA TSOL,TALB/10400.0,480.0/
00114     C
00117          IF(LTT.GT.1) GO TO 910
00121          DO 1  J = 1,5
00124          QMP(J)  = 0.0
00125          DO 1  I = 1,5
00130        1 QFN(J,I)= 0.0
00130     C
00133          CALL INTERP(NX,MZ,XIFN,ZETA,TEMP,5,5,XX2,ZZ2,TFIN)
00133     C
00134          DO 5    J = 1,MZ
00137        5 TMPP(J)    = TMP(J,NRMP)
00141          DO 10   J = 1,5
00144          TPR(J)     = YINT(ZETA,TMPP,MZ,3,ZZ2(J))
00145          EBMP(J)    = TPR (J)**4
00146          DO 10   I = 1,5
00151       10 EBFN(J,I) = TFIN(J,I)**4
00151     C
00154          III      = 1
00155        2 DO 3 J = 1,NTM
00160          AX1(J)= QIFN(J,III)
00161          AX2(J)= QSFN(J,III)
00162          AX3(J)= QITB(J,III)
00163        3 AX4(J)= QSTB(J,III)
00165          EXTIFN = YINT(TM,AX1,NTM,3,TX)/QTO
00166          EXTSFN = YINT(TM,AX2,NTM,3,TX)/QTO
00167          EXTIMP = YINT(TM,AX3,NTM,3,TX)/QTO
00170          EXTSMP = YINT(TM,AX4,NTM,3,TX)/QTO
00171          ZFN      = EXTSFN+EXTIFN
00172          ZMP      = EXTSMP+EXTIMP
00173          XCFN     = (EXTSFN*EMIT(TSOL)+EXTIFN*EMIT(TALB))/ZFN
00174          XCMP     = (EXTSMP*EMIT(TSOL)+EXTIMP*EMIT(TALB))/ZMP
00174     C
00175          GO TO (100,500),LCT
00175     C
00176      100 CALL AVGEMT(TO)
00177          XXCFN    = (EXTSFN*XXFN(7)+EXTIFN*XXFN(6))/ZFN
00200          XXCMP    = (EXTSMP*XXFN(7)+EXTIMP*XXFN(6))/ZMP
00201          CALL ABSORB(TO,XCFN,XCMP,XXCFN,XXCMP)
00202          CALL TRMATX
00203          IF (LTT.NE.0) GO TO 500
00205          DO 115   I = 1,30
00210          DO 110   J = 31,60
00213      110 TRMTX(I,J) = 0.0
00215          K            = I+30
00216      115 TRMTX(I,K) = 1.0
00220          CALL MTXINV(30,60)
00221          LCT          = 2
00221     C
00222      500 CALL EXITAV
00223          GO TO (550,600),LCT
00223     C
00224      550 DO 555    I = 1,30
00227      555 TRMTX(I,31) = EXTVCT(I)
00231          CALL MTXINV (30,31)
00232          L            = 31
00233          GO TO 700
```

```
00233         C
00234           600 DO 610   I = 1,30
00237               Z          = 0.0
00240               DO 605 , J = 1,30
00243               K          = J+30
00244           605 Z          = Z+TRMTX(I,K)*EXTVCT(J)
00246           610 TRMTX(I,1) = Z
00250               L          = 1
00250         C
00250         C
00251           700 DO 730  J=1,5
00254               KL        = J+25
00255               DO 720 IL=1,5
00260               DO 715 JL=1,5
00263               K         = (IL-1)*5+JL
00264           715 AX1(JL) = CSF*SS(IL,JL,J)*TRMTX(K,L)
00266               AX3(IL) = SSTT(J,IL)*TRMTX(IL+25,L)
00267           720 AX2(IL) = DEFNT(AX1,0.25,5)
00271               QMP(J)    = -(ZMP+DEFNT(AX2,DXX2,5)+AX2(1)*DXX2/2.0+DEFNT(AX3,
00271              1           0.25,5)-TRMTX(KL,L))/2.0+QMP(J)
00272               DO 730  I=1,5
00275               IJK       = (I-1)*5+J
00276               DO 725 JL=1,5
00301               KJL       = 25+JL
00302           725 AX1(JL) = SS(I,J,JL)*TRMTX(KJL,L)
00304           730 QFN(J,I) = -(ZFN+DEFNT(AX1,0.25,5)-TRMTX(IJK,L))+QFN(J,I)
00304         C
00304         C
00307               CALL INTERP(5,5,XX2,ZZ2,QFN,NX,MZ,XIFN,ZETA,QRFN)
00310               IF(MCVRD.LE.0) GO TO 810
00310         C
00312               DO 800  I = 1,MCVRD
00315               DO 800  J = 1,MZ
00320           800 QRFN(J,I) = 0.0
00320         C
00323           810 DO 815  J = 1,MZ
00326           815 QRMP(J)    = YINT(ZZ2,QMP,5,3,ZETA(J))
00330               IF (III.EQ.2) GO TO 820
00332               IF (NSRD.EQ.1) GO TO 820
00334               III        = 2
00335               GO TO 2
00335         C
00336           820 DO 825 J  = 1,MZ
00341               K          = MCVRD+1
00342           825 QRFN(J,K) = QRFN(J,K)*XSPM
00344               RETURN
00345           910 DO 915 J=1,MZ
00350               QRMP(J)    = 0.0
00351               DO 915 I=1,NX
00354           915 QRFN(J,I) = 0.0
00357               RETURN
00360               END
```

END OF COMPILATION: NO DIAGNOSTICS.

QHDG,P ****** REFP ******

```
@FOR,S ME*NASA5.REFP,ME*NASA5.REFP
FOR S9A-07/13/72-20:57:38 (0,)

   SUBROUTINE REFP      ENTRY POINT 000316

   STORAGE USED: CODE(1) 000367; DATA(0) 000163; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   CPAIR
    0004   POLY
    0005   NEXP6$
    0006   EXP
    0007   NERR3$

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

    0001   000076 2L       0001   000214 20L      0001   000065 223G     0001   000154 3L       0001   000172 4L
    0000 R 000066 A0       0000 R 000067 A1       0000 R 000100 A10      0000 R 000101 A11      0000 R 000070 A2
    0000 R 000071 A3       0000 R 000072 A4       0000 R 000073 A5       0000 R 000074 A6       0000 R 000075 A7
    0000 R 000076 A8       0000 R 000077 A9       0000 R 000064 CF1      0000 R 000065 CF2      0003 R 000000 CPAIR
    0000 R 000056 CP1      0000 R 000057 CP2      0000 R 000060 CP3      0000 R 000061 CP4      0000 R 000110 DH
    0000 R 000063 DT       0000 R 000104 ELEVM    0000 R 000106 GEOH     0000 R 000105 GEOHM    0000 R 000007 GH
    0000 R 000031 GT       0000 R 000052 G0       0000 R 000000 H        0000 I 000107 I        0000   000144 INJP$
    0000 I 000111 J        0000 R 000102 MWT      0000 R 000041 P        0000 R 000113 PATM     0004 R 000000 POLY
    0000 R 000116 PSL      0000 R 000115 PZ       0000 R 000054 RU       0000 R 000055 RU1      0000 R 000020 T
    0000 R 000112 TMB      0000 R 000103 TMK      0000 R 000062 T0       0000 R 000053 WMO      0000 R 000114 Z


00101       1*          SUBROUTINE REFP (ELEV,REFTP,REFPR,REFVIS,REFRHO,REFK,REFCP,
00101       2*         1           REFGAM)
00101       3*       C
00101       4*       C   THIS SUBROUTINE COMPUTES :
00101       5*       C        PROPERTIES OF ATMOSPHERIC AIR EVALUATED AT THE HIGH SPEED
00101       6*       C        REFERENCE TEMPERATURE
00101       7*       C                                      ELEVATION IN FEET
00101       8*       C                                      REFERENCE TEMP. IN DEGREES R.
00101       9*       C                                      PRANDTL NUMBER DIMENSIONLESS
00101      10*       C                                      DYN. VISCOSITY IN LBM/ FT.SEC.
00101      11*       C                                      DENSITY IN LBM/CUBIC FOOT
00101      12*       C                                      THERMAL COND.IN BTU/SEC FT DEG R
00101      13*       C                                      SPECIFIC HEAT IN BTU/LBM DEG R
00101      14*       C
00103      15*          DIMENSION H(7),GH(9),T(9),GT(8),P(9)
00104      16*          DATA H(1),H(2),H(3),H(4),H(5),H(6),H(7) /0.0,1.0,-1.5731262E-07,2.
00104      17*         14656553E-14,-3.8667054E-21,6.0621354E-28,-9.5013649E-35/,GH(1),GH(
00104      18*         22),GH(3),GH(4),GH(5),GH(6),GH(7),GH(8),GH(9) /0.0,11.0,20.0,32.0,4
00104      19*         37.0,52.0,61.0,79.0,90.0/,T(1),T(2),T(3),T(4),T(5),T(6),T(7),T(8),T
00104      20*         4(9) /288.15,216.65,216.65,228.65,270.65,270.65,252.65,180.65,180.6
00104      21*         55/,GT(1),GT(2),GT(3),GT(4),GT(5),GT(6),GT(7),GT(8) /-6.5,0.0,1.0,2
00104      22*         6.8,0.0,-2.0,-4.0,0.0/,P(1),P(2),P(3),P(4),P(5),P(6),P(7),P(8),P(9)
```

```
00104          7 /2116.22,472.681,114.345,18.1298,2.31631,1.23225,0.380323,0.02167
00104          82,0.0027138/,G0,WM0,RU,RU1 /9.80665,28.9644,8314.32,1545.31/,CP1,C
00104          9P2,CP3,CP4 /0.239573,-0.000127,0.000051,0.000014/,T0,DT /270.0,90.
00104          10/,CF1,CF2 /1000.0,0.671969/
00173           DATA  A0,A1,A2,A3,A4,A5,A6,A7,A8,A9,A10,A11/
00173          1      0.10E+01,  0.3533367370E-01,  -0.7474788290E-03,
00173          2      0.2121572232E-03,  -0.1325255219E-04,  0.5344159692E-06,
00173          3      -0.1322745646E-07,  0.1965359762E-09,  -0.1723714966E-11,
00173          4      0.8707590786E-14,  -0.2341816445E-16,  0.2597772972E-19/,
00210           REAL MWT
00211           TMK     =  REFTP/1.8
00212           REFVIS =  ((1.458E-06*TMK**1.5)/(TMK+110.4))*CF2
00213           REFK    = ((6.325E-07*TMK**1.5)/(TMK+245.4*10.0**(-12.0/TMK)))*CF2
00214           REFCP    =  CPAIR(REFTP)
00215           IF (ELEV .GT. 301000.)  GO TO 20
00217           ELEVM  = ELEV*0.3048
00220           GEOHM  = POLY(7,H,ELEVM)
00221           GEOH   = GEOHM/0.3048
00222           DO 1  I=1,9
00225           DH     = GH(I)-GEOHM/CF1
00226           IF (DH.GT.0.0) GO TO 2
00230         1 CONTINUE
00232         2 J      = I-1
00233           DH     = GH(J)-GEOHM/CF1
00234           TMB    =  T(J)-GT(J)*DH
00235           IF (J.EQ.2.OR.J.EQ.5.OR.J.EQ.8) GO TO 3
00237           PATM   = P(J)*(T(J)/TMB)**(G0*WM0*CF1/(RU*GT(J)))
00240           GO TO 4
00241         3 PATM   = P(J)*EXP(G0*WM0*DH*CF1/(RU*T(J)))
00242         4 REFRHO = WM0*PATM/(RU1*REFTP)
00243           REFPR  =  REFVIS*REFCP/REFK
00244           REFGAM  =  REFCP/(REFCP-0.0686)
00245           RETURN
00246        20 Z       =  ELEV/(3280.8399)
00247           MWT     =  28.9644-0.0309491*(Z-90.0)
00250           PZ      =  1.0/((A0+Z*(A1+Z*(A2+Z*(A3+Z*(A4+Z*(A5+Z*(A6+Z*(A7+Z
00250          1           *(A8+Z*(A9+Z*(A10+Z*A11))))))))))))**4)
00251           PSL     =  2116.22657
00252           PATM    =  PSL*PZ
00253           REFRHO =  PATM*MWT/(1545.31*REFTP)
00254           REFPR  =  REFVIS*REFCP/REFK
00255           REFGAM  =  REFCP/(REFCP-(1.98585/MWT))
00256           RETURN
00257           END

        END OF COMPILATION:        NO  DIAGNOSTICS.


QHDG.P  ******  RHOF/CFFC43  ******
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```
QFOR,S ME*NASA5.RHOF/CFFC43,ME*NASA5.RHOF/CFFC43
FOR S9A-07/13/72-20:57:42 (0,)

   FUNCTION RHOF        ENTRY POINT 000014

   STORAGE USED: CODE(1) 000016; DATA(0) 000011; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   NERR3$

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

    0000   000004 INJP$     0000 R 000000 RHOF      0000 R 000001 X1        0000 R 000002 X2


00101      1*            FUNCTION RHOF(P,T)
00101      2*      C
00101      3*      C        THIS FUNCTION SUBPROGRAM COMPUTES :
00101      4*      C        DENSITY AS A FUNCTION OF PRESSURE (LBF/SQ.FT) AND
00101      5*      C             TEMPERATURE (R) OF FC-43
00101      6*      C                                      UNITS SLUG/QU.FT
00101      7*      C
00103      8*            DATA X1,X2 /157.0883,-0.076167/
00106      9*            RHOF = (X1+X2*T)/32.174
00107     10*            RETURN
00110     11*            END

      END OF COMPILATION:        NO  DIAGNOSTICS.


QHDG,P  ******  RHOF/CFFC75  ******
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```
@FOR,S ME*NASA5.RHOF/CFFC75,ME*NASA5.RHOF/CFFC75
FOR S9A-07/13/72-20:57:44 (0,)

   FUNCTION RHOF        ENTRY POINT 000014

   STORAGE USED: CODE(1) 000016; DATA(0) 000011; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   NERR3$

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

    0000   000004 INJP$     0000 R 000000 RHOF      0000 R 000001 X1       0000 R 000002 X2


00101       1*             FUNCTION RHOF(P,T)
00101       2*       C
00101       3*       C        THIS FUNCTION SUBPROGRAM COMPUTES :
00101       4*       C        DENSITY AS A FUNCTION OF PRESSURE (LBF/SQ.FT) AND
00101       5*       C             TEMPERATURE (R) OF FC-75
00101       6*       C                                     UNITS SLUG/QU.FT
00101       7*       C
00103       8*             DATA X1,X2 /155.522,-0.085/
00106       9*             RHOF = (X1+X2*T)/32.174
00107      10*             RETURN
00110      11*             END

      END OF COMPILATION:        NO  DIAGNOSTICS.


@HDG,P  ******  RHOF/CFHE  ******
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****** RHOF/CFHE ******                                                         DATE 071372        PAGE    1

@FOR,S ME*NASA5.RHOF/CFHE,ME*NASA5.RHOF/CFHE
FOR S9A-07/13/72-20:57:47 (0,)

   FUNCTION RHOF        ENTRY POINT 000067

   STORAGE USED: CODE(1) 000077; DATA(0) 000023; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   PF
    0004   CAPPA
    0005   NERR3$

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

    0001   000015 2L       0001   000055 4L       0004 R 000000 CAPPA     0000 R 000005 DIFF      0000 R 000006 DPDRHO
    0000 R 000007 DRHO     0000   000014 INJP$    0000 I 000001 N         0003 R 000000 PF        0000 R 000004 P1
    0000 R 000002 R        0000 R 000000 RHOF     0000 R 000003 RHO1


00101      1*           FUNCTION RHOF(P,T)
00101      2*     C
00101      3*     C        THIS FUNCTION SUBPROGRAM COMPUTES :
00101      4*     C        DENSITY AS A FUNCTION OF PRESSURE (LBF/SQ.FT) AND
00101      5*     C             TEMPERATURE (R) OF HELIUM
00101      6*     C                                         UNITS SLUG/QU.FT
00101      7*     C
00103      8*           N      = 1
00104      9*           R      = 12419.164
00105     10*           RHO1   = P/(R*T)
00106     11*           IF (0.388-RHO1)1,1,2
00111     12*         1 RHO1   = 0.388
00112     13*         2 P1     = PF(RHO1,T)
00113     14*           DIFF   = ABS((P-P1)/P)
00114     15*           IF (DIFF-1.0E-12)4,3,3
00117     16*         3 DPDRHO= 1.0/(RHO1*CAPPA(RHO1,T))
00120     17*           DRHO   = (P-P1)/DPDRHO
00121     18*           RHO1   = RHO1+DRHO
00122     19*           N      = N+1
00123     20*           IF (N-10)2,2,4
00126     21*         4 RHOF   = RHO1
00127     22*           RETURN
00130     23*           END

       END OF COMPILATION:        NO  DIAGNOSTICS.


@HDG,P  ******  RHOF/CFNAK  ******
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******  RHOF/CFNAK  ******                                                                                    DATE 071372        PAGE     1

@FOR,S ME*NASA5.RHOF/CFNAK,ME*NASA5.RHOF/CFNAK
FOR S9A-07/13/72-20:57:49 (0,)

   FUNCTION RHOF        ENTRY POINT 000031

   STORAGE USED: CODE(1) 000040; DATA(0) 000017; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   CAPPA
    0004   NERR3$

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

    0003 R 000000 CAPPA     0000   000011 INJP$     0000 R 000003 P0        0000 R 000006 P1        0000 R 000004 RHO
    0000 R 000000 RHOF      0000 R 000005 TK        0000 R 000001 X1        0000 R 000002 X2


00101        1*             FUNCTION RHOF(P,T)
00101        2*      C
00101        3*      C         THIS FUNCTION SUBPROGRAM COMPUTES :
00101        4*      C         DENSITY AS A FUNCTION OF PRESSURE (LBF/SQ.FT) AND
00101        5*      C              TEMPERATURE (R) OF NAK 78.6
00101        6*      C                                        UNITS SLUG/QU.FT
00101        7*      C
00103        8*             DATA X1,X2 /58.773064,-0.008433/,P0 /2116.224/
00107        9*             RHO  = (X1+X2*T)/32.174
00110       10*             TK   = CAPPA(RHO,T)
00111       11*             P1   = P-P0
00112       12*             RHOF = RHO*(1.0+TK*P1)
00113       13*             RETURN
00114       14*             END

       END OF COMPILATION:        NO  DIAGNOSTICS.


@HDG,P  ******  RHOF/CFSIL  ******
```

```
@FOR,S ME*NASA5.RHOF/CFSIL,ME*NASA5.RHOF/CFSIL
FOR S9A-07/13/72-20:57:51 (0,)

   FUNCTION RHOF        ENTRY POINT 000122

   STORAGE USED: CODE(1) 000127; DATA(0) 000065; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   EXP
    0004   NWDU$
    0005   NIO2$
    0006   NERR3$

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

    0000   000027 1F       0000 R 000022 A        0000 R 000001 A1       0000 R 000002 A2       0000 R 000003 A3
    0000 R 000004 A4       0000 R 000005 A5       0000 R 000023 B        0000 R 000006 B1       0000 R 000007 B2
    0000 R 000010 B3       0000 R 000011 B4       0000 R 000012 B5       0000 R 000024 C        0000 R 000013 C1
    0000 R 000014 C2       0000 R 000017 DT       0000   000054 INJP$    0000 R 000025 P1       0000 R 000026 RHO
    0000 R 000000 RHOF     0000 R 000020 THETA    0000 R 000021 THETA1   0000 R 000015 T0       0000 R 000016 T01


00101           FUNCTION RHOF(P,T)
00101      C
00101      C       THIS FUNCTION SUBPROGRAM COMPUTES :
00101      C       DENSITY AS A FUNCTION OF PRESSURE (LBF/SQ.FT) AND
00101      C            TEMPERATURE (R) OF DOW CORNING 200 SILICON OIL (1 CS)
00101      C                                    UNITS SLUG/CU.FT
00101      C            TEMPERATURE .GE. 359.67 AND .LE. 859.67
00101      C
00103           DATA A1,A2,A3,A4,A5 /12.35,2.98333,1.1,-0.48333,0.1/,B1,B2,B3,B4,
00103          1B5 /-1.5,-0.01333,-1.18,0.57333,-0.1/,C1,C2 /0.7767,-0.0288/,
00103          2T0,T01,DT /559.67,609.67,50.0/
00123           THETA  = (T-T0)/DT
00124           THETA1 = (T-T01)/DT
00125           A  = ((((A5*THETA+A4)*THETA+A3)*THETA+A2)*THETA+A1)*1.0E-06
00126           B  = ((((B5*THETA+B4)*THETA+B3)*THETA+B2)*THETA+B1)*1.0E-09
00127           C  = C1+C2*THETA1
00130           P1 = P/144.0-14.696
00131           RHO  = C*EXP(A*P1+0.5*B*P1*P1)
00132           RHOF = RHO*62.42/32.174
00133           IF (T.GE.360.67.AND.T.LE.860.67) RETURN
00135           WRITE (6,1) T
00140         1 FORMAT (1H0,48HDENSITY OF SILICON OIL, TEMP. OUT OF RANGE, T = ,F8
00140          1.3,/)
00141           RETURN
00142           END

        END OF COMPILATION:        NO  DIAGNOSTICS.
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```
@FOR,S ME*NASA5.RKS,ME*NASA5.RKS
FOR S9A-07/13/72-20:57:54 (0,)

   SUBROUTINE RKS       ENTRY POINT 000643

   STORAGE USED: CODE(1) 001040; DATA(0) 000064; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   NERR2$
    0004   NEXP5$
    0005   NERR3$

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

    0001   000010 10L       0001   000313 110L      0001   000333 120L      0001   000045 126G      0001   000343 130L
    0001   000071 140G      0001   000355 140L      0001   000105 146G      0001   000130 156G      0001   000417 160L
    0001   000150 164G      0001   000177 174G      0001   000500 185L      0001   000510 190L      0001   000013 20L
    0001   000232 205G      0001   000270 217G      0001   000524 220L      0001   000530 230L      0001   000543 240L
    0001   000374 243G      0001   000032 25L       0001   000552 250L      0001   000554 251L      0001   000572 257L
    0001   000604 259L      0001   000623 270L      0001   000456 300L      0001   000615 336G      0001   000054 40L
    0001   000060 45L       0001   000006 5L        0001   000076 50L       0001   000123 70L       0001   000135 80L
    0000 R 000014 AM        0000 R 000007 AMAX      0000 R 000011 C         0000 R 000010 D         0000 R 000001 DDT
    0000 R 000003 DELT      0000 R 000012 E         0000 R 000000 FR10      0000 I 000004 I         0000 I 000005 IFLAG
    0000   000030 INJP$     0000 I 000002 ISYMP     0000 I 000013 J         0000 R 000006 S


00101      1*         SUBROUTINE RKS(DERIV,CNTRL,Y,DY,A,R,T,DEL,N,IFVD,IBKP,NTRY,      DG000100
00101      2*        1IERR,DELY,PD,SD,YS,YST,DYST,YSIMP)                                 DG000200
00103      3*         DIMENSION Y(N),DY(N),A(N),R(N),DELY(N),                            DG000300
00103      4*        1PD(N),SD(N),YS(N),DYST(N),YST(N),YSIMP(N)                          DG000400
00104      5*         EXTERNAL  DERIV, CNTRL                                             DG000500
00104      6*   C     FR10 IS  FIFTH ROOT OF TEN                                         DG000600
00105      7*         FR10=1.5848932                                                     DG000700
00106      8*         IERR=0                                                             DG000800
00106      9*   C
00106     10*   C    THIS SUBROUTINE COMPUTES :
00106     11*   C      RUNGE-KUTTA INTEGRATION (PRIMARY)
00106     12*   C
00106     13*   C         YS  CONTAINS Y VALUES AT LEFT END POINT OF INTEGRATION INTERVAL DG000900
00106     14*   C                                                                     DG001000
00106     15*   C         YSIMP CONTAINS Y FOR SIMPSONS RULE CHECK  CHECK NOT MADE FOR    DG001100
00106     16*   C             FIXED STEP MODE    ISYMP IS CONTROL PARAMETER =1,FIXED,2 VARDG001200
00106     17*   C                                                                     DG001300
00106     18*   C         IF FIXED STEP SIZE GO ONE INTERVAL OF LENGTH DELT AND RETURN TO DG001400
00106     19*   C            CNTRL, IF VAR GO TWO INTERVALS BEFORE RETURN TO CONTRL      DG001500
00106     20*   C                                                                     DG001600
00106     21*   C         IFVD  = 0     VARIABLE INTERVAL                                 DG001700
00106     22*   C               = 1     FIXED                                             DG001800
00106     23*   C         IBKP  = 0     CUT INTERVAL ONCE BEFORE REPEAT  (UNDER IFVD=0 )  DG001900
00106     24*   C               = 1     CUT AS REQUIRED                                   DG002000
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00106     C       NTRY  = 1    CONTINUE INTEGRATING                          DG002100
00106     C               2    RETURN FROM RKS                               DG002200
00106     C               3    STEP REPEATED WITH NEW DELT                   DG002300
00106     C               4    RESTART                                       DG002400
00106     C       IERR  = 0    NORMAL                                        DG002500
00106     C              -1    DELT=0, RETURN FROM RKS                       DG002600
00106     C               1    A(I)+ R(I)*ABS(Y(I)) = 0. , RETURN FROM RKS   DG002700
00107        5 IF(DEL) 20,10,20                                              DG002800
00112       10 IERR=-1                                                       DG002900
00113          GO TO 270                                                     DG003000
00114       20 CALL DERIV(Y,DY,T)                                            DG003100
00115          NTRY=1                                                        DG003200
00116          CALL CNTRL(Y,DY,DEL,T,NTRY,IFVD)                              DG003300
00117       25 DDT=DEL                                                       DG003400
00120          IF(IFVD) 40,30,40                                             DG003500
00123       30 ISYMP=2                                                       DG003600
00124          DELT=DEL/2.                                                   DG003700
00125          DO 31 I=1,N                                                   DG003800
00130       31 SD(I)=0.0                                                     DG003900
00132          IFLAG=1                                                       DG004000
00133          S=1.                                                          DG004100
00134          GO TO 45                                                      DG004200
00135       40 ISYMP=1                                                       DG004300
00136          DELT=DEL                                                      DG004400
00137       45 DO 46 I=1,N                                                   DG004500
00142          YST(I)=Y(I)                                                   DG004600
00143       46 DYST(I)=DY(I)                                                 DG004700
00145       50 DO 60 I=1,N                                                   DG004800
00150          DELY(I)=DELT*DY(I)                                            DG004900
00151          PD(I)=DELY(I)                                                 DG005000
00152       60 CONTINUE                                                      DG005100
00154          GO TO (80,70),ISYMP                                           DG005200
00155       70 DO 71 I=1,N                                                   DG005300
00160       71 SD(I)=SD(I)+S*DY(I)                                           DG005400
00162       80 T=T+DELT/2.                                                   DG005500
00163          DO 85 I=1,N                                                   DG005600
00166          YS(I)=Y(I)                                                    DG005700
00167          Y(I)=YS(I)+DELY(I)/2.                                         DG005800
00170       85 CONTINUE                                                      DG005900
00172          CALL DERIV(Y,DY,T)                                            DG006000
00173          DO 90 I=1,N                                                   DG006100
00176          DELY(I)=DELT*DY(I)                                            DG006200
00177          PD(I)=PD(I)+2.*DELY(I)                                        DG006300
00200          Y(I)=YS(I)+DELY(I)/2.                                         DG006400
00201       90 CONTINUE                                                      DG006500
00203          CALL DERIV(Y,DY,T)                                            DG006600
00204          DO 95 I=1,N                                                   DG006700
00207          DELY(I)=DELT*DY(I)                                            DG006800
00210          PD(I)=PD(I)+2.*DELY(I)                                        DG006900
00211          Y(I)=YS(I)+DELY(I)                                            DG007000
00212       95 CONTINUE                                                      DG007100
00214          T=T+DELT/2.                                                   DG007200
00215          CALL DERIV(Y,DY,T)                                            DG007300
00216          DO 100 I=1,N                                                  DG007400
00221          DELY(I)=DELT*DY(I)                                            DG007500
00222          PD(I)=PD(I)+DELY(I)                                           DG007600
00223          Y(I)=YS(I)+PD(I)/6.                                           DG007700
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00224     82*       100 CONTINUE                                              DG007800
00226     83*           GO TO (110,120),ISYMP                                 DG007900
00227     84*       110 NTRY=1                                                DG008000
00230     85*           CALL DERIV(Y,DY,T)                                    DG008100
00231     86*           CALL CNTRL(Y,DY,DEL,T,NTRY,IFVD)                      DG008200
00232     87*           GO TO 300                                             DG008300
00233     88*       120 GO TO (130,140),IFLAG                                 DG008400
00234     89*       130 S=4.                                                  DG008500
00235     90*           IFLAG=2                                               DG008600
00236     91*           CALL DERIV(Y,DY,T)                                    DG008700
00237     92*           GO TO 50                                              DG008800
00240     93*       140 CALL DERIV(Y,DY,T)                                    DG008900
00241     94*           AMAX =0.0                                             DG009000
00242     95*           DO 180 I=1,N                                          DG009100
00245     96*           SD(I)=SD(I)+DY(I)                                     DG009200
00246     97*           YSIMP(I)=YST(I)+DELT*SD(I)/3.                         DG009300
00247     98*           D    =ABS(Y(I)-YSIMP(I))                              DG009400
00250     99*           C    =A(I)+R(I)*ABS(Y(I))                             DG009500
00251    100*           IF(C    ) 160,150,160                                 DG009600
00254    101*       150 IERR=1                                                DG009700
00255    102*           GO TO 270                                             DG009800
00256    103*       160 E    =ABS(D    /C    )                                DG009900
00257    104*           AMAX=AMAX1(AMAX,E)                                    DG010000
00260    105*       180 CONTINUE                                              DG010100
00262    106*           IF(AMAX-1.) 215,215,230                               DG010200
00265    107*       215 NTRY= 1                                               DG010300
00266    108*           CALL CNTRL(Y,DY,DEL,T,NTRY,IFVD)                      DG010400
00267    109*       300 IF(NTRY-1) 185,185,310                                DG010500
00272    110*       310 IF(NTRY-2) 270,270,330                                DG010600
00275    111*       330 IF(NTRY-3) 340,340,5                                  DG010700
00300    112*       340 T=T-DDT                                               DG010800
00301    113*           IF(DEL) 259,10,259                                    DG010900
00304    114*       185 GO TO (40,190),ISYMP                                  DG011000
00305    115*       190 IF(AMAX-.75) 200,25,220                               DG011100
00310    116*       200 IF(AMAX-.075) 210,25,25                               DG011200
00313    117*       210 DEL=DEL*FR10                                          DG011300
00314    118*           GO TO 25                                              DG011400
00315    119*       220 DEL=DEL/FR10                                          DG011500
00316    120*           GO TO 25                                              DG011600
00317    121*       230 I =1+ IBKP                                            DG011700
00320    122*           GO TO (240,250),I                                     DG011800
00321    123*       240 T=T-DEL                                               DG011900
00322    124*           DEL=DEL/FR10                                          DG012000
00323    125*           GO TO  259                                            DG012100
00324    126*       250 J=1                                                   DG012200
00325    127*       251 AM=AMAX/10.**J                                        DG012300
00326    128*           IF(1.-AM) 255,257,257                                 DG012400
00331    129*       255 J=J+1                                                 DG012500
00332    130*           GO TO 251                                             DG012600
00333    131*       257 T=T-DEL                                               DG012700
00334    132*           DEL=DEL/(FR10**J)                                     DG012800
00335    133*       259 DO 245 I=1,N                                          DG012900
00340    134*           DY(I)=DYST(I)                                         DG013000
00341    135*       245 Y(I)=YST(I)                                           DG013100
00343    136*           GO TO 25                                              DG013200
00344    137*       270 RETURN                                                DG013300
00345    138*           END                                                   DG013400
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END OF COMPILATION:        NO  DIAGNOSTICS.

@HDG.P ****** RKSF ******
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@FOR,S ME*NASA5.RKSF,ME*NASA5.RKSF
FOR S9A-07/13/72-20:57:59 (0,)

   SUBROUTINE RKSF       ENTRY POINT 000643

   STORAGE USED: CODE(1) 001040; DATA(0) 000064; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003    NERR2$
    0004    NEXP5$
    0005    NERR3$

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

    0001    000010 10L        0001    000313 110L       0001    000333 120L       0001    000045 126G       0001    000343 130L
    0001    000071 140G       0001    000355 140L       0001    000105 146G       0001    000130 156G       0001    000417 160L
    0001    000150 164G       0001    000177 174G       0001    000500 185L       0001    000510 190L       0001    000013 20L
    0001    000232 205G       0001    000270 217G       0001    000524 220L       0001    000530 230L       0001    000543 240L
    0001    000374 243G       0001    000032 25L        0001    000552 250L       0001    000554 251L       0001    000572 257L
    0001    000604 259L       0001    000623 270L       0001    000456 300L       0001    000615 336G       0001    000054 40L
    0001    000060 45L        0001    000006 5L         0001    000076 50L        0001    000123 70L        0001    000135 80L
    0000 R  000014 AM         0000 R  000007 AMAX       0000 R  000011 C          0000 R  000010 D          0000 R  000001 DDT
    0000 R  000003 DELT       0000 R  000012 E          0000 R  000000 FR10       0000 I  000004 I          0000 I  000005 IFLAG
    0000    000030 INJP$      0000 I  000002 ISYMP      0000 I  000013 J          0000 R  000006 S


00101      1*            SUBROUTINE RKSF(DERIV,CNTRL,Y,DY,A,R,T,DEL,N,IFVD,IBKP,NTRY,      DG000100
00101      2*           1IERR,DELY,PD,SD,YS,YST,DYST,YSIMP)                                 DG000200
00103      3*            DIMENSION Y(N),DY(N),A(N),R(N),DELY(N),                             DG000300
00103      4*           1PD(N),SD(N),YS(N),DYST(N),YST(N),YSIMP(N)                          DG000400
00104      5*            EXTERNAL  DERIV, CNTRL                                              DG000500
00104      6*      C     FR10 IS  FIFTH ROOT OF TEN                                          DG000600
00105      7*            FR10=1.5848932                                                      DG000700
00106      8*            IERR=0                                                              DG000800
00106      9*      C
00106     10*      C    THIS SUBROUTINE COMPUTES :
00106     11*      C      RUNGE-KUTTA INTEGRATION (SECONDARY)
00106     12*      C        YS  CONTAINS Y VALUES AT LEFT END POINT OF INTEGRATION INTERVAL DG000900
00106     13*      C                                                                         DG001000
00106     14*      C        YSIMP CONTAINS Y FOR SIMPSONS RULE CHECK  CHECK NOT MADE FOR    DG001100
00106     15*      C            FIXED STEP MODE    ISYMP IS CONTROL PARAMETER =1,FIXED,2 VARDG001200
00106     16*      C                                                                         DG001300
00106     17*      C        IF FIXED STEP SIZE GO ONE INTERVAL OF LENGTH DELT AND RETURN TO DG001400
00106     18*      C           CNTRL, IF VAR GO TWO INTERVALS BEFORE RETURN TO CONTRL       DG001500
00106     19*      C                                                                         DG001600
00106     20*      C        IFVD  = 0    VARIABLE INTERVAL                                   DG001700
00106     21*      C              = 1    FIXED                                               DG001800
00106     22*      C        IBKP  = 0    CUT INTERVAL ONCE BEFORE REPEAT  (UNDER IFVD=0 )    DG001900
00106     23*      C              = 1    CUT AS REQUIRED                                     DG002000
00106     24*      C        NTRY  = 1    CONTINUE INTEGRATING                                DG002100
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00106   25*   C                2   RETURN FROM RKS                                  DG002200
00106   26*   C                3   STEP REPEATED WITH NEW DELT                      DG002300
00106   27*   C                4   RESTART                                          DG002400
00106   28*   C        IERR  = 0   NORMAL                                           DG002500
00106   29*   C               -1   DELT=0, RETURN FROM RKS                          DG002600
00106   30*   C                1   A(I)+ R(I)*ABS(Y(I)) = 0. , RETURN FROM RKS      DG002700
00107   31*          5 IF(DEL) 20,10,20                                           DG002800
00112   32*         10 IERR=-1                                                    DG002900
00113   33*            GO TO 270                                                  DG003000
00114   34*         20 CALL DERIV(Y,DY,T)                                         DG003100
00115   35*            NTRY=1                                                     DG003200
00116   36*            CALL CNTRL(Y,DY,DEL,T,NTRY,IFVD)                           DG003300
00117   37*         25 DDT=DEL                                                    DG003400
00120   38*            IF(IFVD) 40,30,40                                          DG003500
00123   39*         30 ISYMP=2                                                    DG003600
00124   40*            DELT=DEL/2.                                                DG003700
00125   41*            DO 31 I=1,N                                                DG003800
00130   42*         31 SD(I)=0.0                                                  DG003900
00132   43*            IFLAG=1                                                    DG004000
00133   44*            S=1.                                                       DG004100
00134   45*            GO TO 45                                                   DG004200
00135   46*         40 ISYMP=1                                                    DG004300
00136   47*            DELT=DEL                                                   DG004400
00137   48*         45 DO 46 I=1,N                                                DG004500
00142   49*            YST(I)=Y(I)                                                DG004600
00143   50*         46 DYST(I)=DY(I)                                              DG004700
00145   51*         50 DO 60 I=1,N                                                DG004800
00150   52*            DELY(I)=DELT*DY(I)                                         DG004900
00151   53*            PD(I)=DELY(I)                                              DG005000
00152   54*         60 CONTINUE                                                   DG005100
00154   55*            GO TO (80,70),ISYMP                                        DG005200
00155   56*         70 DO 71 I=1,N                                                DG005300
00160   57*         71 SD(I)=SD(I)+S*DY(I)                                        DG005400
00162   58*         80 T=T+DELT/2.                                                DG005500
00163   59*            DO 85 I=1,N                                                DG005600
00166   60*            YS(I)=Y(I)                                                 DG005700
00167   61*            Y(I)=YS(I)+DELY(I)/2.                                      DG005800
00170   62*         85 CONTINUE                                                   DG005900
00172   63*            CALL DERIV(Y,DY,T)                                         DG006000
00173   64*            DO 90 I=1,N                                                DG006100
00176   65*            DELY(I)=DELT*DY(I)                                         DG006200
00177   66*            PD(I)=PD(I)+2.*DELY(I)                                     DG006300
00200   67*            Y(I)=YS(I)+DELY(I)/2.                                      DG006400
00201   68*         90 CONTINUE                                                   DG006500
00203   69*            CALL DERIV(Y,DY,T)                                         DG006600
00204   70*            DO 95 I=1,N                                                DG006700
00207   71*            DELY(I)=DELT*DY(I)                                         DG006800
00210   72*            PD(I)=PD(I)+2.*DELY(I)                                     DG006900
00211   73*            Y(I)=YS(I)+DELY(I)                                         DG007000
00212   74*         95 CONTINUE                                                   DG007100
00214   75*            T=T+DELT/2.                                                DG007200
00215   76*            CALL DERIV(Y,DY,T)                                         DG007300
00216   77*            DO 100 I=1,N                                               DG007400
00221   78*            DELY(I)=DELT*DY(I)                                         DG007500
00222   79*            PD(I)=PD(I)+DELY(I)                                        DG007600
00223   80*            Y(I)=YS(I)+PD(I)/6.                                        DG007700
00224   81*        100 CONTINUE                                                   DG007800
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00226          GO TO (110,120),ISYMP                         DG007900
00227      110 NTRY=1                                        DG008000
00230          CALL DERIV(Y,DY,T)                            DG008100
00231          CALL CNTRL(Y,DY,DEL,T,NTRY,IFVD)              DG008200
00232          GO TO 300                                     DG008300
00233      120 GO TO (130,140),IFLAG                         DG008400
00234      130 S=4.                                          DG008500
00235          IFLAG=2                                       DG008600
00236          CALL DERIV(Y,DY,T)                            DG008700
00237          GO TO 50                                      DG008800
00240      140 CALL DERIV(Y,DY,T)                            DG008900
00241          AMAX =0.0                                     DG009000
00242          DO 180 I=1,N                                  DG009100
00245          SD(I)=SD(I)+DY(I)                             DG009200
00246          YSIMP(I)=YST(I)+DELT*SD(I)/3.                 DG009300
00247          D    =ABS(Y(I)-YSIMP(I))                      DG009400
00250          C    =A(I)+R(I)*ABS(Y(I))                     DG009500
00251          IF(C    ) 160,150,160                         DG009600
00254      150 IERR=1                                        DG009700
00255          GO TO 270                                     DG009800
00256      160 E    =ABS(D    /C    )                        DG009900
00257          AMAX=AMAX1(AMAX,E)                            DG010000
00260      180 CONTINUE                                      DG010100
00262          IF(AMAX-1.) 215,215,230                       DG010200
00265      215 NTRY= 1                                       DG010300
00266          CALL CNTRL(Y,DY,DEL,T,NTRY,IFVD)              DG010400
00267      300 IF(NTRY-1) 185,185,310                        DG010500
00272      310 IF(NTRY-2) 270,270,330                        DG010600
00275      330 IF(NTRY-3) 340,340,5                          DG010700
00300      340 T=T-DDT                                       DG010800
00301          IF(DEL) 259,10,259                            DG010900
00304      185 GO TO (40,190),ISYMP                          DG011000
00305      190 IF(AMAX-.75) 200,25,220                       DG011100
00310      200 IF(AMAX-.075) 210,25,25                       DG011200
00313      210 DEL=DEL*FR10                                  DG011300
00314          GO TO 25                                      DG011400
00315      220 DEL=DEL/FR10                                  DG011500
00316          GO TO 25                                      DG011600
00317      230 I =1+ IBKP                                    DG011700
00320          GO TO (240,250),I                             DG011800
00321      240 T=T-DEL                                       DG011900
00322          DEL=DEL/FR10                                  DG012000
00323          GO TO  259                                    DG012100
00324      250 J=1                                           DG012200
00325      251 AM=AMAX/10.**J                                DG012300
00326          IF(1.-AM) 255,257,257                         DG012400
00331      255 J=J+1                                         DG012500
00332          GO TO 251                                     DG012600
00333      257 T=T-DEL                                       DG012700
00334          DEL=DEL/(FR10**J)                             DG012800
00335      259 DO 245 I=1,N                                  DG012900
00340          DY(I)=DYST(I)                                 DG013000
00341      245 Y(I)=YST(I)                                   DG013100
00343          GO TO 25                                      DG013200
00344      270 RETURN                                        DG013300
00345          END                                           DG013400
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****** RKSF ******
      END OF COMPILATION:       NO  DIAGNOSTICS.

QHDG.P  ******  SHADE  ****** .
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@FOR,S ME*NASA5.SHADE,ME*NASA5.SHADE
FOR S9A-07/13/72-20:58:04 (0,)

   SUBROUTINE SHADE     ENTRY POINT 000073

   STORAGE USED: CODE(1) 000104; DATA(0) 000023; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   NERR3$

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

    0001   000027 10L       0001   000015 106G      0001   000057 123G      0000   000005 INJP$     0000 I 000001 J
    0000 I 000003 J1        0000 I 000002 J2        0000 R 000000 QM


00101      1*             SUBROUTINE SHADE(Q,NS)
00103      2*             DIMENSION Q(1)
00104      3*             QM = 0.0
00105      4*             DO 10 J = 1,NS
00110      5*             IF (QM.GT.Q(J)) GO TO 10
00112      6*             QM = Q(J)
00113      7*             J2 = J
00114      8*      10     CONTINUE
00116      9*             J1 = 1
00117     10*             IF (J2.LE.NS/2) J1 = NS/2+1
00121     11*             J2 = J1+NS/2-1
00122     12*             DO 20 J = J1,J2
00125     13*      20     Q(J) = 0.0
00127     14*             RETURN
00130     15*             END

      END OF COMPILATION:        NO  DIAGNOSTICS.


@HDG,P  ******  SHAPEF  ******
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****** SHAPEF ******                                                                  DATE 071372        PAGE     1

@FOR,S ME*NASA5.SHAPEF,ME*NASA5.SHAPEF
FOR S9A-07/13/72-20:58:06 (0,)

   SUBROUTINE SHAPEF     ENTRY POINT 001020

   STORAGE USED: CODE(1) 001035; DATA(0) 000152; BLANK COMMON(2) 000000

    COMMON BLOCKS:

    0003   QRD    003721
    0004   SSF    000010

   EXTERNAL REFERENCES (BLOCK, NAME)

    0005   ACOS
    0006   ATAN
    0007   SQRT
    0010   COS
    0011   SIN
    0012   NEXP6$
    0013   ASIN
    0014   ALOG
    0015   NERR3$

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

    0001   000036 117G     0001   000037 122G     0001   000040 125G     0001   000066 135G     0001   000307 174G
    0001   000053 20L      0001   000447 216G     0001   000452 221G     0001   000457 225G     0001   000671 261G
    0001   000752 274G     0001   000107 30L      0001   000757 300G     0001   000115 35L      0001   000603 62L
    0001   000620 64L      0001   000634 65L      0001   000442 70L      0000 R 000046 A        0004 R 000002 ALPFN
    0000 R 000047 AR       0000 R 000050 ARC      0000 R 000051 AR2      0000 R 000035 BA       0000 R 000027 BETA
    0000 R 000066 BETA1    0000 R 000067 BETA2    0000 R 000014 CF       0000 R 000043 CPB      0003 R 003465 CSF
    0000 R 000015 DCL      0003   003464 DXX2     0003   003472 DXX21    0000 R 000064 DZ       0003 R 003463 DZMFN
    0000 R 000045 DZ2      0003   003410 EBFN     0003   003441 EBMP     0003   003467 EXTIFN   0003   003471 EXTIMP
    0003   003466 EXTSFN   0003   003470 EXTSMP   0000 R 000062 GAMA     0000 R 000036 GAMMA    0000 I 000021 I
    0000   000112 INJP$    0000 I 000022 J        0000 I 000023 K        0000 I 000024 L        0003   003461 LCT
    0003   003462 LTT      0000 I 000052 M        0003   003460 MCVRD    0000 R 000032 OB       0000 R 000034 OP
    0000 R 000033 PB       0000 R 000017 PHI      0000 R 000037 PHIO     0000 R 000055 PHI1     0000 R 000012 PI
    0000 R 000013 PI2      0000 R 000040 PR4      0000 R 000044 RC       0000 R 000031 RHO      0000 R 000030 RHO2
    0000 R 000053 RL       0000 R 000057 RL2      0000 R 000016 RR       0000 R 000041 RRO      0000 R 000042 RRO2
    0000 R 000054 RT       0000 R 000061 RTL      0000 R 000056 RT2      0004 R 000003 R1       0004 R 000000 R2
    0003 R 003473 SS       0000 R 000063 SST      0003 R 003670 SSTT     0004 R 000001 T        0000 R 000020 THETA
    0000 R 000060 THETA1   0003   000000 TRMTX    0000 R 000070 WF       0004 R 000006 WWA      0004 R 000007 WWB
    0000 R 000000 X        0000 R 000065 XB       0004 R 000005 XSMP     0004   000004 XSPM     0000 R 000005 XX
    0003 R 003446 XX2      0000 R 000025 Y        0000 R 000026 YY       0003 R 003453 ZZ2


00101      1*           SUBROUTINE   SHAPEF
00101      2*       C
00101      3*       C   THIS SUBROUTINE COMPUTES THE SHAPE FACTOR BETWEEN :
00101      4*       C     1- TUBE AND NEAR FIN
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00101      C      1- TUBE AND FAR FIN
00101      C      3- ADJACENT TUBES
00101      C
00103             COMMON /QRD/ TRMTX(30,60),EBFN(5,5),EBMP(5),XX2(5),ZZ2(5),
00103            1             MCVRD,LCT,LTT,DZMFN,
00103            2             DXX2,CSF,EXTSFN,EXTIFN,EXTSMP,EXTIMP,DXX21,SS(5,5,5)
00103            3             ,SSTT(5,5)
00104             COMMON /SSF/R2, T, ALPFN,R1,XSPM,XSMP,WWA,WWB
00105             DIMENSION X(5), XX(5)
00106             PI     = 3.14159
00107             PI2    = PI/2.0
00110             CF     = DZMFN*4.0
00111             DCL    = 2.0+2.0*R1
00112             RR     = R2*R2
00113             PHI    = ACOS((XSMP+R1)/R2)
00114             THETA  =1.570796-PHI
00115             CSF    = 1.0/(R2*THETA)
00116             DO 10 I=1,5
00121             DO 10 J=1,5
00124             DO 10 K=1,5
00127          10 SS(I,J,K) = 0.0
00133             L      = 0
00134          20 DO  50 I=1,5
00137             IF (L.EQ.1) GO TO 30
00141             X(I)   = XX2(I)+R1
00142             XX(I)  = XX2(I)
00143             Y      = WWA*X(I)+WWB
00144             YY     = Y*Y
00145             IF (L.EQ.0) GO TO 35
00147          30 X(I)   = DCL-X(I)
00150             XX(I)  = 2.0-XX2(I)
00151          35 BETA   = ATAN(Y/X(I))
00152             RHO2   = X(I)*X(I)+YY
00153             RHO    = SQRT(RHO2)
00154             OB     = ACOS(R2/RHO)
00155             PB     = PHI-BETA
00156             OP     = OB-PB
00157             BA     = BETA+ALPFN
00160             GAMMA  = OB+BA
00161             IF (L.EQ.1) BA = BETA-ALPFN
00163             PHIO   = ATAN(DZMFN/(2.0*XX(I)))
00164             SS(I,1,1) = ((1.0-SIN(GAMMA))/PI)*(PHIO+SIN(2.0*PHIO)/2.0)*4.0+
00164            1           SS(I,1,1)
00165             PR4    = 4.*PI*RHO
00166             RRO    = 2.*R2*RHO
00167             RRO2   = RRO*RRO
00170             CPB    = COS(PB)
00171             RC     = RRO*CPB
00172             J      = 1
00173             DO 50 K=2,5
00176             DZ2    = ((ZZ2(K)-ZZ2(J))*CF)**2
00177             A      = RR+RHO2+DZ2
00200             AR     = A*A-RRO2
00201             ARC    = A-RC
00202             AR2    = A-2.0*RR
00203             SS(I,J,K) = (COS(BA)/PR4*(ALOG(ARC/AR2)-1.0+AR2/ARC)+SIN(BA)/PR4*
00203            1           (OP+(2.0*RRO2*DZ2-A*AR)/(AR**1.5)*(ASIN((RRO-A*COS(OB)
```

```
00203          2          )/AR2)-ASIN((RRO-A*CPB)/ARC))+(4.0*A*DZ2/AR-2.0)*((R2
00203          3          *RHO*SIN(OB))/AR2-(R2*RHO*SIN(PB))/ARC)))*CF+SS(I,J,K)
00204             IF (SS(I,J,K) .LT. 0.0) SS(I,J,K) = 0.0
00206          50 CONTINUE
00211             IF (L.EQ.1) GO TO 70
00213             L      = 1
00214             GO TO 20
00215          70 DO 60 I=1,5
00220             DO 60 K=2,5
00223             SS(I,K,1) = SS(I,1,K)
00224             DO 60 J=2,5
00227             M      *= ABS(J-K)+1
00230          60 SS(I,J,K) = SS(I,1,M)
00234             RL     = DCL/R2-COS(PHI)
00235             RT     = T/R2
00236             PHI1   = ATAN(RT/RL)
00237             RT2    = RT*RT
00240             RL2    = RL*RL
00241             THETA1 = ACOS(1.0/SQRT(RT2+RL2))
00242             RTL    = (1.0-RT2)/RL2
00243             GAMA   = PI2-PHI1-THETA1
00244             IF (RTL-1.0E-03) 62,62,61
00247          61 SST    = (GAMA+RL*(SQRT(1.0-RTL)-1.0))/(PI2-PHI)
00250             GO TO 65
00251          62 IF(RTL-1.0E-04) 63,64,64
00254          63 SST    = (GAMA-RL*RTL/2.0)/(PI2-PHI)
00255             GO TO 65
00256          64 SST    = (GAMA-RL*(RTL/2.0+RTL*RTL/8.0))/(PI2-PHI)
00257          65 J      = 1
00260             DO 80 K=1,5
00263             DZ     = (ZZ2(K)-ZZ2(J))*CF
00264             XB     = 2.0*(1.0+R1-R2*COS((PHI1+THETA1)/2.0))
00265             BETA1  = ATAN((DZ-DZMFN/2.0)/XB)
00266             BETA2  = ATAN((DZ+DZMFN/2.0)/XB)
00267             WF     = (BETA2-BETA1)/2.0+(SIN(2.0*BETA2)-SIN(2.0*BETA1))/4.0
00270             SSTT(J,K) = 8.0*SST*WF/PI
00271          80 CONTINUE
00273             DO 90 K=2,5
00276             SSTT(K,1) = SSTT(1,K)
00277             DO 90 J=2,5
00302             M      = ABS(J-K)+1
00303          90 SSTT(J,K) = SSTT(1,M)
00306             RETURN
00307             END

      END OF COMPILATION:       NO  DIAGNOSTICS.

@HDG,P  ******  TCALC  ******
```

```
@FOR,S ME*NASA5.TCALC,ME*NASA5.TCALC
FOR S9A-07/13/72-20:58:10 (0,)

   SUBROUTINE TCALC      ENTRY POINT 000635

   STORAGE USED: CODE(1) 000652; DATA(0) 000670; BLANK COMMON(2) 000000

    COMMON BLOCKS:

    0003   ADBH    000352
    0004   TC      000042
    0005   QIN     001610

   EXTERNAL REFERENCES (BLOCK, NAME)

    0006   YINT
    0007   SHADE
    0010   NRBJ$
    0011   NI02$
    0012   NBSP$
    0013   NI01$
    0014   NEXP6$
    0015   NREW$
    0016   NERR3$

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

    0001    000024 10L        0001    000426 110L       0001    000024 125G       0001    000047 141G       0001    000121 160G
    0001    000127 165G       0001    000146 173G       0001    000164 203G       0001    000247 220G       0001    000252 223G
    0001    000276 232G       0001    000504 261G       0001    000042 30L        0001    000070 50L        0001    000254 90L
    0004 R  000003 ABEMF      0003    000001 AL         0000 R  000562 ANG        0003    000161 CONFL      0003    000173 CONFNA
    0003    000147 CP         0003    000000 D          0003    000326 DTL        0003    000244 EFF        0003    000205 EMIS
    0003    000013 H          0000 R  000623 HA         0003    000231 HAB        0000 R  000624 HP         0000 R  000622 HS
    0000 I  000611 I          0004 I  000001 ICASE      0000    000637 INJP$      0000 I  000614 ISYM       0004 I  000000 ITAPE
    0000 I  000615 IJ         0000 I  000613 IUL        0000 I  000612 J          0000 I  000616 J1         0000 I  000617 J2
    0000 I  000621 K          0003 R  000064 M          0000 I  000610 NS         0005 I  001605 NSRD       0003    000076 NT
    0005 I  001604 NTF        0000 R  000620 PANG       0004 R  000004 PHIN       0003    000052 PIN        0000 R  000436 QA
    0000 R  000124 QALB       0005    000454 QIFN       0005    001274 QITB       0003    000314 QOUT       0000 R  000510 QP
    0000 R  000244 QPLN       0000 R  000364 QS         0005    000144 QSFN       0005    000764 QSTB       0000 R  000004 QSUN
    0005    001606 QTO        0000 R  000607 STFBOL     0003    000217 TB         0003    000026 TH         0000 R  000000 TIM
    0003    000040 TIN        0003    000270 TL         0005    000000 TM         0004 R  000002 TO         0003    000340 TOUT
    0003 R  000077 TSTAR      0005    001607 TX         0003    000135 VSC        0006 R  000000 YINT


00101       1*             SUBROUTINE TCALC(NTF)
00103       2*             PARAMETER NTP = 10
00104       3*             PARAMETER MAXSID = 20
00105       4*             PARAMETER NTP1 = NTP+1
00106       5*             PARAMETER MAXSD1 = MAXSID+1
00107       6*             REAL M
00110       7*             COMMON /ADBH/ D,AL(NTP),H(NTP1),TH(NTP),TIN(NTP),PIN(NTP),
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00110          1   M(NTP),NT,TSTAR(NTP,3),VSC(NTP),CP(NTP),CONFL(NTP),
00110          2   CONFNA(NTP),EMIS(NTP),TB(NTP),HAB(NTP1),EFF(NTP,2),TL(NTP,2),
00110          3   QOUT(NTP),DTL(NTP),TOUT(NTP)
00111              COMMON /TC/ ITAPE,ICASE,TO,ABEMF,PHIN(NTP,3)
00112              COMMON /QIN/ TM(100),QSFN(100,2),QIFN(100,2),QSTB(100,2),
00112          1   QITB(100,2),NTM,NSRD,QTO,TX
00113              DIMENSION TIM(4),QSUN(4,MAXSID),QALB(4,MAXSID),QPLN(4,MAXSID),
00113          1   QS(MAXSD1,2),QA(MAXSD1,2),QP(MAXSD1,2),ANG(MAXSD1)
00114              DATA STFBOL/0.1714E-8/
00116              READ (ITAPE) NS,TIM(1)
00122              IF (ICASE.LE.1) GO TO 30
00124              DO 20 I = 2,ICASE
00127     10       TIM(2) = TIM(1)
00130              READ (ITAPE) NS,TIM(1)
00134              IF (TIM(1).GT.TIM(2)) GO TO 10
00136     20       CONTINUE
00140     30       DO 40 J = 0,NS
00143     40       ANG(J+1) = FLOAT(J*360+180)/NS
00145              READ (ITAPE)
00147              I = 2
00150     50       READ (ITAPE) NS,TIM(1)
00154              I = I+1
00155              IF (TIM(1).LT.TO.AND.I.LT.NTM-1) GO TO 50
00157              DO 60 I = 1,3
00162     60       BACKSPACE ITAPE
00164              DO 70 I = 1,4
00167     70       READ (ITAPE) NS,TIM(I),(QSUN(I,J),QALB(I,J),QPLN(I,J),J=1,NS)
00202              DO 80 J = 1,NS
00205              QS(J,1) = YINT(TIM,QSUN(1,J),4,4,TO)
00206              QA(J,1) = YINT(TIM,QALB(1,J),4,4,TO)
00207     80       QP(J,1) = YINT(TIM,QPLN(1,J),4,4,TO)
00211              QS(NS+1,1) = QS(1,1)
00212              QA(NS+1,1) = QA(1,1)
00213              QP(NS+1,1) = QP(1,1)
00214              IUL = 1
00215              IF (ISYM.EQ.3) IUL = 3
00217              DO 120 IU = 1,IUL
00222              DO 120 I = 1,NTF
00225              J1 = 0
00226     90       J1 = J1+1
00227              IF (ANG(J1)+ANG(1).LE.PHIN(I,IU)) GO TO 90
00231              DO 100 J = 1,NS
00234              J2 = MIN(MAX(MOD(J+J1-2,NS),1),NS-2)
00235              PANG = ANG(J)+PHIN(I,IU)
00236              IF (PANG.GE.ANG(NS+1)) PANG = PANG-360.0
00240              QS(J,2) = YINT(ANG(J2),QS(J2,1),4,4,PANG)
00241              QA(J,2) = YINT(ANG(J2),QA(J2,1),4,4,PANG)
00242     100      QP(J,2) = YINT(ANG(J2),QP(J2,1),4,4,PANG)
00244              CALL SHADE(QS(1,2),NS)
00245              CALL SHADE(QA(1,2),NS)
00246              CALL SHADE(QP(1,2),NS)
00247              PANG = AMOD(PHIN(I,IU)+90.0,360.0)
00250              J1 = 0
00251     110      J1 = J1+1
00252              IF (ANG(J1).LE.PANG) GO TO 110
00254              J2 = 0
00255              IF (PANG.GE.180.0) J2 = NS/2
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```
00257              K = J2+MIN(MAX(J1-J2-2,1),NS/2-3)
00260              DO 120 J = IU,NSRD
00263              IF (J.NE.IU) K = MOD(K+NS/2,NS)
00265              HS = YINT(ANG(K),QS(K,2),4,4,PANG)
00266              HA = YINT(ANG(K),QA(K,2),4,4,PANG)
00267              HP = YINT(ANG(K),QP(K,2),4,4,PANG)
00270        120   TSTAR(I,J) = ((HP+(HA+HS)*ABEMF)/STFBOL)**0.25
00274              REWIND ITAPE
00275              RETURN
00276              END

       END OF COMPILATION:       NO  DIAGNOSTICS.


QHDG,P  ******  THCF/CFFC43  ******
```

```
@FOR,S ME*NASA5.THCF/CFFC43,ME*NASA5.THCF/CFFC43
FOR S9A-07/13/72-20:58:14 (0,)

   FUNCTION THCF        ENTRY POINT 000013

   STORAGE USED: CODE(1) 000015; DATA(0) 000010; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   NERR3$

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

    0000   000003 INJP$    0000 R 000000 THCF    0000 R 000001 X1    0000 R 000002 X2


00101            FUNCTION THCF(RHO,T)
00101       C
00101       C       THIS FUNCTION SUBPROGRAM COMPUTES :
00101       C       THERMAL CONDUCTIVITY AS A FUNCTION OF DENSITY (SLUG/CU.FT)
00101       C            AND TEMPERATURE (R) OF FC-43
00101       C                                   UNITS BTU/(HR.FT.R)
00101       C
00103            DATA X1,X2 /0.061442,-2.5E-05/
00106            THCF = X1+X2*T
00107            RETURN
00110            END

      END OF COMPILATION:       NO  DIAGNOSTICS.


@HDG,P  ******  THCF/CFFC75  ******
```

```
@FOR,S ME*NASA5.THCF/CFFC75,ME*NASA5.THCF/CFFC75
FOR S9A-07/13/72-20:58:16 (0,)

   FUNCTION THCF        ENTRY POINT 000013

   STORAGE USED: CODE(1) 000015; DATA(0) 000010; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   NERR3$

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

    0000   000003 INJP$     0000 R 000000 THCF      0000 R 000001 X1        0000 R 000002 X2


00101       1*           FUNCTION THCF(RHO,T)
00101       2*      C
00101       3*      C       THIS FUNCTION SUBPROGRAM COMPUTES :
00101       4*      C       THERMAL CONDUCTIVITY AS A FUNCTION OF DENSITY (SLUG/CU.FT)
00101       5*      C            AND TEMPERATURE (R) OF FC-75
00101       6*      C                                     UNITS BTU/(HR.FT.R)
00101       7*      C
00103       8*           DATA X1,X2 /0.114181,-6.53E-05/
00106       9*           THCF = X1+X2*T
00107      10*           RETURN
00110      11*           END

      END OF COMPILATION:        NO  DIAGNOSTICS.


@HDG,P  ******  THCF/CFHE  ******
```

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****** THCF/CFHE ******                                                        DATE 071372        PAGE    1

@FOR,S ME*NASA5.THCF/CFHE,ME*NASA5.THCF/CFHE
FOR S9A-07/13/72-20:58:18 (0,)

   FUNCTION THCF        ENTRY POINT 000022

   STORAGE USED: CODE(1) 000024; DATA(0) 000015; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   NERR3$

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

    0000 R 000006 DT       0000   000010 INJP$     0000 R 000000 THCF      0000 R 000007 THETA     0000 R 000005 TO
    0000 R 000001 X1       0000 R 000002 X2        0000 R 000003 X3        0000 R 000004 X4


00101      1*           FUNCTION THCF(RHO,T)
00101      2*      C
00101      3*      C        THIS FUNCTION SUBPROGRAM COMPUTES :
00101      4*      C        THERMAL CONDUCTIVITY AS A FUNCTION OF DENSITY (SLUG/CU.FT)
00101      5*      C             AND TEMPERATURE (R) OF HELIUM
00101      6*      C                                     UNITS BTU/(HR.FT.R)
00101      7*      C
00103      8*           DATA X1,X2,X3,X4 /0.0404,0.0302,-0.0033,0.0003/,TO,DT /160.0,20
00103      9*          10.0/
00112     10*           THETA = (T-TO)/DT
00113     11*           THCF  = ((X4*THETA+X3)*THETA+X2)*THETA+X1
00114     12*           RETURN
00115     13*           END

      END OF COMPILATION:       NO  DIAGNOSTICS.


@HDG,P  ******  THCF/CFNAK  ******
```

```
@FOR,S ME*NASA5.THCF/CFNAK,ME*NASA5.THCF/CFNAK
FOR S9A-07/13/72-20:58:20 (0,)

   FUNCTION THCF        ENTRY POINT 000024

   STORAGE USED: CODE(1) 000026; DATA(0) 000016; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   NERR3$

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

    0000 R 000007 DT        0000   000011 INJP$     0000 R 000000 THCF      0000 R 000010 THETA     0000 R 000006 T0
    0000 R 000001 X1        0000 R 000002 X2        0000 R 000003 X3        0000 R 000004 X4        0000 R 000005 X5


00101            FUNCTION THCF(RHO,T)
00101       C
00101       C       THIS FUNCTION SUBPROGRAM COMPUTES :
00101       C       THERMAL CONDUCTIVITY AS A FUNCTION OF DENSITY (SLUG/CU.FT)
00101       C            AND TEMPERATURE (R) OF NAK 78.6
00101       C                                     UNITS BTU/(HR.FT.R)
00101       C
00103            DATA X1,X2,X3,X4,X5 /13.36,1.414167,-0.142083,-0.069167,0.007083/,
00103           1T0,DT /659.67,300.0/
00113            THETA = (T-T0)/DT
00114            THCF  = (((X5*THETA+X4)*THETA+X3)*THETA+X2)*THETA+X1
00115            RETURN
00116            END

      END OF COMPILATION:        NO  DIAGNOSTICS.


@HDG,P  ******  THCF/CFSIL  ******
```

```
****** THCF/CFSIL ******                                                          DATE 071372        PAGE     1

@FOR,S ME*NASA5.THCF/CFSIL,ME*NASA5.THCF/CFSIL
FOR S9A-07/13/72-20:58:22 (0,)

   FUNCTION THCF        ENTRY POINT 000043

   STORAGE USED: CODE(1) 000047; DATA(0) 000031; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   NWDU$
    0004   NIO2$
    0005   NERR3$

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

    0000   000003 1F       0000   000023 INJP$     0000 R 000000 THCF      0000 R 000001 X1        0000 R 000002 X2


00101      1*              FUNCTION THCF(RHO,T)
00101      2*      C
00101      3*      C          THIS FUNCTION SUBPROGRAM COMPUTES :
00101      4*      C          THERMAL CONDUCTIVITY AS A FUNCTION OF DENSITY (SLUG/CU.FT) AND
00101      5*      C               TEMPERATURE (R) OF DOW CORNING 200 SILICON OIL (1 CS)
00101      6*      C                                       UNITS BTU/(HR.FT.R)
00101      7*      C               TEMPERATURE .GE. 359.67 AND .LE. 859.67
00101      8*      C
00103      9*              DATA X1,X2 /0.070052,-2.2105E-05/
00106     10*              THCF = X1+X2*T
00107     11*              IF (T.GE.359.67.AND.T.LE.859.67) RETURN
00111     12*              WRITE (6,1) T
00114     13*            1 FORMAT (1H0,61HTHERMAL CONDUCTIVITY OF SILICON OIL, TEMP. OUT OF R
00114     14*             1ANGE, T = ,F8.3,/)
00115     15*              RETURN
00116     16*              END
        END OF COMPILATION:        NO  DIAGNOSTICS.


@HDG,P ****** THCFN/FNAL ******
```

```
@FOR,S ME*NASA5.THCFN/FNAL,ME*NASA5.THCFN/FNAL
FOR S9A-07/13/72-20:58:25 (0,)

   FUNCTION THCFN       ENTRY POINT 000054

   STORAGE USED: CODE(1) 000060; DATA(0) 000037; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   NWDU$
    0004   NIO2$
    0005   NERR3$

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

    0000    000011 1F        0000 R 000007 DT        0000    000031 INJP$      0000 R 000000 THCFN       0000 R 000010 THETA
    0000 R 000006 T0         0000 R 000001 X1        0000 R 000002 X2          0000 R 000003 X3          0000 R 000004 X4
    0000 R 000005 X5


00101          FUNCTION THCFN(T)
00101     C
00101     C       THIS FUNCTION SUBPROGRAM COMPUTES :
00101     C     THERMAL CONDUCTIVITY AS A FUNCTION OF TEMPERATURE (R) OF
00101     C            ALUIMINUM 7075
00101     C                                    UNITS BTU/(HR.FT.R)
00101     C            TEMP. GE. 300.0.AND.LE. 1200.0 R
00101     C
00103          DATA X1,X2,X3,X4,X5 /88.5,13.0665,0.33275,-1.758,0.25375/,T0,DT /
00103         1400.0,200.0/
00113          THETA = (T-T0)/DT
00114          THCFN = (((X5*THETA+X4)*THETA+X3)*THETA+X2)*THETA+X1
00115          IF (T.GE.300.0.AND.T.LE.1200.0) RETURN
00117          WRITE (6,1) T
00122        1 FORMAT (1H0,58HTHERMAL CONDUCTIVITY OF ALUMINUM, TEMP. OUT OF RANG
00122         1E, T = ,F8.3,/)
00123          RETURN
00124          END

       END OF COMPILATION:       NO  DIAGNOSTICS.


@HDG,P  ******  THCFN/FNBR  ******
```

```
@FOR,S ME*NASA5.THCFN/FNBR,ME*NASA5.THCFN/FNBR
FOR S9A-07/13/72-20:58:27 (0,)

   FUNCTION THCFN        ENTRY POINT 000054

   STORAGE USED: CODE(1) 000060; DATA(0) 000037; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   NWDU$
    0004   NIO2$
    0005   NERR3$

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

    0000   000011 1F       0000 R 000007 DT       0000   000031 INJP$     0000 R 000000 THCFN     0000 R 000010 THETA
    0000 R 000006 T0       0000 R 000001 X1       0000 R 000002 X2       0000 R 000003 X3        0000 R 000004 X4
    0000 R 000005 X5


 00101          FUNCTION THCFN(T)
 00101     C
 00101     C       THIS FUNCTION SUBPROGRAM COMPUTES :
 00101     C       THERMAL CONDUCTIVITY AS A FUNCTION OF TEMPERATURE (R) OF
 00101     C            BERYLIUM WITH 0.84-1.68 DEO
 00101     C                                         UNITS BTU/(HR.FT.R)
 00101     C            TEMP. GE. 400.0 AND LE. 1700.0 R
 00101     C
 00103          DATA X1,X2,X3,X4,X5 /108.863,-10.5643,0.82683,-0.20167,0.020167/,
 00103         1T0,DT /400.0,200.0/
 00113          THETA = (T-T0)/DT
 00114          THCFN = (((X5*THETA+X4)*THETA+X3)*THETA+X2)*THETA+X1
 00115          IF (T.GE.400.0.AND.T.LE.1700.0) RETURN
 00117          WRITE (6,1) T
 00122        1 FORMAT (1H0,58HTHERMAL CONDUCTIVITY OF BERYLIUM, TEMP. OUT OF RANG
 00122         1E, T = ,F8.3,/)
 00123          RETURN
 00124          END

      END OF COMPILATION:        NO  DIAGNOSTICS.

@HDG,P  ******  THCFN/FNCU  ******
```

```
@FOR,S ME*NASA5.THCFN/FNCU,ME*NASA5.THCFN/FNCU
FOR S9A-07/13/72-20:58:29 (0,)

   FUNCTION THCFN       ENTRY POINT 000051

   STORAGE USED: CODE(1) 000055; DATA(0) 000034; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   NWDU$
    0004   NIO2$
    0005   NERR3$

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

    0000   000007 1F       0000 R 000005 DT       0000   000026 INJP$     0000 R 000000 THCFN     0000 R 000006 THETA
    0000 R 000004 T0       0000 R 000001 X1       0000 R 000002 X2       0000 R 000003 X3


00101       C          FUNCTION THCFN(T)
00101       C
00101       C             THIS FUNCTION SUBPROGRAM COMPUTES :
00101       C             THERMAL CONDUCTIVITY AS A FUNCTION OF TEMPERATURE (R) OF COPPER
00101       C                                              UNITS BTU/(HR.FT.R)
00101       C                  TEMP. GE. 500.0 AND LE. 1800.0 R
00101       C
00103                  DATA X1,X2,X3 /228.369,-2.62067,-0.04033/,T0,DT /600.0,200.0/
00111                  THETA = (T-T0)/DT
00112                  THCFN = (X3*THETA*THETA+X2)*THETA+X1
00113                  IF (T.GE.500.0.AND.T.LE.1800.0) RETURN
00115                  WRITE (6,1) T
00120                1 FORMAT (1H0,56HTHERMAL CONDUCTIVITY OF COPPER, TEMP. OUT OF RANGE,
00120                 1 T = ,F8.3,/)
00121                  RETURN
00122                  END

       END OF COMPILATION:       NO  DIAGNOSTICS.


@HDG,P  ******  THCMP/MPAL  ******
```

```
@FOR,S ME*NASA5.THCMP/MPAL,ME*NASA5.THCMP/MPAL
FOR S9A-07/13/72-20:58:31 (0,)

   FUNCTION THCMP       ENTRY POINT 000054

   STORAGE USED: CODE(1) 000060; DATA(0) 000037; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   NWDU$
    0004   NI02$
    0005   NERR3$

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

    0000   000011 1F        0000 R 000007 DT        0000   000031 INJP$      0000 R 000000 THCMP      0000 R 000010 THETA
    0000 R 000006 T0        0000 R 000001 X1        0000 R 000002 X2        0000 R 000003 X3         0000 R 000004.X4
    0000 R 000005 X5


00101            FUNCTION THCMP(T)
00101      C
00101      C        THIS FUNCTION SUBPROGRAM COMPUTES :
00101      C      THERMAL CONDUCTIVITY AS A FUNCTION OF TEMPERATURE (R) OF
00101      C             ALUIMINUM 7075
00101      C                                    UNITS BTU/(HR.FT.R)
00101      C             TEMP. GE. 300.0.AND.LE. 1200.0 R
00101      C
00103            DATA X1,X2,X3,X4,X5 /88.5,13.0665,0.33275,-1.758,0.25375/,T0,DT /
00103           1400.0,200.0/
00113            THETA = (T-T0)/DT
00114            THCMP = (((X5*THETA+X4)*THETA+X3)*THETA+X2)*THETA+X1
00115            IF (T.GE.300.0.AND.T.LE.1200.0) RETURN
00117            WRITE (6,1) T
00122          1 FORMAT (1H0,58HTHERMAL CONDUCTIVITY OF ALUMINUM, TEMP. OUT OF RANG
00122           1E, T = ,F8.3,/)
00123            RETURN
00124            END

      END OF COMPILATION:        NO  DIAGNOSTICS.


@HDG,P  ******  THCMP/MPBR  ******
```

```
QFOR,S ME*NASA5.THCMP/MPBR,ME*NASA5.THCMP/MPBR
FOR S9A-07/13/72-20:58:34 (0,)

   FUNCTION THCMP        ENTRY POINT 000054

   STORAGE USED: CODE(1) 000060; DATA(0) 000037; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   NWDU$
    0004   NIO2$
    0005   NERR3$

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

    0000   000011 1F       0000 R 000007 DT       0000   000031 INJP$     0000 R 000000 THCMP     0000 R 000010 THETA
    0000 R 000006 T0       0000 R 000001 X1       0000 R 000002 X2       0000 R 000003 X3        0000 R 000004 X4
    0000 R 000005 X5


00101      1*          FUNCTION THCMP(T)
00101      2*     C
00101      3*     C       THIS FUNCTION SUBPROGRAM COMPUTES :
00101      4*     C       THERMAL CONDUCTIVITY AS A FUNCTION OF TEMPERATURE (R) OF
00101      5*     C            BERYLLIUM WITH 0.84-1.68 BEO
00101      6*     C                                    UNITS BTU/(HR.FT.R)
00101      7*     C            TEMP. GE. 400.0 AND LE. 1700.0 R
00101      8*     C
00103      9*          DATA X1,X2,X3,X4,X5 /108.863,-10.5643,0.82683,-0.20167,0.020167/,
00103     10*         1T0,DT /400.0,200.0/
00113     11*          THETA = (T-T0)/DT
00114     12*          THCMP = (((X5*THETA+X4)*THETA+X3)*THETA+X2)*THETA+X1
00115     13*          IF (T.GE.400.0.AND.T.LE.1700.0) RETURN
00117     14*          WRITE (6,1) T
00122     15*        1 FORMAT (1H0,58HTHERMAL CONDUCTIVITY OF BERYLLIUM, TEMP. OUT OF RANG
00122     16*         1E, T = ,F8.3,/)
00123     17*          RETURN
00124     18*          END

      END OF COMPILATION:       NO  DIAGNOSTICS.


QHDG,P  ******  THCMP/MPCU  ******
```

```
****** THCMP/MPCU ******                                                                    DATE 071372      PAGE    1

@FOR,S ME*NASA5.THCMP/MPCU,ME*NASA5.THCMP/MPCU
FOR S9A-07/13/72-20:58:36 (0,)

   FUNCTION THCMP        ENTRY POINT 000051

   STORAGE USED: CODE(1) 000055; DATA(0) 000034; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   NWDU$
    0004   NIO2$
    0005   NERR3$

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

    0000   000007 1F        0000 R 000005 DT        0000   000026 INJP$     0000 R 000000 THCMP     0000 R 000006 THETA
    0000 R 000004 T0        0000 R 000001 X1        0000 R 000002 X2        0000 R 000003 X3



00101      1*            FUNCTION THCMP(T)
00101      2*      C
00101      3*      C        THIS FUNCTION SUBPROGRAM COMPUTES :
00101      4*      C        THERMAL CONDUCTIVITY AS A FUNCTION OF TEMPERATURE (R) OF COPPER
00101      5*      C                                 UNITS BTU/(HR.FT.R)
00101      6*      C             TEMP. GE. 500.0 AND LE. 1800.0 R
00101      7*      C
00103      8*            DATA X1,X2,X3 /228.369,-2.62067,-0.04033/,T0,DT /600.0,200.0/
00111      9*            THETA = (T-T0)/DT
00112     10*            THCMP = (X3*THETA*THETA+X2)*THETA+X1
00113     11*            IF (T.GE.500.0.AND.T.LE.1800.0) RETURN
00115     12*            WRITE (6,1) T
00120     13*          1 FORMAT (1H0,56HTHERMAL CONDUCTIVITY OF COPPER, TEMP. OUT OF RANGE,
00120     14*           1 T = ,F8.3,/)
00121     15*            RETURN
00122     16*            END

      END OF COMPILATION:        NO  DIAGNOSTICS.


@HDG,P  ******  THCTB/TBAL  ******
```

```
QFOR,S ME*NASA5.THCTB/TBAL,ME*NASA5.THCTB/TBAL
FOR S9A-07/13/72-20:58:40 (0,)

   FUNCTION THCTB        ENTRY POINT 000054

   STORAGE USED: CODE(1) 000060; DATA(0) 000037; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   NWDU$
    0004   NI02$
    0005   NERR3$

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

    0000   000011 1F       0000 R 000007 DT       0000   000031 INJP$      0000 R 000000 THCTB      0000 R 000010 THETA
    0000 R 000006 T0       0000 R 000001 X1       0000 R 000002 X2       0000 R 000003 X3       0000 R 000004 X4
    0000 R 000005 X5


00101      1*           FUNCTION THCTB(T)
00101      2*      C
00101      3*      C       THIS FUNCTION SUBPROGRAM COMPUTES :
00101      4*      C     THERMAL CONDUCTIVITY AS A FUNCTION OF TEMPERATURE (R) OF
00101      5*      C            ALUIMINUM 7075
00101      6*      C                                  UNITS BTU/(HR.FT.R)
00101      7*      C            TEMP. GE. 300.0.AND.LE. 1200.0 R
00101      8*      C
00103      9*           DATA X1,X2,X3,X4,X5 /88.5,13.0665,0.33275,-1.758,0.25375/,T0,DT /
00103     10*          1400.0,200.0/
00113     11*           THETA = (T-T0)/DT
00114     12*           THCTB = (((X5*THETA+X4)*THETA+X3)*THETA+X2)*THETA+X1
00115     13*           IF (T.GE.300.0.AND.T.LE.1200.0) RETURN
00117     14*           WRITE (6,1) T
00122     15*         1 FORMAT (1H0,58HTHERMAL CONDUCTIVITY OF ALUMINUM, TEMP. OUT OF RANG
00122     16*          1E, T = ,F8.3,/)
00123     17*           RETURN
00124     18*           END

      END OF COMPILATION:        NO  DIAGNOSTICS.


QHDG,P  ******  THCTB/TBBR  ******
```

```
@FOR,S ME*NASA5.THCTB/TBBR,ME*NASA5.THCTB/TBBR
FOR S9A-07/13/72-20:58:42 (0,)

   FUNCTION THCTB       ENTRY POINT 000054

   STORAGE USED: CODE(1) 000060; DATA(0) 000037; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   NWDU$
    0004   NIO2$
    0005   NERR3$

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

    0000   000011 1F       0000 R 000007 DT        0000   000031 INJP$     0000 R 000000 THCTB     0000 R 000010 THETA
    0000 R 000006 T0       0000 R 000001 X1        0000 R 000002 X2        0000 R 000003 X3        0000 R 000004 X4
    0000 R 000005 X5


00101      1*          FUNCTION THCTB(T)
00101      2*      C
00101      3*      C      THIS FUNCTION SUBPROGRAM COMPUTES :
00101      4*      C      THERMAL CONDUCTIVITY AS A FUNCTION OF TEMPERATURE (R) OF
00101      5*      C          BERYLIUM WITH 0.84-1.68 BEO
00101      6*      C                                      UNITS BTU/(HR.FT.R)
00101      7*      C          TEMP. GE. 400.0 AND LE. 1700.0 R
00101      8*      C
00103      9*          DATA X1,X2,X3,X4,X5 /108.863,-10.5643,0.82683,-0.20167,0.020167/,
00103     10*         1T0,DT /400.0,200.0/
00113     11*          THETA = (T-T0)/DT
00114     12*          THCTB = (((X5*THETA+X4)*THETA+X3)*THETA+X2)*THETA+X1
00115     13*          IF (T.GE.400.0.AND.T.LE.1700.0) RETURN
00117     14*          WRITE (6,1) T
00122     15*        1 FORMAT (1H0,58HTHERMAL CONDUCTIVITY OF BERYLIUM, TEMP. OUT OF RANG
00122     16*         1E, T = ,F8.3,/)
00123     17*          RETURN
00124     18*          END

      END OF COMPILATION:        NO  DIAGNOSTICS.


@HDG,P  ******  THCTB/TBCU  ******
```

```
****** THCTB/TBCU ******                                                   DATE 071372     PAGE    1

@FOR,S ME*NASA5.THCTB/TBCU,ME*NASA5.THCTB/TBCU
FOR S9A-07/13/72-20:58:44 (0,)

   FUNCTION THCTB       ENTRY POINT 000051

   STORAGE USED: CODE(1) 000055; DATA(0) 000034; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003    NWDU$
    0004    NIO2$
    0005    NERR3$

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

    0000    000007 1F       0000 R 000005 DT       0000    000026 INJP$     0000 R 000000 THCTB     0000 R 000006 THETA
    0000 R 000004 T0        0000 R 000001 X1       0000 R 000002 X2         0000 R 000003 X3


00101      1*          FUNCTION THCTB(T)
00101      2*      C
00101      3*      C      THIS FUNCTION SUBPROGRAM COMPUTES :
00101      4*      C      THERMAL CONDUCTIVITY AS A FUNCTION OF TEMPERATURE (R) OF COPPER
00101      5*      C                                UNITS BTU/(HR.FT.R)
00101      6*      C           TEMP. GE. 500.0 AND LE. 1800.0 R
00101      7*      C
00103      8*          DATA X1,X2,X3 /228.369,-2.62067,-0.04033/,T0,DT /600.0,200.0/
00111      9*          THETA = (T-T0)/DT
00112     10*          THCTB = (X3*THETA*THETA+X2)*THETA+X1
00113     11*          IF (T.GE.500.0.AND.T.LE.1800.0) RETURN
00115     12*          WRITE (6,1) T
00120     13*        1 FORMAT (1H0,56HTHERMAL CONDUCTIVITY OF COPPER, TEMP. OUT OF RANGE,
00120     14*         1 T = ,F8.3,/)
00121     15*          RETURN
00122     16*          END

      END OF COMPILATION:       NO  DIAGNOSTICS.


@HDG,P ****** TK ******
```

```
QFOR,S ME*NASA5.TK,ME*NASA5.TK
FOR S9A-07/13/72-20:58:46 (0,)

   FUNCTION TK          ENTRY POINT 000211

   STORAGE USED: CODE(1) 000245; DATA(0) 000062; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   ELAS
    0004   ALOG
    0005   NEXP6$
    0006   SQRT
    0007   NWDU$
    0010   NIO2$
    0011   NERR3$

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

    0001   000112 13L      0001   000127 14L      0001   000174 15L      0000   000020 16F      0001   000201 17L
    0000 R 000003 B        0000 R 000001 C        0000 R 000017 CC       0000 R 000004 D        0000 R 000015 E
    0000 R 000002 EE       0003 R 000000 ELAS     0000 R 000005 F        0000 R 000006 G        0000   000040 INJP$
    0000 I 000012 KG       0000 R 000007 P        0000 R 000010 Q        0000 R 000016 R        0000 R 000011 S
    0000 R 000000 TK       0000 R 000013 TN       0000 R 000014 V


00101             FUNCTION  TK(GAMMA,A,BETA,DENSM,THETA,PHI,AN,ALPHA,VELM,
00101            1        PO,TAU,DENST,W,TNN,AMAN,TIN,ROUT)
00101       C
00101       C   THIS FUNCTION SUBPROGRAM COMPUTES :
00101       C     THE THICKNESS OF THE PROTECTION LAYET TK ,IN INCHES
00101       C
00103             DATA C/1.2407013/
00105             EE = 1./(3.*BETA)
00106             B  = GAMMA*A
00107             D  = 0.0436332*TNN*W
00110             F  = (ALPHA*TAU/(-ALOG(PO)))**EE
00111             G  = (1./DENSM)**.33333
00112             P  = (DENSM/DENST)**PHI
00113             Q  = (VELM/(12.0*SQRT(ELAS(TIN)*32.174/DENST)))**THETA
00114             S  = (2./(3.*AN*THETA*BETA+2.))**EE
00115             KG = 0
00116             TN = 0.5
00117          13 KG = KG+1
00120             IF (KG.EQ.1) GO TO 14
00122             IF (KG.GT.10) GO TO 15
00124             TN = TK
00125          14 V  = (D*(ROUT+TN)+AMAN)
00126             E  = V**EE
00127             R  = B*C*E*F*G*P*Q*S
00130             TK = TN-((TN-R)/(1.-(EE*R*D/V)))
```

```
00131              CC = TK/TN-1.
00132              IF (ABS(CC).LT..0001) GO TO 17
00134              GO TO 13
00135           15 WRITE (6,16)
00137           16 FORMAT (29HEQN FOR THICK DOESNT CONVERGE)
00140           17 RETURN
00141              END

      END OF COMPILATION:        NO  DIAGNOSTICS.


QHDG,P  ******  TNH  ******
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```
****** TNH ******                                                                                          DATE 071372        PAGE    1

@FOR,S ME*NASA5.TNH,ME*NASA5.TNH
FOR S9A-07/13/72-20:58:48 (0,)

   FUNCTION TNH         ENTRY POINT 000056

   STORAGE USED: CODE(1) 000064; DATA(0) 000030; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   CPAIR
    0004   ENTAIR
    0005   NERR3$

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

    0001   000037 10L       0001   000004 106G      0001   000041 30L       0003 R 000000 CPAIR     0000 R 000014 DFTN
    0004 R 000000 ENTAIR    0000 R 000015 FTN       0000   000020 INJP$     0000 I 000013 N         0000 R 000001 TN
    0000 R 000000 TNH


 00101      1*          FUNCTION TNH(ENT)
 00101      2*     C
 00101      3*     C       THIS FUNCTION SUBPROGRAM COMPUTES :
 00101      4*     C       TEMPERATURE OF THE ATMOSPHERE AS A FUNCTION OF ENTHALPY (BTU/LBM)
 00101      5*     C                                          UNITS R
 00101      6*     C
 00103      7*          DIMENSION TN(10)
 00104      8*          TN(1)   = 2500.0
 00105      9*          DO 10 N = 1,10
 00110     10*          DFTN    =  CPAIR(TN(N))
 00111     11*          FTN     =  ENTAIR(TN(N))-ENT
 00112     12*          TN(N+1) =  TN(N)-FTN/DFTN
 00113     13*          IF (N .EQ. 1)  GO TO 10
 00115     14*          IF (ABS(TN(N+1)-TN(N)) .LE. 2.0)  GO TO 30
 00117     15*       10 CONTINUE
 00121     16*       30 TNH     =  TN(N+1)
 00122     17*          RETURN
 00123     18*          END

      END OF COMPILATION:       NO  DIAGNOSTICS.


 @HDG,P ****** TRMATX ******
```

```
@FOR,S ME*NASA5.TRMATX,ME*NASA5.TRMATX
FOR S9A-07/13/72-20:58:50 (0,)

   SUBROUTINE TRMATX    ENTRY POINT 000262

   STORAGE USED: CODE(1) 000275; DATA(0) 000051; BLANK COMMON(2) 000000

    COMMON BLOCKS:

    0003   QRD    003721
    0004   ABSRST 000601

   EXTERNAL REFERENCES (BLOCK, NAME)

    0005   NERR3$

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

    0001   000003 106G      0001   000004 111G      0001   000021 120G      0001   000022 123G      0001   000053 134G
    0001   000056 137G      0001   000066 142G      0001   000121 153G      0001   000137 162G      0001   000145 166G
    0001   000154 171G      0001   000211 201G      0001   000212 204G      0001   000217 211G      0001   000224 216G
    0004 R 000000 ALPHFN    0004 R 000226 ALPHMP    0003 R 003465 CSF       0000 R 000005 CSFXZ     0003 R 003464 DXX2
    0003   003472 DXX21     0003   003463 DZMFN     0003   003410 EBFN      0003   003441 EBMP      0004   000461 EMITFN
    0004   000512 EMITMP    0003   003467 EXTIFN    0003   003471 EXTIMP    0003   003466 EXTSFN    0003   003470 EXTSMP
    0004   000517 EXTVCT    0000 I 000000 I         0000   000027 INJP$     0000 I 000001 J         0000 I 000007 JK
    0000 I 000002 K         0000 I 000004 L         0003   003461 LCT       0003   003462 LTT       0003   003460 MCVRD
    0000 I 000003 M1        0000 I 000006 M2        0003 R 003473 SS        0003 R 003670 SSTT      0003 R 000000 TRMTX
    0003   003446 XX2       0003   003453 ZZ2


00101      1*          SUBROUTINE TRMATX
00101      2*    C
00101      3*    C   THIS SUBROUTINE COMPUTES :
00101      4*    C     THE TRANSFER MATRIX NECESSARY FOR THE CALCULATION OF THE INCIDENT
00101      5*    C     NET RADIANT FLUX
00101      6*    C
00103      7*          COMMON /QRD/ TRMTX(30,60),EBFN(5,5),EBMP(5),XX2(5),ZZ2(5),
00103      8*         1             MCVRD,LCT,LTT,DZMFN,
00103      9*         2             DXX2,CSF,EXTSFN,EXTIFN,EXTSMP,EXTIMP,DXX21,SS(5,5,5)
00103     10*         3             ,SSTT(5,5)
00104     11*          COMMON /ABSRST/ALPHFN(5,5,6),ALPHMP(5,31),EMITFN(5,5),EMITMP(5),
00104     12*         1               EXTVCT(50)
00105     13*          DO 2 I=1,25
00110     14*          DO 1 J=1,25
00113     15*        1 TRMTX(I,J)=0.0
00115     16*        2 TRMTX(I,I)=1.0
00117     17*          DO 4 I=26,30
00122     18*          DO 3 J=26,30
00125     19*        3 TRMTX(I,J)=-(1.0-ALPHMP(I-25,J))*SSTT(I-25,J-25)*0.25
00127     20*          TRMTX(I,26)=TRMTX(I,26)/2.0
00130     21*          TRMTX(I,30)=TRMTX(I,30)/2.0
```

```
00131           4 TRMTX(I,I)=1.0+TRMTX(I,I)
00133             DO 5 I=1,5
00136             DO 5 J=1,5
00141             DO 5 K=1,5
00144             M1    =25+K
00145             L     =(I-1)*5 +J
00146           5 TRMTX(L,M1) =-(1.0-ALPHFN(I,J,K))*SS(I,J,K)/4.0
00152             DO 6 I=1,25
00155             TRMTX(I,26) =TRMTX(I,26)/2.0
00156           6 TRMTX(I,30) =TRMTX(I,30)/2.0
00160             CSFXZ  = CSF*DXX2/4.0
00161             DO 7  I=1,5
00164             M2     =25+I
00165             DO 7  J=1,5
00170             DO 7  K=1,5
00173             JK     =(J-1)*5+K
00174           7 TRMTX(M2,JK)=-(1.0-ALPHMP(I,JK))*SS(J,K,I)*CSFXZ
00200             DO 10 I=26,30
00203             DO 8  K=21,25
00206           8 TRMTX(I,K)  =TRMTX(I,K)/2.0
00210             DO 9  J=1,21,5
00213           9 TRMTX(I,J)  =TRMTX(I,J)/2.0
00215             DO 10 J=5,25,5
00220          10 TRMTX(I,J)  =TRMTX(I,J)/2.0
00223             RETURN
00224             END
```

END OF COMPILATION: NO DIAGNOSTICS.

@HDG,P ****** TRNSPT ******

```
@FOR,S ME*NASA5.TRNSPT,ME*NASA5.TRNSPT
FOR S9A-07/13/72-20:58:53 (0,)

   SUBROUTINE TRNSPT    ENTRY POINT 000143

   STORAGE USED: CODE(1) 000171; DATA(0) 000040; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   NEXP6$
    0004   NERR3$

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

    0001   000062 10L       0001   000106 15L       0001   000050 5L        0000   000030 INJP$     0000 R 000000 NUL
    0000 R 000001 XX


00101      1*            SUBROUTINE TRNSPT (RE,PRL,DELTA,FR,FNU)                                  01
00101      2*      C
00101      3*      C   THIS SUBROUTINE COMPUTES :
00101      4*      C     THE NON-DIMENSIONAL FRICTION FACTOR FR ,AND THE NON-DIMENSIONAL
00101      5*      C     CONVECTIVE FILM COEFFICIENT FNU
00101      6*      C
00103      7*            REAL NUL                                                                 02
00103      8*      C                                                                              03
00104      9*            IF (RE.LT.2300.0) GO TO 10                                               04
00106     10*            NUL = 0.116*(RE**0.667-125.0)*PRL**0.3333*(1.0+DELTA**0.667)             05
00107     11*            IF (RE.GT.1.0E+06) GO TO 5                                               06
00111     12*            FR = (0.0054+0.396/RE**0.3)/DELTA                                        07
00112     13*            GO TO 15                                                                 08
00113     14*          5 FR = (0.0032+0.222/RE**0.237)/DELTA                                      09
00114     15*            GO TO 15                                                                 010
00115     16*         10 FR = 64.0/(RE*DELTA)                                                     011
00116     17*            XX = RE*PRL*DELTA                                                        012
00117     18*            NUL = 3.65+0.0668*XX/(1.0+0.045*XX**0.667)
00120     19*         15 IF (PRL.LT.0.1) NUL = 6.5+0.025*(RE*PRL)**0.8                            014
00122     20*            FNU = 4.0*NUL/(DELTA*RE*PRL)                                             015
00123     21*            RETURN                                                                   016
00124     22*            END                                                                      017
      END OF COMPILATION:        NO  DIAGNOSTICS.


@HDG,P ****** TTIP ******
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****** TTIP ******                                                                    DATE 071372        PAGE     1

QFOR,S ME*NASA5.TTIP,ME*NASA5.TTIP
FOR S9A-07/13/72-20:58:55 (0,)

  SUBROUTINE TTIP      ENTRY POINT 000043

  STORAGE USED: CODE(1) 000060; DATA(0) 000101; BLANK COMMON(2) 000000

  EXTERNAL REFERENCES (BLOCK, NAME)

   0003   POLY
   0004   NERR3$

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

   0001   000005 116G      0001    000007 121G      0000 R 000043 AA        0000 R 000000 CC        0000 R 000052 COEF
   0000 I 000057 I         0000    000067 INJP$     0000 I 000060 J         0003 R 000000 POLY


00101       1*            SUBROUTINE TTIP (NC,TSOTB,TLOTB)
00103       2*            DIMENSION CC(5,7),AA(7),COEF(5)
00104       3*            REAL NC
00105       4*            DATA(CC(I,2),I=1,5)/-.4815,-.8920814,4.894438,-14.89583,10.39930/,
00105       5*           1 (CC(I,3),I=1,5)/.5365006,.7351966,-12.35190,40.88471,-30.65782/,
00105       6*           2 (CC(I,4),I=1,5)/-.440667,.2304286,11.64157,-44.56229,35.26028/,
00105       7*           3 (CC(I,5),I=1,5)/.212667,-.4978796,-5.648548,24.37024,-19.93047/,
00105       8*           4 (CC(I,6),I=1,5)/-.05333347,.198336,1.40554,-6.58330,5.48609/,
00105       9*           5 (CC(I,7),I=1,5)/.00533335,-.02525962,-.139998,.6925878,-.5833303/
00114      10*            AA(1)   =  1.0
00115      11*            DO 20  I=2,7
00120      12*            DO 10  J=1,5
00123      13*         10 COEF(J) =  CC(J,I)
00125      14*         20 AA(I)   =  POLY (5,COEF,TSOTB)
00127      15*            TLOTB   =  POLY (7,AA,NC)
00130      16*            RETURN
00131      17*            END

      END OF COMPILATION:       NO  DIAGNOSTICS.


QHDG,P  ******  TTIPS  ******
```

```
@FOR,S ME*NASA5.TTIPS,ME*NASA5.TTIPS
FOR S9A-07/13/72-20:58:57 (0,)

   SUBROUTINE TTIPS      ENTRY POINT 000345

   STORAGE USED: CODE(1) 000366; DATA(0) 000110; BLANK COMMON(2) 000000

    COMMON BLOCKS:

    0003   ADBH   000352
    0004   QIN    001610

   EXTERNAL REFERENCES (BLOCK, NAME)

    0005   NUSA
    0006   EFFICY
    0007   TTIP
    0010   EXP
    0011   NEXP6$
    0012   NPRT$
    0013   NIO2$
    0014   NSTOP$
    0015   NERR3$

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

    0000   000041 105F      0001   000303 110L      0001   000136 136G      0001   000120 20L       0001   000126 30L
    0000 R 000033 AA        0003 R 000001 AL        0000 R 000021 BB1       0000 R 000022 BB2       0000 R 000006 COEF
    0003 R 000161 CONFL     0003 R 000173 CONFNA    0003 R 000147 CP        0000 R 000013 C1        0000 R 000014 C2
    0000 R 000030 C4        0000 R 000020 C5        0003 R 000000 D         0000 R 000035 DFNTB     0000 R 000011 DOL
    0000 R 000036 DTB       0003   000326 DTL       0003 R 000244 EFF       0003 R 000205 EMIS      0000 R 000025 ETAPR1
    0000 R 000027 ETAPR2    0000 R 000024 ETA1      0000 R 000026 ETA2      0000 R 000034 FNTB      0003   000013 H
    0003   000231 HAB       0000   000064 INJP$     0000 I 000017 L         0003 R 000064 M         0000 R 000002 NCPR1
    0000 R 000003 NCPR2     0000 R 000000 NC1       0000 R 000001 NC2       0004 I 001605 NSRD      0003   000076 NT
    0004   001604 NTM       0005 R 000000 NUSA      0000 R 000004 PI        0003   000052 PIN       0000 R 000007 PR
    0004   000454 QIFN      0004   001274 QITB      0003   000314 QOUT      0004   000144 QSFN      0004   000764 QSTB
    0004   001606 QTO       0000 R 000010 REY       0000 R 000005 SIGMA     0003 R 000217 TB        0000 R 000031 TB3
    0000 R 000032 TB4       0003 R 000026 TH        0003 R 000040 TIN       0003   000270 TL        0000 R 000037 TLOTB1
    0000 R 000040 TLOTB2    0004   000000 TM        0003   000340 TOUT      0000 R 000023 TSOTB     0003 R 000077 TSTAR
    0000 R 000016 TSTR      0000 R 000015 TS4       0004   001607 TX        0000 R 000012 U         0003 R 000135 VSC


00101      1*                 SUBROUTINE TTIPS(IT,ITST,H1,H2,TL1,TL2)
00103      2*                 PARAMETER NTP = 10
00104      3*                 PARAMETER NTP1 = NTP+1
00105      4*                 REAL M
00106      5*                 COMMON /ADBH/ D,AL(NTP),H(NTP1),TH(NTP),TIN(NTP),PIN(NTP),
00106      6*            1    M(NTP),NT,TSTAR(NTP,3),VSC(NTP),CP(NTP),CONFL(NTP),
00106      7*            2    CONFNA(NTP),EMIS(NTP),TB(NTP),HAB(NTP1),EFF(NTP,2),TL(NTP,2),
00106      8*            3    QOUT(NTP),DTL(NTP),TOUT(NTP)
00107      9*                 COMMON /QIN/ TM(100),QSFN(100,2),QIFN(100,2),QSTB(100,2),
```

```
          1     QITB(100,2),NTM,NSRD,QTO,TX
           REAL NUSA,NC1,NC2,NCPR1,NCPR2
           DATA PI/3.1415927/
           DATA SIGMA/1.714E-9/
           COEF=EMIS(IT)*SIGMA/(CONFNA(IT)*TM(IT))
           PR=VSC(IT)*CP(IT)/CONFL(IT)
           REY=48*M(IT)/(PI*D*VSC(IT))
           DOL=D/(12*AL(IT))
           U=PI*CONFL(IT)*AL(IT)*NUSA(REY,PR,DOL)/(M(IT)*CP(IT))
           C1=M(IT)*CP(IT)*(1-EXP(-U))
           C2=NSRD*EMIS(IT)*SIGMA*AL(IT)/12
           TB(IT)=.9*TIN(IT)
           IF(NSRD.NE.2)GO TO 20
           TS4=(TSTAR(IT,1)**4+TSTAR(IT,2)**4)/2
           TSTR=TS4**.25
           GO TO 30
   20      TS4=TSTAR(IT,ITST)**4
           TSTR=TSTAR(IT,ITST)
   30      CONTINUE
           DO 100 L=2,10
           C5=TB(IT)**2*COEF/12
           BB1=C5*H1**2
           BB2=C5*H2**2
           NC1=TB(IT)*BB1
           NC2=TB(IT)*BB2
           NCPR1=3*BB1
           NCPR2=3*BB2
           TSOTB=TSTR/TB(IT)
           CALL EFFICY(NC1,NCPR1,TSOTB,TB(IT),ETA1,ETAPR1)
               EFF(IT,1) = ETA1*100.0
           CALL EFFICY(NC2,NCPR2,TSOTB,TB(IT),ETA2,ETAPR2)
               EFF(IT,2) = ETA2*100.0
           C4=ETA1*H1+ETA2*H2
           TB3=TB(IT)**3
           TB4=TB3*TB(IT)
           AA=TB4-TS4
           FNTB=C1*(TIN(IT)-TB(IT))-C2*C4*AA
           DFNTB=-C1-C2*(4*TB3*C4+AA*(ETAPR1*H1+ETAPR2*H2))
           DTB=FNTB/DFNTB
           TB(IT)=TB(IT)-DTB
           IF(ABS(DTB).LE.0.005)GO TO 110
  100      CONTINUE
               PRINT 105
  105      FORMAT(' BASE TEMPERATURE DOES NOT CONVERGE')
           STOP
  110      CONTINUE
           CALL TTIP(NC1,TSOTB,TLOTB1)
           CALL TTIP(NC2,TSOTB,TLOTB2)
           TL1=TLOTB1*(TB(IT)-TSTR)+TSTR
           TL2=TLOTB2*(TB(IT)-TSTR)+TSTR
           RETURN
           END

     END OF COMPILATION:       NO  DIAGNOSTICS.
```

```
****** VISC/CFFC43 ******                                                                        DATE 071372        PAGE     1

@FOR,S ME*NASA5.VISC/CFFC43,ME*NASA5.VISC/CFFC43
FOR S9A-07/13/72-20:59:00 (0,)

  FUNCTION VISC        ENTRY POINT 000032

  STORAGE USED: CODE(1) 000036; DATA(0) 000021; BLANK COMMON(2) 000000

  EXTERNAL REFERENCES (BLOCK, NAME)

   0003   EXP
   0004   NERR3$

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

   0000 R 000006 DT        0000   000012 INJP$     0000 R 000007 THETA     0000 R 000005 T0        0000 R 000000 VISC
   0000 R 000010 VNU       0000 R 000001 X1        0000 R 000002 X2        0000 R 000003 X3        0000 R 000004 X4


00101       1*           FUNCTION VISC(RHO,T)
00101       2*      C
00101       3*      C        THIS FUNCTION SUBPROGRAM COMPUTES :
00101       4*      C        VISCOSITY AS A FUNCTION OF DENSITY (SLUG/CU.FT)
00101       5*      C             AND TEMPERATURE (R) OF FC-43
00101       6*      C                                  UNITS SLUG/(FT.HR)
00101       7*      C
00103       8*           DATA X1,X2,X3,X4 /2.76,-2.043483,0.362,-0.034717/,T0,DT /439.67,90
00103       9*          1.0/
00112      10*           THETA = (T-T0)/DT
00113      11*           VNU   = EXP(((X4*THETA+X3)*THETA+X2)*THETA+X1)
00114      12*           VISC = VNU*RHO*0.03875
00115      13*           RETURN
00116      14*           END

      END OF COMPILATION:        NO  DIAGNOSTICS.


@HDG,P  ******  VISC/CFFC75  ******
```

```
****** VISC/CFFC75 ******                                                                   DATE 071372      PAGE    1

@FOR,S ME*NASA5.VISC/CFFC75,ME*NASA5.VISC/CFFC75
FOR S9A-07/13/72-20:59:03 (0,)

   FUNCTION VISC        ENTRY POINT 000032

   STORAGE USED: CODE(1) 000036; DATA(0) 000021; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   EXP
    0004   NERR3$

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

    0000 R 000006 DT        0000   000012 INJP$      0000 R 000007 THETA     0000 R 000005 T0        0000 R 000000 VISC
    0000 R 000010 VNU       0000 R 000001 X1         0000 R 000002 X2        0000 R 000003 X3        0000 R 000004 X4


00101       1*          FUNCTION VISC(RHO,T)
00101       2*     C
00101       3*     C       THIS FUNCTION SUBPROGRAM COMPUTES :
00101       4*     C       VISCOSITY AS A FUNCTION OF DENSITY (SLUG/CU.FT)
00101       5*     C            AND TEMPERATURE (R) OF FC-75
00101       6*     C                                     UNITS SLUG/(FT.HR)
00101       7*     C
00103       8*          DATA X1,X2,X3,X4 /1.639,-1.312933,0.25265,-0.02471667/,T0,DT / 409
00103       9*         1.67,60.0/
00112      10*          THETA = (T-T0)/DT
00113      11*          VNU   = EXP(((X4*THETA+X3)*THETA+X2)*THETA+X1)
00114      12*          VISC = VNU*RHO*0.03875
00115      13*          RETURN
00116      14*          END

       END OF COMPILATION:        NO  DIAGNOSTICS.


@HDG,P  ******  VISC/CFHE  ******
```

```
@FOR,S ME*NASA5.VISC/CFHE,ME*NASA5.VISC/CFHE
FOR S9A-07/13/72-20:59:04 (0,)

   FUNCTION VISC        ENTRY POINT 000016

   STORAGE USED: CODE(1) 000022; DATA(0) 000011; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   NEXP6$
    0004   NERR3$

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

    0000   000003 INJP$     0000 R 000000 VISC


00101      1*          FUNCTION VISC(RHO,T)
00101      2*     C
00101      3*     C       THIS FUNCTION SUBPROGRAM COMPUTES :
00101      4*     C       VISCOSITY AS A FUNCTION OF DENSITY (SLUG/CU.FT)
00101      5*     C            AND TEMPERATURE (R) OF HELIUM
00101      6*     C                                    UNITS SLUG/(FT.HR)
00101      7*     C
00103      8*          VISC = 2.58394E-05*T**0.647
00104      9*          RETURN
00105     10*          END

     END OF COMPILATION:        NO  DIAGNOSTICS.


@HDG,P ****** VISC/CFNAK ******
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```
@FOR,S ME*NASA5.VISC/CFNAK,ME*NASA5.VISC/CFNAK
FOR S9A-07/13/72-20:59:07 (0,)

   FUNCTION VISC        ENTRY POINT 000025

   STORAGE USED: CODE(1) 000027; DATA(0) 000017; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   NERR3$

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

    0000 R 000007 DT        0000   000012 INJP$     0000 R 000010 THETA     0000 R 000006 TO        0000 R 000000 VISC
    0000 R 000001 X1        0000 R 000002 X2        0000 R 000003 X3        0000 R 000004 X4        0000 R 000005 X5


00101      1*           FUNCTION VISC(RHO,T)
00101      2*     C
00101      3*     C        THIS FUNCTION SUBPROGRAM COMPUTES :
00101      4*     C        VISCOSITY AS A FUNCTION OF DENSITY (SLUG/CU.FT)
00101      5*     C             AND TEMPERATURE (R) OF NAK 78.6
00101      6*     C                                  UNITS SLUG/(FT.HR)
00101      7*     C
00103      8*           DATA X1,X2,X3,X4,X5 /1.316,-0.896667,0.419833,-0.102833,0.009667/,
00103      9*          1TO,DT /659.67,300.0/
00113     10*           THETA = (T-TO)/DT
00114     11*           VISC  = ((((X5*THETA+X4)*THETA+X3)*THETA+X2)*THETA+X1)/32.174
00115     12*           RETURN
00116     13*           END

       END OF COMPILATION:        NO  DIAGNOSTICS.


@HDG,P  ******  VISC/CFSIL  ******
```

```
****** VISC/CFSIL ******                                                                     DATE 071372        PAGE      1

@FOR,S ME*NASA5.VISC/CFSIL,ME*NASA5.VISC/CFSIL
FOR S9A-07/13/72-20:59:09 (0,)

   FUNCTION VISC          ENTRY POINT 000061

   STORAGE USED: CODE(1) 000067; DATA(0) 000040; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   EXP
    0004   NWDU$
    0005   NI02$
    0006   NERR3$

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

    0000   000011 1F        0000 R 000006 DT       0000   000030 INJP$     0000 R 000007 THETA     0000 R 000005 T0
    0000 R 000000 VISC      0000 R 000010 VNU      0000 R 000001 X1       0000 R 000002 X2        0000 R 000003 X3
    0000 R 000004 X4


00100    C
00100    C        THIS FUNCTION SUBPROGRAM COMPUTES :
00101          FUNCTION VISC(RHO,T)
00101    C        VISCOSITY AS A FUNCTION OF DENSITY (SLUG/CU.FT) AND
00101    C             TEMPERATURE (R) OF DOW CORNING 200 SILICON OIL (1 CS)
00101    C                                  UNITS SLUG/(FT.HR)
00101    C             TEMPERATURE .GE. 359.67 AND .LE. 859.67
00101    C
00103          DATA X1,X2,X3,X4 /0.683,-1.0845,0.3065,-0.04/,T0,DT /459.67,100.0/
00112          THETA = (T-T0)/DT
00113          VNU   = EXP(((X4*THETA+X3)*THETA+X2)*THETA+X1)
00114          VISC = VNU*RHO*0.03875
00115          IF (T.GE.360.67.AND.T.LE.860.67) RETURN
00117          WRITE (6,1) T
00122        1 FORMAT (1H0,50HVISCOSITY OF SILICON OIL, TEMP. OUT OF RANGE, T = ,
00122         1F8.3,/)
00123          RETURN
00124          END
       END OF COMPILATION:        NO  DIAGNOSTICS.


@HDG,P  ******  YINT  ******
```

```
QFOR,S ME*NASA5.YINT,ME*NASA5.YINT
FOR S9A-07/13/72-20:59:11 (0,)

   FUNCTION YINT        ENTRY POINT 000265

   STORAGE USED: CODE(1) 000315; DATA(0) 000136; BLANK COMMON(2) 000000

   EXTERNAL REFERENCES (BLOCK, NAME)

    0003   NWDU$
    0004   NIO2$
    0005   NERR3$

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

    0001   000075 113G    0001   000146 130G    0001   000172 140G    0001   000201 143G    0001   000215 150G
    0001   000106 2L      0001   000230 6L      0000   000060 7F      0001   000240 8L      0000   000072 9F
    0000 I 000053 I       0000   000111 INJP$   0000 I 000057 J       0000 I 000056 L       0000 I 000055 ME
    0000 I 000051 MM      0000 I 000054 M0      0000 I 000052 M1      0000 R 000013 XP      0000 R 000025 XQ
    0000 R 000001 XX      0000 R 000000 YINT    0000 R 000037 YY

00101             FUNCTION YINT(X,Y,N,M,P)
00101        C
00101        C  THIS SUBROUTINE COMPUTES :
00101        C    AITKEN INTERPOLATION
00101        C    X ARRAY OF ABSCISSAE
00101        C    Y ARRAY OF ORDINATES
00101        C    N NUMBER OF ELEMENTS IN ARRAYS X AND Y
00101        C    P X-VALUE OF INTERPOLATION
00101        C    M DEGREE OF POLYNOMIAL PASSING THROUGH Y(X) IN THE VICINITY OF P
00101        C
00103             DIMENSION X(N),Y(N),XX(10),XP(10),XQ(10),YY(10)
00104             IF(P.LT.(2.*X(1)-X(2)).OR.P.GT.(2.*X(N)-X(N-1))) GO TO 8
00106                 MM = MAX(MIN(M,10),2)
00107                 IF (N.LT.MM.OR.N.LE.2) GO TO 6
00111                 M1 = MM/2
00112             DO 1 I = 1,N
00115             IF (P .LE. X(I)) GO TO 2
00117           1 CONTINUE
00121           2 M0      =  I-M1
00122             ME      = M0+MM-1
00123             IF (M0 .LT. 1) M0 = 1
00125             IF (ME .GT. N) M0 = N-MM+1
00127             DO 3 I = 1,MM
00132             L       =  M0+I-1
00133             XP(I)   =  X(L)-P
00134             XQ(I)   =  X(L)
00135           3 YY(I)   =  Y(L)
00137             DO 5 I = 2,MM
00142             DO 4 J = I,MM
```

```
00145    30*        4  XX(J) =  (YY(I-1)*XP(J)-YY(J)*XP(I-1))/(XQ(J)-XQ(I-1))
00147    31*           DO 5 J = 1,MM
00152    32*        5  YY(J) =  XX(J)
00155    33*           YINT   =  YY(MM)
00156    34*           RETURN
00157    35*        6 WRITE (6,7)
00161    36*        7 FORMAT (/,1X,45HINTERPOL. IS IMPOSSIBLE, DATA ARRAY TOO SMALL)
00162    37*           RETURN
00163    38*        8 WRITE (6,9) P
00166    39*        9 FORMAT (/,1X,29HINTERPOL. IS IMPOSSIBLE, P = ,E12.4,12HOUT OF RANG
00166    40*          1E)
00167    41*           RETURN
00170    42*           END

       END OF COMPILATION:        NO  DIAGNOSTICS.


QHDG,P  ******  CFFC43  ******
```

```
@ELT,L ME*NASA5.CFFC43
ELT 005-07/13-20:59
000001      000   CLASS      CFFC43
000002      000   IN         BETA,CAPPA,CPF,HFL,RHOF,THCF,VISC
000003      000   DEF        BETA,CAPPA,CPF,HFL,RHOF,THCF,VISC
000004      000   END


@HDG,P  ******  CFFC75  ******
```

```
****** CFFC75 ******                                                                        DATE 071372        PAGE    1

@ELT,L ME*NASA5.CFFC75
ELT 005-07/13-20:59
000001      000   CLASS     CFFC75
000002      000   IN        BETA,CAPPA,CPF,HFL,RHOF,THCF,VISC
000003      000   DEF       BETA,CAPPA,CPF,HFL,RHOF,THCF,VISC
000004      000   END


@HDG,P  ******  CFHE  ******
```

```
@ELT,L ME*NASA5.CFHE
ELT 005-07/13-20:59
000001      000   CLASS    CFHE
000002      000   IN       BETA,CAPPA,CPF,HFL,PF,RHOF,THCF,VISC
000003      000   DEF      BETA,CAPPA,CPF,HFL,PF,RHOF,THCF,VISC
000004      000   END
```

@HDG,P ****** CFNAK ******

```
@ELT,L ME*NASA5.CFNAK
ELT 005-07/13-20:59
000001      000   CLASS     CFNAK
000002      000   IN        BETA,CAPPA,CPF,HFL,PF,RHOF,THCF,VISC
000003      000   DEF       BETA,CAPPA,CPF,HFL,PF,RHOF,THCF,VISC
000004      000   END
```

@HDG,P ****** CFSIL ******

```
@ELT,L ME*NASA5.CFSIL
ELT 005-07/13-20:59
000001      000   CLASS     CFSIL
000002      000   IN        BETA,CAPPA,CPF,HFL,PF,RHOF,THCF,VISC
000003      000   DEF       BETA,CAPPA,CPF,HFL,PF,RHOF,THCF,VISC
000004      000   END

@HDG,P  ******  FNAL  ******
```

```
****** FNAL ******

@ELT,L ME*NASA5.FNAL
ELT 005-07/13-20:59
000001       000   CLASS     FNAL
000002       000   IN        CPFN,DTHCFN,THCFN
000003       000   DEF       CPFN,DTHCFN,THCFN
000004       000   END

@HDG,P  ******  FNBR  ******
```

```
@ELT,L ME*NASA5.FNBR
ELT 005-07/13-20:59
000001      000   CLASS     FNBR
000002      000   IN        CPFN,DTHCFN,THCFN
000003      000   DEF       CPFN,DTHCFN,THCFN
000004      000   END


@HDG,P  ******  FNCU  ******
```

```
@ELT,L ME*NASA5.FNCU
ELT 005-07/13-20:59
000001      000   CLASS    FNCU
000002      000   IN       CPFN,DTHCFN,THCFN
000003      000   DEF      CPFN,DTHCFN,THCFN
000004      000   END
```

@HDG,P ****** MPAL ******

```
@ELT,L ME*NASA5.MPAL
ELT 005-07/13-20:59
000001       000   CLASS     MPAL
000002       000   IN        CPMP,DTHCMP,ELAS,THCMP
000003       000   DEF       CPMP,DTHCMP,ELAS,THCMP
000004       000   END

@HDG,P  ******  MPBR  ******
```

```
@ELT,L ME*NASA5.MPBR
ELT 005-07/13-20:59
000001       000   CLASS     MPBR
000002       000   IN        CPMP,DTHCMP,ELAS,THCMP
000003       000   DEF       CPMP,DTHCMP,ELAS,THCMP
000004       000   END
```

```
@HDG,P  ******  MPCU  ******
```

```
@ELT,L ME*NASA5.MPCU
ELT 005-07/13-20:59
000001      000   CLASS     MPCU
000002      000   IN        CPMP,DTHCMP,ELAS,THCMP
000003      000   DEF       CPMP,DTHCMP,ELAS,THCMP
000004      000   END
```

@HDG,P ****** SC293 ******

```
@ELT,L ME*NASA5.SCZ93
ELT 005-07/13-20:59
000001      000   CLASS     SCZ93
000002      000   IN        AVGEMT,EMIT
000003      000   DEF       AVGEMT,EMIT
000004      000   END


@HDG,P  ******  TBAL  ******
```

```
@ELT,L ME*NASA5.TBAL
ELT 005-07/13-20:59
000001      000   CLASS     TBAL
000002      000   IN        CPTB,DTHCTB,THCTB
000003      000   DEF       CPTB,DTHCTB,THCTB
000004      000   END


@HDG,P  ******  TBBR  ******
```

```
****** TBBR ******

@ELT,L ME*NASA5.TBBR
ELT 005-07/13-20:59
000001      000   CLASS     TBBR
000002      000   IN        CPTB,DTHCTB,THCTB
000003      000   DEF       CPTB,DTHCTB,THCTB
000004      000   END


@HDG,P  ******  TBCU  ******
```

```
@ELT,L ME*NASA5.TBCU
ELT 005-07/13-20:59
000001      000   CLASS     TBCU
000002      000   IN        CPTB,DTHCTB,THCTB
000003      000   DEF       CPTB,DTHCTB,THCTB
000004      000   END
```

@HDG,P ****** VER1 ******

```
******  VER1  ******                                                   DATE 071372      PAGE    1

@ELT,L ME*NASA5.VER1
ELT 005-07/13-20:59
000001       000   IN          CFSIL,FNAL,MPBR,TBAL,SCZ93
000002       000   IN          MAIN
000003       000   END

@HDG,N

@HDG,P  ******  CFFC43  ******
```

```
@MAP,RS   ME*NASA5.CFFC43
MAP 0023-07/13-20:53 -(0,)

    1.NEW   LIB      ME*NASA5.

    2.      CLASS    CFFC43

    3.      IN       BETA,CAPPA,CPF,HFL,RHOF,THCF,VISC

    4.      DEF      BETA,CAPPA,CPF,HFL,RHOF,THCF,VISC

    5.      END



      R-OPTION COLLECTION

LENGTHS OF LOCATION COUNTERS ASSIGNED
$(1)  COMBINED ODD COUNTERS      000164  OCTAL      116  DECIMAL
$(2)  COMBINED EVEN COUNTERS     000105  OCTAL       69  DECIMAL
  3   COMMONBLOCK BLANK$COMMON   000000  OCTAL        0  DECIMAL



      COMBINED ELEMENTS

BETA/CFFC43            1   000000 000016    0   000000 000007
                                            2   BLANK$COMMON
CAPPA/CFFC43           1   000017 000030    0   000010 000015
                                            2   BLANK$COMMON
CPF/CFFC43             1   000031 000046    0   000016 000026
                                            2   BLANK$COMMON
HFL/CFFC43             1   000047 000072    0   000027 000042
                                            2   BLANK$COMMON
RHOF/CFFC43            1   000073 000110    0   000043 000053
                                            2   BLANK$COMMON
THCF/CFFC43            1   000111 000125    0   000054 000063
                                            2   BLANK$COMMON
VISC/CFFC43            1   000126 000163    0   000064 000104
                                            2   BLANK$COMMON

END OF COLLECTION - TIME 0.303 SECONDS
```

QHDG,P ****** CFFC75 ******

```
@MAP,RS   ME*NASA5.CFFC75
MAP 0023-07/13-20:59 -(0,)

    1.NEW   LIB     ME*NASA5.

    2.      CLASS   CFFC75

    3.      IN      BETA,CAPPA,CPF,HFL,RHOF,THCF,VISC

    4.      DEF     BETA,CAPPA,CPF,HFL,RHOF,THCF,VISC

    5.      END



     R-OPTION COLLECTION


LENGTHS OF LOCATION COUNTERS ASSIGNED
$(1)  COMBINED ODD COUNTERS      000164  OCTAL     116  DECIMAL
$(2)  COMBINED EVEN COUNTERS     000105  OCTAL      69  DECIMAL
  3   COMMONBLOCK BLANK$COMMON   000000  OCTAL       0  DECIMAL



     COMBINED ELEMENTS

BETA/CFFC75          1   000000 000016    0   000000 000007
                                          2   BLANK$COMMON
CAPPA/CFFC75         1   000017 000030    0   000010 000015
                                          2   BLANK$COMMON
CPF/CFFC75           1   000031 000046    0   000016 000026
                                          2   BLANK$COMMON
HFL/CFFC75           1   000047 000072    0   000027 000042
                                          2   BLANK$COMMON
RHOF/CFFC75          1   000073 000110    0   000043 000053
                                          2   BLANK$COMMON
THCF/CFFC75          1   000111 000125    0   000054 000063
                                          2   BLANK$COMMON
VISC/CFFC75          1   000126 000163    0   000064 000104
                                          2   BLANK$COMMON

END OF COLLECTION - TIME 0.203 SECONDS
```

QHDG,P ****** CFHE ******

```
****** CFHE ******                                                    DATE 071372        PAGE    1

QMAP,RS   ME*NASA5.CFHE
MAP 0023-07/13-20:59 -(0,)

    1.NEW   LIB      ME*NASA5.

    2.      CLASS    CFHE

    3.      IN       BETA,CAPPA,CPF,HFL,PF,RHOF,THCF,VISC

    4.      DEF      BETA,CAPPA,CPF,HFL,PF,RHOF,THCF,VISC

    5.      END


      R-OPTION COLLECTION

LENGTHS OF LOCATION COUNTERS ASSIGNED
$(1)  COMBINED ODD COUNTERS     000635  OCTAL      413  DECIMAL
$(2)  COMBINED EVEN COUNTERS    000267  OCTAL      183  DECIMAL
  3   COMMONBLOCK BLANK$COMMON 000000  OCTAL        0  DECIMAL


      COMBINED ELEMENTS

BETA/CFHE               1   000000 000111      0   000000 000036
                                               2   BLANK$COMMON
CAPPA/CFHE              1   000112 000200      0   000037 000067
                                               2   BLANK$COMMON
CPF/CFHE                1   000201 000271      0   000070 000120
                                               2   BLANK$COMMON
HFL/CFHE                1   000272 000415      0   000121 000167
                                               2   BLANK$COMMON
PF/CFHE                 1   000416 000467      0   000170 000215
                                               2   BLANK$COMMON
RHOF/CFHE               1   000470 000566      0   000216 000240
                                               2   BLANK$COMMON
THCF/CFHE               1   000567 000612      0   000241 000255
                                               2   BLANK$COMMON
VISC/CFHE               1   000613 000634      0   000256 000266
                                               2   BLANK$COMMON

END OF COLLECTION - TIME 0.315 SECONDS
```

QHDG,P ****** CFNAK ******

```
@MAP,RS   ME*NASA5.CFNAK
MAP 0023-07/13-20:59 -(0,)

    1.NEW   LIB      ME*NASA5.

    2.      CLASS    CFNAK

    3.      IN       BETA,CAPPA,CPF,HFL,PF,RHOF,THCF,VISC

    4.      DEF      BETA,CAPPA,CPF,HFL,PF,RHOF,THCF,VISC

    5.      END



      R-OPTION COLLECTION

LENGTHS OF LOCATION COUNTERS ASSIGNED
$(1)  COMBINED ODD COUNTERS      000467  OCTAL      311  DECIMAL
$(2)  COMBINED EVEN COUNTERS     000224  OCTAL      148  DECIMAL
  3   COMMONBLOCK BLANK$COMMON   000000  OCTAL        0  DECIMAL



      COMBINED ELEMENTS

BETA/CFNAK          1   000000 000016     0   000000 000007
                                          2   BLANK$COMMON
CAPPA/CFNAK         1   000017 000073     0   000010 000041
                                          2   BLANK$COMMON
CPF/CFNAK           1   000074 000177     0   000042 000073
                                          2   BLANK$COMMON
HFL/CFNAK           1   000200 000311     0   000074 000132
                                          2   BLANK$COMMON
PF/CFNAK            1   000312 000351     0   000133 000147
                                          2   BLANK$COMMON
RHOF/CFNAK          1   000352 000411     0   000150 000166
                                          2   BLANK$COMMON
THCF/CFNAK          1   000412 000437     0   000167 000204
                                          2   BLANK$COMMON
VISC/CFNAK          1   000440 000466     0   000205 000223
                                          2   BLANK$COMMON

END OF COLLECTION - TIME 0.273 SECONDS
```

QHDG.P ****** CFSIL ******

```
****** CFSIL ******                                                        DATE 071372        PAGE    1

@MAP,RS   ME*NASA5.CFSIL
MAP 0023-07/13-20:59 -(0,)

    1.NEW   LIB      ME*NASA5.

    2.      CLASS    CFSIL

    3.      IN       BETA,CAPPA,CPF,HFL,PF,RHOF,THCF,VISC

    4.      DEF      BETA,CAPPA,CPF,HFL,PF,RHOF,THCF,VISC

    5.      END



     R-OPTION COLLECTION

LENGTHS OF LOCATION COUNTERS ASSIGNED
$(1)  COMBINED ODD COUNTERS     001734  OCTAL      988  DECIMAL
$(2)  COMBINED EVEN COUNTERS    000717  OCTAL      463  DECIMAL
  3   COMMONBLOCK BLANK$COMMON  000000  OCTAL        0  DECIMAL



     COMBINED ELEMENTS

BETA/CFSIL              1   000000 000176     0   000000 000075
                                              2   BLANK$COMMON
CAPPA/CFSIL             1   000177 000344     0   000076 000161
                                              2   BLANK$COMMON
CPF/CFSIL               1   000345 000736     0   000162 000314
                                              2   BLANK$COMMON
HFL/CFSIL               1   000737 001264     0   000315 000446
                                              2   BLANK$COMMON
PF/CFSIL                1   001265 001446     0   000447 000540
                                              2   BLANK$COMMON
RHOF/CFSIL              1   001447 001575     0   000541 000625
                                              2   BLANK$COMMON
THCF/CFSIL              1   001576 001644     0   000626 000656
                                              2   BLANK$COMMON
VISC/CFSIL              1   001645 001733     0   000657 000716
                                              2   BLANK$COMMON

END OF COLLECTION - TIME 0.469 SECONDS
```

QHDG.P ****** FNAL ******

```
****** FNAL ******                                                                  DATE 071372        PAGE      1

@MAP,RS   ME*NASA5.FNAL
MAP 0023-07/13-20:59 -(0,)

    1.NEW    LIB        ME*NASA5.

    2.       CLASS      FNAL

    3.       IN         CPFN,DTHCFN,THCFN

    4.       DEF        CPFN,DTHCFN,THCFN

    5.       END



      R-OPTION COLLECTION


LENGTHS OF LOCATION COUNTERS ASSIGNED
$(1)  COMBINED ODD COUNTERS     000202  OCTAL        130  DECIMAL
$(2)  COMBINED EVEN COUNTERS    000116  OCTAL         78  DECIMAL
  3   COMMONBLOCK BLANK$COMMON  000000  OCTAL          0  DECIMAL



      COMBINED ELEMENTS

CPFN/FNAL                   1   000000 000061     0   000000 000037
                                                  2   BLANK$COMMON
DTHCFN/FNAL                 1   000062 000121     0   000040 000056
                                                  2   BLANK$COMMON
THCFN/FNAL                  1   000122 000201     0   000057 000115
                                                  2   BLANK$COMMON

END OF COLLECTION - TIME 0.171 SECONDS


@HDG,P  ******  FNBR  ******
```

```
@MAP,RS   ME*NASA5.FNBR
MAP 0023-07/13-20:59 -(0,)

    1.NEW   LIB      ME*NASA5.
    2.      CLASS    FNBR
    3.      IN       CPFN,DTHCFN,THCFN
    4.      DEF      CPFN,DTHCFN,THCFN
    5.      END


      R-OPTION COLLECTION

LENGTHS OF LOCATION COUNTERS ASSIGNED
$(1)  COMBINED ODD COUNTERS     000200  OCTAL      128  DECIMAL
$(2)  COMBINED EVEN COUNTERS    000115  OCTAL       77  DECIMAL
  3   COMMONBLOCK BLANK$COMMON 000000  OCTAL        0  DECIMAL


      COMBINED ELEMENTS

CPFN/FNBR              1   000000 000057      0   000000 000036
                                              2   BLANK$COMMON
DTHCFN/FNBR            1   000060 000117      0   000037 000055
                                              2   BLANK$COMMON
THCFN/FNBR             1   000120 000177      0   000056 000114
                                              2   BLANK$COMMON

END OF COLLECTION - TIME 0.169 SECONDS


@HDG,P  ******  FNCU  ******
```

```
@MAP,RS   ME*NASA5.FNCU
MAP 0023-07/13-20:59 -(0,)

    1.NEW    LIB      ME*NASA5.

    2.       CLASS    FNCU

    3.       IN       CPFN,DTHCFN,THCFN

    4.       DEF      CPFN,DTHCFN,THCFN

    5.       END


      R-OPTION COLLECTION

LENGTHS OF LOCATION COUNTERS ASSIGNED
$(1)  COMBINED ODD COUNTERS     000163  OCTAL      115  DECIMAL
$(2)  COMBINED EVEN COUNTERS    000102  OCTAL       66  DECIMAL
  3   COMMONBLOCK BLANK$COMMON  000000  OCTAL        0  DECIMAL


      COMBINED ELEMENTS

CPFN/FNCU               1   000000 000050    0   000000 000030
                                             2   BLANK$COMMON
DTHCFN/FNCU             1   000051 000105    0   000031 000045
                                             2   BLANK$COMMON
THCFN/FNCU              1   000106 000162    0   000046 000101
                                             2   BLANK$COMMON

END OF COLLECTION - TIME 0.165 SECONDS

@HDG,P  ******  MPAL  ******
```

```
****** MPAL ******

@MAP,RS   ME*NASA5.MPAL
MAP 0023-07/13-20:59 -(0,)

     1.NEW   LIB      ME*NASA5.
     2.      CLASS    MPAL
     3.      IN       CPMP,DTHCMP,ELAS,THCMP
     4.      DEF      CPMP,DTHCMP,ELAS,THCMP
     5.      END

      R-OPTION COLLECTION

LENGTHS OF LOCATION COUNTERS ASSIGNED
$(1)  COMBINED ODD COUNTERS     000263  OCTAL      179  DECIMAL
$(2)  COMBINED EVEN COUNTERS    000156  OCTAL      110  DECIMAL
  3   COMMONBLOCK BLANK$COMMON 000000  OCTAL        0  DECIMAL

      COMBINED ELEMENTS

CPMP/MPAL              1   000000 000061     0   000000 000037
                                             2   BLANK$COMMON
DTHCMP/MPAL            1   000062 000121     0   000040 000056
                                             2   BLANK$COMMON
ELAS/MPAL              1   000122 000202     0   000057 000116
                                             2   BLANK$COMMON
THCMP/MPAL             1   000203 000262     0   000117 000155
                                             2   BLANK$COMMON

END OF COLLECTION - TIME 0.206 SECONDS

@HDG,P ****** MPBR ******
```

```
@MAP,RS   ME*NASA5.MPBR
MAP 0023-07/13-20:59 -(0,)

    1.NEW    LIB        ME*NASA5.

    2.       CLASS      MPBR

    3.       IN         CPMP,DTHCMP,ELAS,THCMP

    4.       DEF        CPMP,DTHCMP,ELAS,THCMP

    5.       END



      R-OPTION COLLECTION


LENGTHS OF LOCATION COUNTERS ASSIGNED
$(1)  COMBINED ODD COUNTERS     000261   OCTAL        177  DECIMAL
$(2)  COMBINED EVEN COUNTERS    000155   OCTAL        109  DECIMAL
  3   COMMONBLOCK BLANK$COMMON 000000   OCTAL          0  DECIMAL



      COMBINED ELEMENTS

CPMP/MPBR                  1    000000 000057       0    000000 000036
                                                    2    BLANK$COMMON
DTHCMP/MPBR                1    000060 000117       0    000037 000055
                                                    2    BLANK$COMMON
ELAS/MPBR                  1    000120 000200       0    000056 000115
                                                    2    BLANK$COMMON
THCMP/MPBR                 1    000201 000260       0    000116 000154
                                                    2    BLANK$COMMON

END OF COLLECTION - TIME 0.192 SECONDS


@HDG,P  ******  MPCU  ******
```

```
****** MPCU ******                                                    DATE 071372        PAGE     1

@MAP,RS   ME*NASA5.MPCU
MAP 0023-07/13-20:59 -(0,)

    1.NEW    LIB       ME*NASA5.

    2.       CLASS     MPCU

    3.       IN        CPMP,DTHCMP,ELAS,THCMP

    4.       DEF       CPMP,DTHCMP,ELAS,THCMP

    5.       END



      R-OPTION COLLECTION

LENGTHS OF LOCATION COUNTERS ASSIGNED
$(1)  COMBINED ODD COUNTERS    000244  OCTAL      164  DECIMAL
$(2)  COMBINED EVEN COUNTERS   000142  OCTAL       98  DECIMAL
  3   COMMONBLOCK BLANK$COMMON 000000  OCTAL        0  DECIMAL



      COMBINED ELEMENTS

CPMP/MPCU                 1   000000 000050      0   000000 000030
                                                 2   BLANK$COMMON
DTHCMP/MPCU               1   000051 000105      0   000031 000045
                                                 2   BLANK$COMMON
ELAS/MPCU                 1   000106 000166      0   000046 000105
                                                 2   BLANK$COMMON
THCMP/MPCU                1   000167 000243      0   000106 000141
                                                 2   BLANK$COMMON

END OF COLLECTION - TIME 0.187 SECONDS


@HDG,P  ******  SCZ93  ******
```

```
@MAP,RS   ME*NASA5.SCZ93
MAP 0023-07/13-20:59 -(0,)

    1.NEW   LIB      ME*NASA5.
    2.      CLASS    SCZ93
    3.      IN       AVGEMT,EMIT
    4.      DEF      AVGEMT,EMIT
    5.      END


      R-OPTION COLLECTION

LENGTHS OF LOCATION COUNTERS ASSIGNED
$(1)  COMBINED ODD COUNTERS     000156  OCTAL      110  DECIMAL
$(2)  COMBINED EVEN COUNTERS    000056  OCTAL       46  DECIMAL
  3   COMMONBLOCK AVGABS        000251  OCTAL      169  DECIMAL
  4   COMMONBLOCK BLANK$COMMON  000000  OCTAL        0  DECIMAL


      COMBINED ELEMENTS

AVGEMT/SCZ93          1    000000 000120     0    000000 000037
                      3    AVGABS            2    BLANK$COMMON
EMIT/SCZ93            1    000121 000155     0    000040 000055
                                             2    BLANK$COMMON

END OF COLLECTION - TIME 0.148 SECONDS


@HDG,P  ******  TBAL  ******
```

```
@MAP,RS   ME*NASA5.TBAL
MAP 0023-07/13-21:00 -(0,)

    1.NEW    LIB      ME*NASA5.
    2.       CLASS    TBAL
    3.       IN       CPTB,DTHCTB,THCTB
    4.       DEF      CPTB,DTHCTB,THCTB
    5.       END



      R-OPTION COLLECTION

LENGTHS OF LOCATION COUNTERS ASSIGNED
$(1)  COMBINED ODD COUNTERS     000202  OCTAL      130  DECIMAL
$(2)  COMBINED EVEN COUNTERS    000116  OCTAL       78  DECIMAL
  3   COMMONBLOCK BLANK$COMMON 000000  OCTAL        0  DECIMAL



      COMBINED ELEMENTS

CPTB/TBAL              1   000000 000061     0   000000 000037
                                             2   BLANK$COMMON
DTHCTB/TBAL            1   000062 000121     0   000040 000056
                                             2   BLANK$COMMON
THCTB/TBAL             1   000122 000201     0   000057 000115
                                             2   BLANK$COMMON

END OF COLLECTION - TIME 0.170 SECONDS


@HDG,P  ******  TBBR  ******
```

```
@MAP,RS   ME*NASA5.TBBR
MAP 0023-07/13-21:00 -(0,)

    1.NEW   LIB       ME*NASA5.

    2.      CLASS     TBBR

    3.      IN        CPTB,DTHCTB,THCTB

    4.      DEF       CPTB,DTHCTB,THCTB

    5.      END



      R-OPTION COLLECTION


LENGTHS OF LOCATION COUNTERS ASSIGNED
$(1)  COMBINED ODD COUNTERS    000200  OCTAL       128  DECIMAL
$(2)  COMBINED EVEN COUNTERS   000115  OCTAL        77  DECIMAL
  3   COMMONBLOCK BLANK$COMMON 000000  OCTAL         0  DECIMAL



      COMBINED ELEMENTS

CPTB/TBBR                1   000000 000057       0   000000 000036
                                                 2   BLANK$COMMON
DTHCTB/TBBR              1   000060 000117       0   000037 000055
                                                 2   BLANK$COMMON
THCTB/TBBR               1   000120 000177       0   000056 000114
                                                 2   BLANK$COMMON

END OF COLLECTION - TIME 0.167 SECONDS


@HDG,P  ******  TBCU  ******
```

```
@MAP,RS   ME*NASA5.TBCU
MAP 0023-07/13-21:00 -(0,)

   1.NEW   LIB     ME*NASA5.
   2.      CLASS   TBCU
   3.      IN      CPTB,DTHCTB,THCTB
   4.      DEF     CPTB,DTHCTB,THCTB
   5.      END


      R-OPTION COLLECTION

LENGTHS OF LOCATION COUNTERS ASSIGNED
$(1)  COMBINED ODD COUNTERS     000163  OCTAL      115  DECIMAL
$(2)  COMBINED EVEN COUNTERS    000102  OCTAL       66  DECIMAL
  3   COMMONBLOCK BLANK$COMMON 000000  OCTAL        0  DECIMAL


      COMBINED ELEMENTS

CPTB/TBCU              1   000000 000050    0   000000 000030
                                            2   BLANK$COMMON
DTHCTB/TBCU            1   000051 000105    0   000031 000045
                                            2   BLANK$COMMON
THCTB/TBCU             1   000106 000162    0   000046 000101
                                            2   BLANK$COMMON

END OF COLLECTION - TIME 0.165 SECONDS


@PREP     ME*NASA5.
FURPUR 023A-07/13-21:00


@HDG,P  ******  VER1  ******
```

```
@MAP,S    ME*NASA5.VER1
MAP 0023-07/13-21:00 -(0,)

    1.NEW   LIB      ME*NASA5.
    2.      IN       CFSIL,FNAL,MPBR,TBAL,SCZ93
    3.      IN       MAIN
    4.      END

ADDRESS LIMITS     001000 052007     053000 116661
STARTING ADDRESS   046014

WORDS DECIMAL       21000 IBANK       18354 DBANK


               SEGMENT MAIN           001000 052007     053000 116661

NFTV$/FOR                1   001000 001022
NBF00$/FOR                                    2    053000 055201
NRBLK$/FOR               1   001023 001045
NBDCV$/FOR               1   001046 001200    2    055202 055237
NSWTC$/FOR               1   001201 001222
NBSBL$/FOR               1   001223 001257
NUPDA$/FOR               1   001260 001312
NWBLK$/FOR               1   001313 001434
NFTCH$/FOR               1   001435 001725    2    055240 055275
NINPT$/FOR               1   001726 002570    2    055276 055315
NOTIN$/FOR               1   002571 003104    2    055316 055321
NOUT$/FOR                1   003105 004073    2    055322 055346
NFMT$/FOR                1   004074 004752    2    055347 055423
NCNVT$/FOR               1   004753 005177    2    055424 055513
NIOER$/FOR               1   005200 005352    2    055514 055620
NININ$/FOR               1   005353 005563    2    055621 055632
NFCHK$/FOR               1   005564 006445    2    055633 055771
                                              4    055772 056043
NWEF$/FOR                1   006446 006647    2    056044 056063
ERU$/MISC
NTAB$/FOR                                     2    056064 056122
NEXP5$/FOR               1   006650 006735    2    056123 056132
SINCOS$/FOR              1   006736 007070    2    056133 056154
ATAN$/FOR                1   007071 007274    2    056155 056206
NOSYM$/FOR               1   007275 007534    2    056207 056213
NRWND$/FOR               1   007535 007614    2    056214 056225
NEXP6$/FOR               1   007615 010011    2    056226 056277
NBKSP$/FOR               1   010012 010510    2    056300 056326
```

```
EXP$/FOR                1   010511 010600   2   056327 056347
ALOG$/FOR               1   010601 010720   2   056350 056410
NERR$/FOR               1   010721 011245   2   056411 056554
ASINCOS$/FOR            1   011246 011462   0   056555 056602
SQRT$/FOR               1   011463 011523   2   056603 056614
NLOUT$/FOR              1   011524 012606   2   056615 056652
NFOUT$/FOR              1   012607 013117   2   056653 056674
NFINP$/FOR              1   013120 013433   2   056675 056761
NIBUF$/FOR              1   013434 013476   2   056762 056762
NIER$/FOR               1   013477 013560   2   056763 057116
NOBUF$/FOR              1   013561 013625
NLINP$/FOR              1   013626 015341   2   057117 057300
TIR$/TECH               1   015342 016026   0   057301 057331
                                            2   057332 057611
NCLOS$/FOR              1   016027 016175   2   057612 057643
TTIP                    1   016176 016255   0   057644 057744
                                            2   BLANK$COMMON
EFFICY                  1   016256 016436   0   057745 060075
                                            2   BLANK$COMMON
DEFNT                   1   016437 016516   0   060076 060120
                                            2   BLANK$COMMON
EXITAV                  1   016517 016626   0   060121 060150
                        3   QRD             2   BLANK$COMMON
                        5   ABSRST          4   QIN
MTXINV                  1   016627 017034   0   060151 060207
                        3   QRD             2   BLANK$COMMON
TRMATX                  1   017035 017331   0   060210 060260
                        3   QRD             2   BLANK$COMMON
                                            4   ABSRST
ABSORB                  1   017332 020131   0   060261 060375
                        3   QRD             2   BLANK$COMMON
                        5   AVGABS          4   ABSRST
INTERP                  1   020132 020357   0   060376 060460
                                            2   BLANK$COMMON
NUS                     1   020360 021221   0   060461 060574
                                            2   BLANK$COMMON
REFP                    1   021222 021610   0   060575 060757
                                            2   BLANK$COMMON
CPAIR                   1   021611 021720   0   060760 061014
                                            2   BLANK$COMMON
TNH                     1   021721 022004   0   061015 061044
                                            2   BLANK$COMMON
ENTAIR                  1   022005 022231   0   061045 061135
                                            2   BLANK$COMMON
ATMOS                   1   022232 022512   0   061136 061346
                                            2   BLANK$COMMON
ALTVEL                  1   022513 022721   0   061347 061364
                                            2   BLANK$COMMON
RKSF                    1   022722 023761   0   061365 061450
                                            2   BLANK$COMMON
TRNSPT                  1   023762 024152   0   061451 061510
                                            2   BLANK$COMMON
DRVLCN (COMMON BLOCK)                           061511 061511
DRVLCM (COMMON BLOCK)                           061512 061535
CNTLN                   1   024153 024263   0   061536 061560
                        3   DRVLCM          2   BLANK$COMMON
                                            4   DRVLCN
```

```
DERIVL                     1  024264 024542     0  061561 061633
                           3  FLCMP             2  BLANK$COMMON
FMINV                      1  024543 025050     0  061634 063113
                                                2  BLANK$COMMON
PDERIV                     1  025051 025254     0  063114 063133
                           3  ADBH              2  BLANK$COMMON
TTIPS                      1  025255 025642     0  063134 063243
                           3  ADBH              2  BLANK$COMMON
                                                4  QIN
NUSA                       1  025643 025745     0  063244 063267
                                                2  BLANK$COMMON
SHADE                      1  025746 026051     0  063270 063312
                                                2  BLANK$COMMON
FINT                       1  026052 026162     0  063313 063341
                                                2  BLANK$COMMON
YINT                       1  026163 026477     0  063342 063477
                                                2  BLANK$COMMON
D2DX2                      1  026500 026662     0  063500 063545
                                                2  BLANK$COMMON
DDX                        1  026663 027035     0  063546 063613
                                                2  BLANK$COMMON
QRAD                       1  027036 030050     0  063614 064712
                           3  QRD               2  BLANK$COMMON
                           5  ABSRST            4  QIN
                           7  AVGABS            6  SSF
CONVEC                     1  030051 030631     0  064713 065056
                           3  VELALT            2  BLANK$COMMON
                           5  SRTCNV            4  CNV
                           7  SSF               6  QRD
POLY                       1  030632 030675     0  065057 065073
                                                2  BLANK$COMMON
RKS                        1  030676 031735     0  065074 065157
                                                2  BLANK$COMMON
SHAPEF                     1  031736 032772     0  065160 065331
                           3  QRD               2  BLANK$COMMON
                                                4  SSF
DEFINT                     1  032773 033217     0  065332 065377
                                                2  BLANK$COMMON
FLCMP (COMMON BLOCK)                               065400 065423
FLSTRT                     1  033220 033464     0  065424 065656
                           3  DVCMFL            2  BLANK$COMMON
                                                4  FLCMP
TK                         1  033465 033731     0  065657 065740
                                                2  BLANK$COMMON
QINCID                     1  033732 034760     0  065741 066625
                           3  QIN               2  BLANK$COMMON
                                                4  TC
ADIABH                     1  034761 035502     0  066626 067276
                           3  ADBH              2  BLANK$COMMON
TCALC                      1  035503 036354     0  067277 070166
                           3  ADBH              2  BLANK$COMMON
                           5  QIN               4  TC
SRTCNV (COMMON BLOCK)                              070167 070171
CNTLM                      1  036355 040434     0  070172 073614
                           3  SRTCNV            2  BLANK$COMMON
                           5  QIN               4  QRD
                           7  FLDINL            6  GEOM
```

```
                                                        8  DVCMFL
DERIVM                          1  040435 043014       0  073615 074675
                                3  DVM                 2  BLANK$COMMON
                                5  FLDINL              4  QIN
                                                       6  DVCMFL
AVGABS (COMMON BLOCK)                                     074676 075146
DVCMFL (COMMON BLOCK)                                     075147 075150
FLDINL (COMMON BLOCK)                                     075151 075627
GEOM (COMMON BLOCK)                                       075630 075647
SSF (COMMON BLOCK)                                        075650 075657
ABSRST (COMMON BLOCK)                                     075660 076460
TC (COMMON BLOCK)                                         076461 076522
QIN (COMMON BLOCK)                                        076523 100332
QRD (COMMON BLOCK)                                        100333 104253
CNV (COMMON BLOCK)                                        104254 104263
VELALT (COMMON BLOCK)                                     104264 105415
DVM (COMMON BLOCK)                                        105416 105417
ADBH (COMMON BLOCK)                                       105420 105771
BLANK$COMMON (COMMON BLOCK)                               105772 107106
CFSIL                           1  043015 044750       2  107107 110025
                                3  BLANK$COMMON
FNAL                            1  044751 045152       2  110026 110143
                                3  BLANK$COMMON
MPBR                            1  045153 045433       2  110144 110320
                                3  BLANK$COMMON
TBAL                            1  045434 045635       2  110321 110436
                                3  BLANK$COMMON
SCZ93                           1  045636 046013       2  110437 110514
                                3  AVGABS              4  BLANK$COMMON
MAIN                            1  046014 052007       0  110515 116661
                                3  ADBH                2  BLANK$COMMON
                                5  VELALT              4  DVM
                                7  QRD                 6  CNV
                                9  TC                  8  QIN
                               11  SSF                10  ABSRST
                               13  FLDINL             12  GEOM
                                                      14  DVCMFL

SYS$*RLIB$. LEVEL 63
END OF COLLECTION - TIME 4.525 SECONDS


QHDG,P  ******  TABLE OF CONTENTS  ******.L,1
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@PRT,T ME*NASA5.
FURPUR 023A-07/13-21:00

ME*NASA5 ELEMENT TABLE

D	NAME	VERSION	TYPE	DATE	TIME	SEQ #	SIZE-PRE,TEXT	(CYCLE	WORD)	PSRMODE	LOCATION
	ABSORB		FOR SYMB	09 MAY 72	16:50:13	1	21	5	0	1	1792
	ADIABH		FOR SYMB	02 MAY 72	15:31:15	2	24	5	0	1	1813
	ALTVEL		FOR SYMB	09 MAY 72	16:50:24	3	7	5	0	1	1837
	ATMOS		FOR SYMB	09 MAY 72	16:50:26	4	24	5	0	1	1844
	AVGEMT	SCZ93	FOR SYMB	09 MAY 72	15:48:01	5	8	5	0	1	1868
	BETA	CFFC43	FOR SYMB	09 MAY 72	16:43:19	6	3	5	0	1	1876
	BETA	CFFC75	FOR SYMB	09 MAY 72	16:44:12	7	3	5	0	1	1879
	BETA	CFHE	FOR SYMB	09 MAY 72	16:40:41	8	6	5	0	1	1882
	BETA	CFNAK	FOR SYMB	09 MAY 72	16:42:30	9	3	5	0	1	1888
	BETA	CFSIL	FOR SYMB	30 JUN 72	15:44:49	10	8	5	0	1	1891
	CAPPA	CFFC43	FOR SYMB	09 MAY 72	16:43:25	11	3	5	0	1	1899
	CAPPA	CFFC75	FOR SYMB	09 MAY 72	16:44:34	12	3	5	0	1	1902
	CAPPA	CFHE	FOR SYMB	09 MAY 72	16:40:48	13	5	5	0	1	1905
	CAPPA	CFNAK	FOR SYMB	09 MAY 72	16:42:37	14	5	5	0	1	1910
	CAPPA	CFSIL	FOR SYMB	30 JUN 72	15:44:52	15	7	5	0	1	1915
	CFFC43		MAP SYMB	10 MAY 72	08:56:52	16	1	5	0	1	1922
	CFFC75		MAP SYMB	10 MAY 72	08:57:18	17	1	5	0	1	1923
	CFHE		MAP SYMB	10 MAY 72	08:58:15	18	1	5	0	1	1924
	CFNAK		MAP SYMB	10 MAY 72	08:58:40	19	1	5	0	1	1925
	CFSIL		MAP SYMB	10 MAY 72	08:59:02	20	1	5	0	1	1926
	CNTLM		FOR SYMB	12 MAY 72	09:06:54	21	77	5	0	1	1927
	CNTLN		FOR SYMB	09 MAY 72	16:49:43	22	12	5	0	1	2004
	CONVEC		FOR SYMB	09 MAY 72	16:51:04	23	28	5	0	1	2016
	CPAIR		FOR SYMB	09 MAY 72	16:50:38	24	6	5	0	1	2044
	CPF	CFFC43	FOR SYMB	09 MAY 72	16:43:31	25	3	5	0	1	2050
	CPF	CFFC75	FOR SYMB	09 MAY 72	16:44:44	26	3	5	0	1	2053
	CPF	CFHE	FOR SYMB	09 MAY 72	16:40:55	27	5	5	0	1	2056
	CPF	CFNAK	FOR SYMB	09 MAY 72	16:42:43	28	5	5	0	1	2061
	CPF	CFSIL	FOR SYMB	30 JUN 72	15:44:54	29	13	5	0	1	2066
	CPFN	FNAL	FOR SYMB	09 MAY 72	16:47:50	30	5	5	0	1	2079
	CPFN	FNBR	FOR SYMB	09 MAY 72	16:48:28	31	5	5	0	1	2084
	CPFN	FNCU	FOR SYMB	09 MAY 72	16:48:13	32	4	5	0	1	2089
	CPMP	MPAL	FOR SYMB	09 MAY 72	16:48:38	33	5	5	0	1	2093
	CPMP	MPBR	FOR SYMB	09 MAY 72	16:49:21	34	5	5	0	1	2098
	CPMP	MPCU	FOR SYMB	09 MAY 72	16:48:52	35	4	5	0	1	2103
	CPTB	TBAL	FOR SYMB	09 MAY 72	16:46:59	36	5	5	0	1	2107
	CPTB	TBBR	FOR SYMB	09 MAY 72	16:47:32	37	5	5	0	1	2112
	CPTB	TBCU	FOR SYMB	09 MAY 72	16:47:18	38	4	5	0	1	2117
	DATA		ELT SYMB	09 MAY 72	14:02:46	39	24	5	0	1	2121
	DDX		FOR SYMB	09 MAY 72	16:51:51	40	8	5	0	1	2145
	DEFINT		FOR SYMB	09 MAY 72	16:52:40	41	6	5	0	1	2153
	DEFNT		FOR SYMB	09 MAY 72	16:52:04	42	3	5	0	1	2159
	DERIVL		FOR SYMB	11 MAY 72	15:27:24	43	18	5	0	1	2162
	DERIVM		FOR SYMB	09 MAY 72	16:52:10	44	61	5	0	1	2180
	DTHCFN	FNAL	FOR SYMB	09 MAY 72	16:47:46	45	4	5	0	1	2241
	DTHCFN	FNBR	FOR SYMB	09 MAY 72	16:48:23	46	4	5	0	1	2245
	DTHCFN	FNCU	FOR SYMB	09 MAY 72	16:48:10	47	4	5	0	1	2249
	DTHCMP	MPAL	FOR SYMB	09 MAY 72	16:48:35	48	4	5	0	1	2253
	DTHCMP	MPBR	FOR SYMB	09 MAY 72	16:49:13	49	4	5	0	1	2257
	DTHCMP	MPCU	FOR SYMB	09 MAY 72	16:48:49	50	4	5	0	1	2261
	DTHCTB	TBAL	FOR SYMB	09 MAY 72	16:46:53	51	4	5	0	1	2265

THCFN	FNBR	FOR SYMB	09 MAY 72	16:48:17	109		5	5	0	1	2991
THCFN	FNCU	FOR SYMB	09 MAY 72	16:47:57	110		5	5	0	1	2996
THCMP	MPAL	FOR SYMB	09 MAY 72	16:48:33	111		5	5	0	1	3001
THCMP	MPBR	FOR SYMB	09 MAY 72	16:48:57	112		5	5	0	1	3006
THCMP	MPCU	FOR SYMB	09 MAY 72	16:48:44	113		5	5	0	1	3011
THCTB	TBAL	FOR SYMB	09 MAY 72	16:46:49	114		5	5	0	1	3016
THCTB	TBBR	FOR SYMB	09 MAY 72	16:47:24	115		5	5	0	1	3021
THCTB	TBCU	FOR SYMB	09 MAY 72	16:47:04	116		5	5	0	1	3026
TK		FOR SYMB	09 MAY 72	16:51:09	117		7	5	0	1	3031
TNH		FOR SYMB	09 MAY 72	16:50:50	118		4	5	0	1	3038
TRMATX		FOR SYMB	09 MAY 72	16:50:04	119		11	5	0	1	3042
TRNSPT		FOR SYMB	09 MAY 72	16:52:30	120		11	5	0	1	3053
TTIP		FOR SYMB	23 MAR 72	16:33:46	121		5	5	0	1	3064
TTIPS		FOR SYMB	02 MAY 72	15:37:06	122		15	5	0	1	3069
VER1		MAP SYMB	10 MAY 72	16:52:30	123		1	5	0	1	3084
VISC	CFFC43	FOR SYMB	09 MAY 72	16:43:41	124		4	5	0	1	3085
VISC	CFFC75	FOR SYMB	09 MAY 72	16:45:47	125		4	5	0	1	3089
VISC	CFHE	FOR SYMB	09 MAY 72	16:41:03	126		3	5	0	1	3093
VISC	CFNAK	FOR SYMB	09 MAY 72	16:42:52	127		4	5	0	1	3096
VISC	CFSIL	FOR SYMB	30 JUN 72	15:44:58	128		5	5	0	1	3100
YINT		FOR SYMB	09 MAY 72	16:28:50	129		10	5	0	1	3105
ABSORB		RELOCATABLE	13 JUL 72	20:52:57	130	2	22				3115
ADIABH		RELOCATABLE	13 JUL 72	20:53:00	131	2	27				3139
ALTVEL		RELOCATABLE	13 JUL 72	20:53:02	132	1	7				3168
ATMOS		RELOCATABLE	13 JUL 72	20:53:04	133	1	16				3176
AVGEMT	SCZ92	RELOCATABLE	13 JUL 72	20:53:06	134	1	6				3193
BETA	CFFC43	RELOCATABLE	13 JUL 72	20:53:09	135	1	2				3200
BETA	CFFC75	RELOCATABLE	13 JUL 72	20:53:10	136	1	2				3203
BETA	CFHE	RELOCATABLE	13 JUL 72	20:53:12	137	1	5				3206
BETA	CFNAK	RELOCATABLE	13 JUL 72	20:53:14	138	1	2				3212
BETA	CFSIL	RELOCATABLE	13 JUL 72	20:53:16	139	1	10				3215
CAPPA	CFFC43	RELOCATABLE	13 JUL 72	20:53:18	140	1	1				3226
CAPPA	CFFC75	RELOCATABLE	13 JUL 72	20:53:21	141	1	1				3228
CAPPA	CFHE	RELOCATABLE	13 JUL 72	20:53:24	142	1	4				3230
CAPPA	CFNAK	RELOCATABLE	13 JUL 72	20:53:28	143	1	4				3235
CAPPA	CFSIL	RELOCATABLE	13 JUL 72	20:54:16	144	1	8				3240
CNTLM		RELOCATABLE	13 JUL 72	20:54:25	145	3	78				3249
CNTLN		RELOCATABLE	13 JUL 72	20:54:31	146	2	5				3330
CONVEC		RELOCATABLE	13 JUL 72	20:54:37	147	3	22				3337
CPAIR		RELOCATABLE	13 JUL 72	20:54:40	148	1	6				3362
CPF	CFFC43	RELOCATABLE	13 JUL 72	20:54:42	149	1	2				3369
CPF	CFFC75	RELOCATABLE	13 JUL 72	20:54:45	150	1	2				3372
CPF	CFHE	RELOCATABLE	13 JUL 72	20:54:46	151	1	5				3375
CPF	CFNAK	RELOCATABLE	13 JUL 72	20:54:49	152	1	5				3381
CPF	CFSIL	RELOCATABLE	13 JUL 72	20:54:53	153	1	17				3387
CPFN	FNAL	RELOCATABLE	13 JUL 72	20:54:56	154	1	5				3405
CPFN	FNBR	RELOCATABLE	13 JUL 72	20:54:58	155	1	5				3411
CPFN	FNCU	RELOCATABLE	13 JUL 72	20:55:00	156	1	4				3417
CPMP	MPAL	RELOCATABLE	13 JUL 72	20:55:02	157	1	5				3422
CPMP	MPBR	RELOCATABLE	13 JUL 72	20:55:05	158	1	5				3428
CPMP	MPCU	RELOCATABLE	13 JUL 72	20:55:07	159	1	4				3434
CPTB	TBAL	RELOCATABLE	13 JUL 72	20:55:10	160	1	5				3439
CPTB	TBBR	RELOCATABLE	13 JUL 72	20:55:12	161	1	5				3445
CPTB	TBCU	RELOCATABLE	13 JUL 72	20:55:14	162	1	4				3451
DDX		RELOCATABLE	13 JUL 72	20:55:16	163	1	7				3456
DEFINT		RELOCATABLE	13 JUL 72	20:55:21	164	1	9				3464
DEFNT		RELOCATABLE	13 JUL 72	20:55:24	165	1	3				3474

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THCFN	FNCU	RELOCATABLE	13 JUL 72	20:58:31	223	1	4	4241
THCMP	MPAL	RELOCATABLE	13 JUL 72	20:58:33	224	1	5	4246
THCMP	MPBR	RELOCATABLE	13 JUL 72	20:58:36	225	1	5	4252
THCMP	MPCU	RELOCATABLE	13 JUL 72	20:58:38	226	1	4	4258
THCTB	TBAL	RELOCATABLE	13 JUL 72	20:58:41	227	1	5	4263
THCTB	TBBR	RELOCATABLE	13 JUL 72	20:58:43	228	1	5	4269
THCTB	TBCU	RELOCATABLE	13 JUL 72	20:58:45	229	1	4	4275
TK		RELOCATABLE	13 JUL 72	20:58:48	230	2	11	4280
TNH		RELOCATABLE	13 JUL 72	20:58:49	231	1	4	4293
TRMATX		RELOCATABLE	13 JUL 72	20:58:52	232	1	11	4298
TRNSPT		RELOCATABLE	13 JUL 72	20:58:55	233	1	8	4310
TTIP		RELOCATABLE	13 JUL 72	20:58:57	234	1	5	4319
TTIPS		RELOCATABLE	13 JUL 72	20:59:00	235	2	16	4325
VISC	CFFC43	RELOCATABLE	13 JUL 72	20:59:02	236	1	3	4343
VISC	CFFC75	RELOCATABLE	13 JUL 72	20:59:04	237	1	3	4347
VISC	CFHE	RELOCATABLE	13 JUL 72	20:59:06	238	1	2	4351
VISC	CFNAK	RELOCATABLE	13 JUL 72	20:59:09	239	1	2	4354
VISC	CFSIL	RELOCATABLE	13 JUL 72	20:59:10	240	1	5	4357
YINT		RELOCATABLE	13 JUL 72	20:59:13	241	1	13	4363
CFFC43		RELOCATABLE	13 JUL 72	20:59:27	242	2	10	4377
CFFC75		RELOCATABLE	13 JUL 72	20:59:29	243	2	10	4389
CFHE		RELOCATABLE	13 JUL 72	20:59:32	244	2	28	4401
CFNAK		RELOCATABLE	13 JUL 72	20:59:36	245	2	23	4431
CFSIL		RELOCATABLE	13 JUL 72	20:59:39	246	3	69	4456
FNAL		RELOCATABLE	13 JUL 72	20:59:43	247	2	11	4528
FNBR		RELOCATABLE	13 JUL 72	20:59:45	248	2	11	4541
FNCU		RELOCATABLE	13 JUL 72	20:59:48	249	2	10	4554
MPAL		RELOCATABLE	13 JUL 72	20:59:50	250	2	15	4566
MPBR		RELOCATABLE	13 JUL 72	20:59:53	251	2	15	4583
MPCU		RELOCATABLE	13 JUL 72	20:59:55	252	2	14	4600
SCZ93		RELOCATABLE	13 JUL 72	20:59:58	253	2	8	4616
TBAL		RELOCATABLE	13 JUL 72	21:00:01	254	2	11	4626
TBBR		RELOCATABLE	13 JUL 72	21:00:03	255	2	11	4639
TBCU		RELOCATABLE	13 JUL 72	21:00:06	256	2	10	4652
VER1		ABSOLUTE	13 JUL 72	21:00:45	257		948	4664
NEXT AVAILABLE LOCATION-								5612

ASSEMBLER PROCEDURE TABLE EMPTY

COBOL PROCEDURE TABLE EMPTY

FORTRAN PROCEDURE TABLE EMPTY

ENTRY POINT TABLE

D NAME	LINK	D NAME	LINK	D NAME	LINK	D NAME	LINK	D NAME	LINK
ABSORB	130	ADIABH	131	ALTVEL	132	ATMOS	133	AVGEMT	253
AVGEMT	134	BETA	135	BETA	136	BETA	137	BETA	138
BETA	139	BETA	246	BETA	245	BETA	244	BETA	243
BETA	242	CAPPA	140	CAPPA	246	CAPPA	141	CAPPA	245
CAPPA	142	CAPPA	244	CAPPA	143	CAPPA	243	CAPPA	144
CAPPA	242	CNTLM	145	CNTLN	146	CONVEC	147	CPAIR	148
CPF	246	CPF	245	CPF	149	CPF	150	CPF	244
CPF	151	CPF	152	CPF	243	CPF	153	CPF	242
CPFN	249	CPFN	248	CPFN	247	CPFN	154	CPFN	155
CPFN	156	CPMP	157	CPMP	252	CPMP	251	CPMP	250
CPMP	158	CPMP	159	CPTB	256	CPTB	255	CPTB	254

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