NASA Technical Memorandum 102468

CryoTran User's Manual

Version 1.0

Glenn R. Cowgill
Analex Corporation
Cleveland, Ohio

David J. Chato
Lewis Research Center
Cleveland, Ohio

and

Ehab Saad
Analex Corporation
Cleveland, Ohio

December 1989

CRYOTRAN USER'S MANUAL

VERSION 1.0

Glenn R. Cowgill
Analex Corporation
NASA Lewis Research Center
Cleveland, Ohio 44135

David J. Chato
National Aeronautics and Space Administration
Lewis Research Center
Cleveland, Ohio 44135

Ehab Saad
Analex Corporation
NASA Lewis Research Center
Cleveland, Ohio 44135

December 14, 1989

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CRYOTRAN USER'S MANUAL

VERSION 1.0

Glenn R. Cowgill
Analex Corporation
NASA Lewis Research Center
Cleveland, Ohio 44135

and

David J. Chato
National Aeronautics and Space Administration
Lewis Research Center
Cleveland, Ohio 44135

and

Ehab Saad
Analex Corporation
NASA Lewis Research Center
Cleveland, Ohio 44135

SUMMARY

The development of cryogenic fluid management systems for space operation is a major portion of the efforts of the Cryogenic Fluids Technology Office (CFTO) at the NASA Lewis Research Center. Analytical models are a necessary part of experimental programs which are used to verify the results of experiments and are also used as a predictor for parametric studies. The CryoTran computer program is a bridge to obtain analytical results.

The object of CryoTran is to coordinate these separate analyses into an integrated framework with a user-friendly interface and a common cryogenic property database. CryoTran is an integrated software system designed to help solve a diverse set of problems involving cryogenic fluid storage and transfer in both ground and low-g environments.

CryoTran is designed to do the following here at NASA - Lewis Research Center (LeRC):

1. Generate models for the SINDA thermal analyzer.
2. Call on programs to be executed interactively on the front end computer, an IBM mainframe computer running the VM operating system, in line with CryoTran.
3. Generate files containing the Cray runstreams to be submitted to the large scale high speed computer, a Cray computer.
4. Execute analysis programs residing on the Cray.

CryoTran prompts the user for all the information necessary to accomplish the desired task. The input responses are tested for validity or feasibility whenever possible.

INTRODUCTION

As part of its effort to develop cryogenic fluid management systems for space operations, the Cryogenic Fluids Technology Office (CFTO) has been developing analytical models of cryogenic systems. Separate analyses have been conducted in the past by the CFTO and others (refs. 1 through 7).

CryoTran is a software system designed to solve a diverse set of problems involving cryogenic fluid storage, supply, and transfer. CryoTran is not constructed as one comprehensive general purpose program, but is instead divided into a set of modular programs for specific analyses. It is constructed with an open architecture which allows new modules to be added easily. User input is menu driven to facilitate usage. This approach makes CryoTran very versatile.

This report presents the general description of CryoTran, describes the types of problems that may be solved using the system, describes how to access and use the program, describes the output and the steps necessary to incorporate new analyses into the system.

GENERAL

CryoTran is designed to solve several types of problems. This initial release of CryoTran (Version 1.0) has the capability to run routines interactively to analyze tank chilldown fluid usage, select a chilldown wall temperature at which no-vent fill is feasible, or transiently analyze the no-vent fill process (refs. 5 and 7). It will set up heat transfer models to be solved using Systems Improved Numerical Differencing Analyzer (SINDA) (ref. 8) for two-dimensional (2-d) problems involving cryogenic storage in spherical tanks or cylindrical tanks with flat, spherical, or elliptical end caps. CryoTran also provides access to two large scale programs: CSAM (ref. 1) and SOLA-ECLIPSE (refs. 2 and 3).

THREE MAIN PARTS OF CRYOTRAN

CryoTran is divided into the following three main parts: preprocessor, execution and postprocessor. Its construction is modular to allow for expansion. A library of several solution routines is included with the system. Figures 1 and 2 show diagrams of CryoTran.

Preprocessor Part

The preprocessor is the driver of the CryoTran system. It accepts user input to define a specific problem. The preprocessor consists of the main program and subroutines, graphics routines and a database of material and thermal properties which are all maintained on the LeRC VM computer.

The preprocessor is written in the IBM FORTRAN 77 (version 2) programming language (ref. 9) and runs on the LeRC computer system running the IBM VM operating system, herein referred to as "the VM" or the "VM computer." The use of extensions and system-dependent code is kept to a minimum to make the code as transportable as possible. The FORTRAN code is generously commented to make it easy to follow. There are a few features (special purpose routines); however, that have been referenced from subroutine libraries at LeRC. These are noted in the code listings so that substitutions may be inserted at other installations.

The user is prompted for input via menus. This system checks whether or not the input is correct and feasible wherever possible and then the user input is put into a file which is saved for future recall.

The output of the preprocessor is a file which contains either the output from the execution of an interactive analysis or an input model to be submitted to the Cray for execution. If option 1 or 2 is chosen from the main menu, the file, called a "model file," will be a thermal model for SINDA. If option 3 is chosen from the main menu, followed by the option to access one of the large analysis codes resident on the Cray, the model file will contain the information to access the program on the Cray and, input data or a reference to the input data.

This model file has English text comments so that the user may make modifications to it prior to submitting it to the Cray for solution. Geometry plots of the SINDA input models may be obtained as part of the preprocessor.

Execution Part

The execution part of CryoTran executes one of the interactive programs within the system or submits the model file that was generated by the preprocessor to the Cray for execution. This model file contains job control language (JCL) and input data to an analysis program or a SINDA thermal model. This file is then submitted to the high-speed computer (Cray) for execution. The output of this execution is saved in a file and disposed to where the user may print it or save it for further processing in the postprocessor section.

Postprocessor Part

The postprocessor part of the system produces graphical results or analyzes the results obtained by the execution section. The postprocessor section consists of a plotting routine to plot the output of SOLA-ECLIPSE.

The no-vent fill and chilldown modules, which are the programs that run interactively, have been previously documented (refs. 4 to 7). Code details for these modules are not reproduced here. Portions of refs. 4 to 7 are included for convenience in Appendix A which may serve as user's guides for the no-vent fill and chilldown modules. Additionally, the large-scale programs, CSAM and SOLA-ECLIPSE, which are resident on the Cray computer and may be accessed through this system, are documented in refs. 1 through 3. See these references for the limitations of these programs and for input details.

USE OF HEAT TRANSFER NETWORK GENERATOR - SINDA

One of the types of analyses available through CryoTran is thermal/thermo analyses of spherical or cylindrical tanks using SINDA (ref. 8). Some SINDA analyses use models where both the tank and the inside of the tank are nodalized. Other analyses involve models of tanks where the inside of the tank is not nodalized and the thermo analysis problem inside the tank is solved by special purpose subroutines written to solve a particular method of cooling or tank fill procedure. These subroutines are called from the SINDA blocks.

GEOMETRIC MODEL

Modelling

CryoTran uses a two-dimensional analysis on spheres and cylinders. The two dimensions are radial (from the center of the tank outward to the outside surface) and circumferential (along the circumference of the tank from the south pole to the north pole). The tanks are nodalized using wedges.

Spherical Wedge Nodes

Figure 3 shows sketches depicting the spherical wedge nodes. The general model is a wedge with the vertex of the wedge at the center and radiating toward the outer surface at an angle of 1 radian. The nodes are formed by radial lines radiating from the vertex toward the outer surface and then by horizontal arcs at various distances from the vertex. This model looks like a wedge of an orange.

Since all of the radial lines radiate from the center, the thickness of the nodes on the sphere is variable and gets thicker as the distance of the nodes gets farther from the center of the sphere. An input value "n" specifies the number of these wedges along the circumference from the south pole to the north pole, each with angle theta, where theta=180/n.

Cylindrical Nodes

Figure 4 shows sketches indicating the geometry of cylinder nodes. In the case of the cylinder, the nodes are flat, four-sided nodes with two straight sides along the two radii describing the one radian angle and two sides which are circular arcs. On the cylinder the thickness of the nodes is determined by slices through the cylinder from the bottom to the top.

For the cylindrical tanks the ends may be open or closed with flat, spherical, or elliptical ends, or any combination of these. Figure 5 shows possible end configurations.

Regions

When the user is using the options that generate a SINDA model, the model will be somewhat tailored for a specific application. The geometric model is generated using five regions. As specified above, the geometric shapes are spherical wedges or cylindrical wedges. The five regions are as follows:

1. Tank Wall (shell)	Required for all models.
2. Outside Layer 1	Region or shell covering the outside surface of the tank. It could be another material (e.g., insulation) or some type of coating layer. (Optional)
3. Outside Layer 2	Second outside layer on top of Region 2. (Optional)
4. Region 4	Portion of the tank interior that is adjacent to the Tank Wall. (Usually liquid or vapor.)
5. Region 5	Inside of the tank at the center. (Usually liquid or vapor.)

The inside of the tank may be made up of either one or two regions. If the user defines the inside of the tank to be a single region, this will be Region 4. If the user defines two regions for the inside of the tank, they will be Regions 4 and 5. The inside of the tank may be modeled using two regions in order to have two different mesh spacings in the radial direction or to have two different materials, etc. The concept of the regions can be seen in Figure 6 and in Figure 7, which shows a plot of a sample sphere model showing the 5 regions.

If Regions 4 and 5 are both liquid and the tank is not full, then a vapor ullage is assumed for the remainder of the volume. This ullage may be on top and flat if a 1-g case is designated or at the center and spherical for a low-g case. If Regions 4 and 5 are not both liquids, for example if Region 4 is a liquid and Region 5 is a vapor or solid, then it will be assumed that the tank is full with no ullage.

If Regions 4 and 5 are both liquids, the program checks to see if both are the same liquid. If the specified liquids in Regions 4 and 5 are different and the user determines that this is in error, the program then gives the user the option to change either or both of the materials.

Constant Heat Source (Q)

A constant heat source (Q) may be imposed on the outside surface of the model. The Q may be input as a constant Q per unit area BTU/(hr-ft^2) or based on BTU/hr over the entire surface of the sphere.

Outside Constant Temperature

Two constant temperature boundary nodes may be defined outside the top layer of the model to simulate an outside temperature. The conductor paths of these nodes to the outer surface may either be convection (BTU/hr-ft^2-°F) or radiation (°F).

Heat Exchangers

Up to ten heat exchangers may be inserted into the model. In these generated SINDA models, heat exchangers are simulated by constant temperature boundary nodes. These nodes are connected to the adjacent wall or fluid by conduction connectors. These heat exchangers may be placed anywhere in any of the five regions of the SINDA model. See Figure 7 which shows an example of the placement of three such heat exchangers. The system will ask the user for the temperature and position for each heat exchanger to be defined. To specify the position of a heat exchanger, the program asks for the following information:

A. The region number.
B. Which layer, of the region, the heat exchanger is on top of (counting from the outside, right to left, toward the center of the sphere or cylinder).

C. The theta angle (counting from the south pole where the heat exchanger begins).
D. The number of theta angles that the heat exchanger covers.

Figure 7 also shows the existence of constant temperature boundary nodes, 3 heat exchangers and a Q input into the outside surface.

SINDA Specific Input Data

The next input is the name of the SINDA execution routine to be used for the analysis. The SINDA analysis will be specified as transient or steady state. The choice of the execution routine also determines the subsequent input data that is required. The user has a choice of three SINDA execution routines. The STDSTL routine is used for steady state analyses. For the transient cases, the user has a choice of the CNFRDL or FWDBCK routines (see ref. 8 for the descriptions of these SINDA routines). The next input required are SINDA and user constants. The user is prompted for the required values.

SINDA Model File

When the model is generated a file named CRYOTRAN MODEL will be left on the user's A disk. This file will consist of the Cray JCL followed by the SINDA input model. This file is available to the user to immediately submit it to the Cray, to edit it, to make modifications to the model and then submit it to the Cray, or to save it for future use.

USING CRYOTRAN

All of the CryoTran programs, the property database, and the procedure files are owned by the CRYOLIB "userid" on the VM computer at LeRC. (A "userid" is a code name to allow a user to log onto a computer system.) In order to use CryoTran, the user must have an active userid on both the VM and the Cray computers.

Accessing Cryotran

The user must first sign on to the VM computer and then may access CryoTran, by typing the following two commands *:

```
LINK CRYOLIB 200 222 RR
ACCESS 222 M
```

* **Note:** These two commands must be as typed as shown except for the user disk id (222). This user disk id may be any number not presently being used for any of the user's minidisks.

The user has now accessed the CRYOLIB disk containing the CryoTran program. Now type one of the following two commands *:

```
RUNCRYO

RUNCRY
```

* **Note:** Either will run CryoTran; however, the RUNCRY command will not load the graphics routines, thus, the program will be available for use earlier. Keep in mind that the geometry plot options are not available if you use the RUNCRY command.

Once the system is running, the user will be prompted by the system for all the input required to build the desired model or to execute the desired analysis program. The proper physical units will be specified as part of the prompt for each input where units are appropriate. The units used in the program are shown in Table 1.

Note!! When the program prompts the user for input, a response is mandatory.

Do not respond to any prompt by just pressing [Enter]. The user must type in a response to the prompt before pressing [Enter]. If [Enter] is pressed as the response to a prompt, the program will exit with many error messages. After clearing all of the error messages from the screen, the program will then automatically exit CryoTran and the user must restart CryoTran.

Aborting CryoTran

If the user becomes caught in an input loop or would like to abort the system, CryoTran may be exited from almost any input prompt by typing a "q" (quit).

Input Error Checking

CryoTran verifies user input in the following ways:

1. Questions which require replies of Y or N, etc. are checked for correct responses.
2. If an improper response is given to a question the program repeats the question to the user.
3. Upper and lower bound tests are made on integer input.
4. A test is made for the correct number of characters for some character data input.
5. A check is done on real number input to verify that extraneous alphabetic characters do not exist.

Getting Started

The user must first specify the type of problem to be performed by CryoTran. There are 3 types of problems. The first screen of CryoTran asks the user to:

```
ENTER THE NUMBER FOR THE DESIRED PROBLEM TYPE
 THE PROBLEM TYPES ARE AS FOLLOWS:

1   -    THERMO/THERMAL SINDA ANALYSIS ON A SPHERE.
2   -    THERMO/THERMAL SINDA ANALYSIS ON A CYLINDER.
3   -    RUN A PRESTORED ANALYSIS PROGRAM.
```

The 3 options from this initial menu correspond to the 3 problem types respectively. They are:

1. type 1 — Generates a SINDA model for a 2-d analysis of a sphere. The model generated will be a wedge of 1 radian, using the center axis of the sphere from the north pole to the south pole (see Figure 3).

2. type 2 — Generates a 2-d model of a cylinder similar to the sphere wedge. The cylinder model may have the ends open, closed and flat, spherical or elliptical. The two end geometries may differ if so desired (see Figure 5).

3. type 3 Runs an analysis program that is already stored. Some of these programs are stored on the Cray computer. In this case the user will be prompted to make the input data available.

Another option under problem type 3 is the option to run a program that is in the CryoTran library on the front end computer (the VM). This will be run interactively on the VM computer within the CryoTran system.

Note: The user will see on the screens generated by the CryoTran program the variable name "ntyp," which will have the value 1, 2 or 3. This number designates the type of the problem (e.g., a type 1 problem is referred to as ntyp = 1).

As noted above, the user is prompted for all input data. The initial responses to the prompts tell the program which type of analysis the user wants, then prompts the user for the particular analysis program. After this has been established, the program then prompts the user for the proper information to build the SINDA model, if any, or to generate the proper file to execute the desired analysis program. CryoTran also prompts the user for any additional input data required by some programs. A sample of input screens for sample problems is shown in Appendix B.

Program Output

After a normal exit from CryoTran, some files will be left on the user's A disk and a geometry plot may be produced if the user has selected plot option 3.

The output of the CryoTran program consists of the following files that will be left on the user's A disk on the VM computer.

1. One file contains the input model named CRYOTRAN MODEL. This file contains the Cray JCL and input data.

In the case of options 1 and 2 (SINDA model on a sphere or cylinder), the data consists of the SINDA model.

If option 3 is chosen and the user picks an analysis program that is already stored on the Cray, the system will prompt the user for the necessary information to generate the CRYOTRAN MODEL file (consisting of the JCL and the input data for the program). The input data to the program may be stored on the Cray, stored on the VM system or typed in at the terminal. If the input data is stored on the VM system, it must be on the user's A disk, set to LRECL 80 and RECFM F. See ref. 10 for definitions of these two terms.

If the user wishes to retain the CRYOTRAN MODEL file for further use, the name must be changed in the VM disk prior to running CryoTran again or the file will be overwritten. Sample CRYOTRAN MODEL files are shown in Appendix C.

2. PROGRAM OUTPUT is an output file of an analysis routine executed interactively on VM.

3. CRYOTRAN INPUTEKO A, is an echo of all the user input responses to the system prompts as the model is being built. In order to use this file as input to the system at a later time, this file must be renamed by the user prior to any further running of the system to avoid it from being overwritten as it is being used.

   This file, which has been renamed, may then be used as input to the system on a subsequent run or it may be modified using the XEDIT command on the VM system. To use this input echo file as input to the system (unit 5 input), type the following instruction prior to typing the RUNCRYO command:

   ```
   FILEDEF FT05F001 DISK PREVIOUS INEKO
   ```

   where the file name PREVIOUS INEKO is the name to which the user changed the file CRYOTRAN INPUTEKO from a previous run.

4. If the user selects problem type 1 or 2 (sphere or cylinder SINDA model) and also selects plot option 1, a file will be produced by the plotting package to be used later to produce a geometry plot. The plotting package used in this program is the ISSCO DISPLA program (ref 11). When the user requests a geometry plot, the DISPLA package is called which produces a file named STD00001 DATA which is left on the user's A disk. The user must then type PLOTQA which is a VM exec to use the file STD00001 DATA to actually produce the plots. Example geometry plots are shown in Figures 7 and 8.

INTEGRATING NEW PROGRAMS INTO CRYOTRAN

To add programs to the system, some of the system subroutines must be modified and new routines must be added to subroutine libraries.

New Programs for Type 1 or Type 2 Problems

When adding new programs for type 1 or 2 problems the following changes are necessary:

1. In subroutine MENU2 the data statements that must be changed are:

array	ANALTi, where i=1, 2, 3, 4, 5 or 6
array	REG45(j,i), i same as in 1
variable	NALTi i=1, 2, 3, 4, 5 or 6
array	SPECIN(j,k) k=1,2 j=1,15

2. If there are going to be subroutines called from the execution, variables or output blocks, the names of these subroutines are put into the following DATA statements: EXEC1, EXEC2, VBL1, VBL2 and OUT in the system subroutine MENU2.

3. The source code of these subroutines must be in a file on the D disk of userid CRYOLIB. This file must be named CRYOLIB NAME1 where NAME1 is the name of the first subroutine called in the execution block and is also the same name that is put into EXEC1.

   These routines that are put into the system for type 1 or 2 problems will usually contain code to solve the liquid problem inside the tank (Region 4). A SINDA model will be generated for Region 1 (Tank Wall) and possibly for Regions 2 and 3. Usually Region 4 will not be a part of the SINDA model and will not have a nodal mesh as in Regions 1, 2 or 3. The programmer of the code solving the problem in Region 4 must have a way to tie together the Region 4 code and the remainder of the SINDA model. The subroutines for this Region 4 problem will be called from the execution, variables and output blocks of SINDA.

   The programmer must compute "inside tank" boundary temperatures and some sort of convection or heat transfer coefficient for use by SINDA for the heat transfer from the liquid or vapor to the wall. Further, the system supplies certain information to the programmer for use in computing these values. The information to and from these analysis subroutines is in COMMON blocks.

   The COMMON blocks and ARRAYS that the programmer needs to link the thermo routines to SINDA are listed below. These common blocks are inserted by CryoTran into the variables and output blocks of the generated SINDA model.

Common Block	Description	I/O
COMMON/USER1/ NTHETA, NBETAS, BETA, RIN, TVOL		
COMMON/USER2/ PTIME, DELTIM, XC1, XC2, XC3, XC4		
COMMON/INSA /SARIN (NN)	Inside tank surface area	Input
COMMON/OUTSA/SAROUT(NN)	Outside surface area	Input
COMMON/SURFT/TSURF (NN)	Inside tank surface temperature	Input
COMMON/BNDYT/TBDY (NN)	Liquid or vapor temperature	Output
COMMON/HTRCO/HCOEF (NN)	Heat transfer coefficient h	Output
COMMON/SURFQ/QSURF (NN)	Inside tank surface q (if any)	Output
	Where NN is the dimension NTHETA.	

The arrays in the above list that are labelled "Input" are values supplied to the programmer from SINDA for use in the thermo calculations. The arrays labelled "Output" are values that must be computed by the thermo routines and put into the indicated common blocks to interface the thermo computations with SINDA.

New Programs for Type 3 Problems

When a new analysis problem of type 3 is added to the system, the modifications to the system depend on whether the analysis program will run on the Cray or whether the analysis will run on VM.

Modifications to Run a New Program on the VM Computer

If the new program is to run interactively on VM, then the following modifications are necessary:

1. The main program of this new analysis code must be converted into a subroutine. The name of this subroutine may be any standard FORTRAN name (call it "name" for this discussion).

2. In subroutine MENU2 add data to:

array	NALANS	short description up to 15 characters
variable	NALNS	add 1 to this value
array	MAINNM	name of main subroutine "name"
array	NSRUNM	which computer system analysis is to run on

3. In subroutine VMINTR add the line:

IF (NAN .EQ. i) CALL "name"

where "name" is the name of the main subroutine and i is the position of "name" in array MAINNM

4. The source code for this program must be added to the CRYVMSUB FORTRAN file in userid CRYOLIB. This file is then recompiled and the file CRYVMSUB TEXT replaces the former one on the D disk of userid CRYOLIB.

Modifications to Run a New Program on the Cray Computer

If the new analysis program is to run on the Cray then:

1. The compiled program must reside on the Cray in userid CRYOLIB.

2. In subroutine MENU2 add data to:

array	NALANS	short description up to 15 characters
variable	NALNS	add 1 to this value
array	MAINNM	name of main subroutine "name"
array	NSRUNM	which computer system to run on

3. The main program of this new analysis code must be converted into a subroutine. The name of this subroutine may be any standard FORTRAN name (call it "name" for this discussion).

PROGRAM INFORMATION

The following general information about CryoTran will help systems programmers or users make modifications to the system, add new programs to the system, and write subroutines to be called from SINDA models generated by the system.

The FORTRAN call, CALL CLEAR, to clear the screen, is used in CryoTran. This routine is on the Amdahl/VM system at LeRC. The routine (CLEAR) is called from a subroutine in the program named CLEARS (clear screen). On other systems that do not have this routine, the user may comment out the call to CLEAR in subroutine CLEARS or access a substitute routine. When CryoTran is used at LeRC the FTNLIB command is executed prior to the load to access the routine. An alternate way to access the CLEARS routine is to the ADDLIB command (a local LeRC command). See VM exec RUNCRYO in Appendix E part v.

The SYSCMD call, which is in the MAIN PROGRAM and in the DOJCL subroutine, is a local LeRC subroutine to perform VM JCL requests from inside a FORTRAN program. On other systems that do not have this routine, the user may comment out the call to SYSCMD in subroutine DOJCL or access a substitute routine.

Numbering Conventions

There are numbering conventions used in CryoTran to assist with the identification of node data, conductor data and materials for the various regions. These numbering conventions will also assist the programmer with new analysis programs that are to be integrated into CryoTran.

Node Data Numbering Conventions

Region Name	Description	Node Type	Base Node Number	Node Numbers
1 Tank Wall	inner surface	arithmetic	1000	1001, 1002, 1003, ... 1xxx
	N1 layers	diffusion	2000	2001, 2002, 2003, ... 2xxx
	outer surface	arithmetic	3000	3001, 3002, 3003, ... 3xxx
2 *	N2 layers	diffusion	4000	4001, 4002, 4003, ... 4xxx
	outer surface	arithmetic	5000	5001, 5002, 5003, ... 5xxx
3 *	N3 layers	diffusion	6000	6001, 6002, 6003, ... 6xxx
	outer surface	arithmetic	7000	7001, 7002, 7003, ... 7xxx
4 inside tank*	N4 layers	diffusion	8000	8001, 8002, 8003, ... 8xxx
5 inside tank *	N5 layers	diffusion	10000	10001, 10002, 10003, ... 10xxx
Inside tank when Region 4 = .false.		boundary	18000	18001, 18002, 18003, ... 18xxx
Heat Exchangers (maximum of 10)		boundary	20000	20001, 20002, 20003, ... 20xxx
Vapor Cooled Shields (not defined in present version)			Use heat exchangers	
Outside Atmosphere		boundary	20301, 20302	

Where:
1. xxx $\leq$ 999
2. * optional region
3. Where Base Node Number is the base and generated Node Numbers are incremented by 1 from the base. See Figure 6 to see the node numbering convention.

Conductor Numbering Convention

Conductors start with number 1 and then are incremented by 1 for each conductor in the model.

Material Numbering Conventions

The material numbers from the materials database are 4 digit numbers with the following format:

knxx

Where:
1. k represents the material property number (shown below)
2. n represents the material type (shown below)
3. xx represents the number assigned to the material (within the material type)
4. [nxx] is the material number from the prompt screen when choosing the materials for each region

---

The material property numbers (k) are:

Material Property Number (k)	Description	Symbol	Units
1	Specific Heat * Density of material nxx	Cp*Rho	Btu/in^3-°F
2	Specific Heat of material nxx	Cp	Btu/lbm-°F
3	Density of material nxx	Rho	lb/in^3
4	Viscosity of material nxx	Mu	lb hr/in^2
5	Enthalpy of material nxx	h	Btu/lb
6	Thermal Conductivity of material nxx	k	Btu/hr-in-°F

where nxx is the material number from the prompt screen when choosing the materials for each region

---

The material group types (n) are:

Material Type	Description
1	liquid materials
2	solid materials
3	gaseous materials

CryoTran Specification Statements

The following is a list of variables defined in COMMON, LOGICAL and CHARACTER statements that occur in the subroutines of the CryoTran system. Not all of these common blocks, logical or character statements appear in each subroutine. The specific list of statements in each subroutine may be found in the program listing in Appendix E.

```
COMMON/UNITS/MODU, INPEKO, ISCRCH, SINDA
COMMON/TITL/TITLE, TITLE0
COMMON/GEOMTY/NTYP, NAN, GEOM(2)
COMMON/DATA/RIN, ROUT, NLAY, NTHETA, TIMEND, OUTPUT, FFLOW, TGAS, TLIQ, TWALL,
DTIMEI,                DRLXCA, ARLXCA, NLOOP
COMMON/REGION/NTHETA, NBETAS, BETA, RIN, TVOL, ROUT(9), REGNS(9), NLAYRS(9),
TEMPS(9),              THICK(9), THKLAY(9), MATNMS(9), RGNNMS(9)
COMMON/SUBRTS/XCUT1, XCUT2, VBLBL1, VBLBL2, OUTBLK
COMMON/STUFF/NHTT, PI, CONVY, CONVR, THETA0, DTHETA, NBASOS, ROUTSF, BNCOEF(2)
COMMON/ULLAGE/ NLUL4, NLUL5, NTHU41, RINMHH, PCTFUL, RADULG, TVULFT, CT, LG(3),
      LIQVAP(3)
COMMON/HTXGRS/ NHX,HXTEMP(10),NRHX(10),NLHX(10),NTHHX(10),LNGTHX(10)
LOGICAL SPLIPT
LOGICAL SINDA
LOGICAL RGNS, VPCSHD
CHARACTER*6        XCUT1,XCUT2,VBLBL1,VBLBL2,OUTBLK,MAINNM
CHARACTER*50       TITLE0
CHARACTER*80       TITLE
CHARACTER*8        GEOM
CHARACTER*16       MATNM2
CHARACTER*25       RGNNMS
CHARACTER*6        LIQVAP
CHARACTER*16       MATNMS
CHARACTER*1        CT, LG
```

Files Used to Run CryoTran

When running CryoTran, the user links to disk 200 in the userid CRYOLIB and then accesses the M disk. The files necessary to execute CryoTran are on this M disk and are available to the user in read-only mode. They are: TEXT files (binary files resulting from compiling the FORTRAN source code), EXEC files (procedures written in REXX (ref. 12)), material property files and a source code file. The following list contains the files located on the M disk:

File Name	Description
CRYOTRAN TEXT	Binary file of the main program and general system routines
CRYOSPHR TEXT	Binary file of subroutines pertaining to a sphere
CRYOCYL TEXT	Binary file of subroutines pertaining to a cylinder
CRYOPLOT TEXT	Binary plot routines for a sphere
CRYVMSUB TEXT	Binary analysis subroutines
ECLGRAPH TEXT	Binary plot routines for SOLA-ECLIPSE
SYSCMD TEXT	A LeRC system subroutine
RUNCRYO EXEC	VM Exec to put CryoTran into execution
RUNCRY EXEC	VM Exec to put CryoTran into execution without the plot programs
PLOTQA EXEC	VM Exec to produce geometry plots
DOECLPLT EXEC	VM Exec to execute the SOLA-ECLIPSE plot program
CRYOSUBS THWSE1	Subroutines for DeWitt type SINDA analysis
MATERIAL DBASE	Database of material properties
H_2 TABLE	H_2 property data
N_2 TABLE	N_2 property data
O_2 TABLE	O_2 property data

Miscellaneous Information

Other information that may be of interest is:

A table of the FORTRAN files and corresponding unit numbers can be found in Table 2. A detailed flow diagram of CryoTran is given in Figure 9 (9-1 through 9-6). A short description of all the CryoTran subroutines is given in Appendix D and a FORTRAN listing of CryoTran along with some of the VM and the Cray script files is in Appendix E.

CONCLUDING REMARKS

This report presents Version 1.0 of CryoTran. It is a user-friendly modular system expected to be a dynamic and evolving program. It is intended that as new analyses become available they will be incorporated into the system.

Present capabilities include a tank chilldown fluid usage analysis, a transient no-vent fill procedure and a user interface to two large analysis programs, CSAM and SOLA-ECLIPSE. The program also generates SINDA models for 2-dimensional analyses of spherical and cylindrical tanks. These thermal models have the capability of multi-layer geometry and allow the user to include user-written subroutines to modify the analyses or expand them.

It is anticipated that future versions of CryoTran will include additional fill procedures and will be extend to 3-dimensional analyses.

APPENDIX A

NVFILL, TARGET and CRYOCHIL User Guides

[For CryoTran User Guide]

NVFILL Description (excerpted from ref. 5)

NVFILL is a computer model of the no-vent fill process. NVFILL approximates the no-vent fill by splitting the tank into four control volumes: ullage vapor, bulk liquid, liquid-vapor interface and tank wall. Convective heat and mass transfer relationships are used to control mass and heat transfer between the control volumes as well as apportioning the liquid inflow between the ullage and bulk volumes. The no-vent fill process is divided into two stages: a wall cooling stage where heat transfer to the tank wall is dominant and a fill stage where all the thermal energy has been removed from the wall.

Assumptions for the wall cooling stage are as follows. All liquid inflow is flashed to thermodynamic equilibrium on entering the tank as long as the tank pressure is less than the liquid saturation pressure. All remaining liquid after the initial flashing is vaporized upon striking the tank wall. The energy removed from the tank wall is equal to the energy necessary to vaporize this remaining liquid. Heat transfer from the wall to vapor, vapor to liquid and external environment to tank wall are assumed to be negligible.

Assumptions for the fill stage are as follows. The thermal energy of the wall has been removed in the wall cooling phase and can be neglected. The interface temperature is equal to the saturation temperature at the current tank pressure. The condensation rate at the interface is determined by the convective heat transport between the bulk liquid and the interface. Heat (but not mass) transfer to the gas is assumed negligible. The interface area is that of a sphere equal to the ullage volume.

To solve the differential equations of the no-vent fill process, a finite difference approximation is used. During the initial flashing stage the problem adds the mass inflow during the timestep to the ullage, calculates a new ullage density and internal energy, and then uses the density and enthalpy to determine a new ullage pressure. In the fill stage the problem is calculated in a two-step procedure. For the first process, the ullage is held at constant pressure while a mass transfer rate is calculated. For the second process, a new liquid volume is calculated from the mass transfer and current bulk liquid conditions. The ullage vapor is then compressed adiabatically to fill the remaining tank volume. The time step for both these processes combined is set to 10^{-3} hours which is sufficiently small compared to the process rates for most cases of interest to insure a good approximation of the continuous mass transfer and compression processes.

User Interface

The code interactively prompts the user for the following input values:

1. Tank volume (ft^3), volume of the tank being filled

2. Tank mass to volume ratio (lbm/ft^3), mass of the tank divided by its volume

3. Liquid inflow rate (lbm/hr), the rate at which the filling liquid enters the tank.

4. Heat transfer coefficient (Btu/ft^2 hr °R), the convective heat transfer coefficient between the bulk liquid and the gas

5. Incoming liquid temperature (R), the temperature of the incoming liquid

6. Chilldown temperature (R), the tank wall temperature at the start of the fill

Once the user inputs have been specified, the code executes without further user interaction. The code terminates on one of the following criteria:

1. Tank 95% full (normal ending)

2. Tank pressure exceeds 60 psia

3. Tank fill time exceeds 8 hours

4. There is no vapor mass in the ullage.

Sample input screens are shown in table A-1.
The resultant output is shown in table A-2.

TARGET Description (excerpted from ref. 7)

The TARGET code is used to determine the maximum temperature from which the filling of a given tank can be initiated and subsequently filled to a specified pressure and fill level without venting. The main process is the transfer of the energy stored in the thermal mass of the tank walls into the inflowing liquid. This process is modeled by examining the end state of the no-vent fill process. This state is assumed to be a thermal equilibrium between the tank and the fluid which is well mixed and saturated at the tank pressure. No specific assumptions are made as to the processes or the intermediate thermodynamic states during the filling. It is only assumed that the maximum tank pressure occurs at the final state. As stated above, this assumption implies that, during the initial phases of the filling, the injected liquid must pass through the bulk vapor in such a way that it absorbs a sufficient amount of its superheat so that moderate tank pressures can be maintained. It is believed that this is an achievable design goal for liquid injection systems.

In reference 6, the mass-to-volume was found to be the key scaling parameter relating the target temperatures of prototype and subscaled model tanks. For a given tank material and identical operating conditions, this ratio is the determining factor of a tank's target temperature. Therefore, the tank's mass and volume are variable inputs to the TARGET code. The tank material, in addition to its mass and initial temperature, defines the thermal energy which is stored in the tank walls and must be absorbed by the liquid. Currently only 2219 Aluminum is used for the tank material.

The other main inputs required to run TARGET are the pressure and the tank filling percentage of the receiving tank at the completion of the no-vent fill. Since the liquid and vapor phases are assumed to be in equilibrium, the specific internal energy of each phase can be calculated from the final tank pressure. The final fill level quantifies the energy stored in the fluid by defining the liquid and vapor masses. A fluid mass balance equates the injected liquid to the final total mass of the liquid and vapor since there is no venting.

It was assumed in reference 6 that the heat flux into the tank was negligible during the fill operation. Inclusion of the tank heat flux, however, only requires a minor code modification once the heat flux and fill time are quantified. Thus, the only terms missing in the energy balance of the system (Equation 2 of ref. 6) are the enthalpy of the injected liquid and the initial wall temperature. The solution technique of TARGET is a simple incrementing of the initial tank temperature and solving for the required liquid enthalpy to satisfy the energy balance at each temperature. The initial temperature starts at 10 °R above the liquid saturation temperature and then is increased by another 10 °R each time through a DO loop. This assists in maintaining small temperature ranges over which the ALCP subroutine must be called, thus reducing the errors. The trapezoidal rule is employed to increment the change in wall energy term, DELU. The enthalpy required to balance this wall energy change is then calculated and the corresponding fluid saturation pressure can be found from the data table. The actual output is the required pressure difference between the saturation conditions in the source and receiving tanks, i.e. the required liquid subcooling, for the given initial temperature.

Code Specifics:

1a. TARGET can be run with any fluid for which the user has a properties data base. Currently it will only run for hydrogen, oxygen, and nitrogen since the pressure-enthalpy data sets have been created for these fluids only. TARGET will read the data into an array from logical unit 2 at the initiation of execution. Each time the array is scanned it will start at the lowest pressure (2 psia) and continue until the corresponding enthalpy value is greater than or equal to the required enthalpy. It should be noted that if GASP is not used for the other fluid properties these values may be inconsistent with those values obtained from an alternate properties subroutine due to the use of a different reference enthalpy value. Reference A-3 should be consulted in such an instance.

1b. Since the minimum saturation pressure in the data tables for the injected liquid state is 2 psia, the maximum pressure difference available for liquid subcooling is the maximum tank pressure less 2 psia. To avoid unnecessary execution, the code compares the calculated pressure difference to the maximum pressure difference and stops execution if there is an equivalence. The other normal termination of execution occurs if the initial temperature exceeds 540 °R in the incrementing DO loop. This would violate the upper limit for the ALCP subroutine.

2. Final fill level is to be entered in terms of a percentage, e.g., 95.0 not 0.95.

3. All output from the TARGET code goes to logical unit 1 which should be defined as data file, or could be directed to the user terminal.

4. All messages to the user are output to logical unit 1 which should be defined

as data file, or could be directed to the user terminal.

5. There still exist occasional anomalies in the code execution which lead to erroneous values for the pressure difference at random enthalpy values for liquid hydrogen. It is not yet understood whether there is a problem in the data base or in the code execution. Erroneous data should simply be ignored until the problem can be corrected. Note, however, that negative values for the subcooling pressure difference are not erroneous; they merely indicate that subcooling is not required.

Input and output for an example run are shown in tables A-3 and A-4 respectively.

CRYOCHIL Description (excerpted from ref. 7)

The CRYOCHIL (CRYOgenic tank CHILldown) code was developed based on the analyses presented in reference 6. As previously stated, its primary function is to predict the optimum liquid charge to be injected for each of a series of charge-hold-vent chilldown cycles. This information can then be used with specified mass flow rates and valve response times to control a liquid injection system for tank chilldown operations. This will insure that the operations proceed quickly and efficiently.

Realizing that tank chilldown and no-vent fill operations are in essence part of the complete "thermodynamic" fill procedure, it is not surprising to find similar information being required as input for the analyses of each process. Again, the tank mass-to-volume ratio plays an important role; it determines the maximum charge which can be introduced to any tank regardless of its actual mass or volume. The maximum charge is found to decrease with increasing mass-to-volume ratios. Obviously the total mass required over a given temperature range is a direct function of the tank's thermal mass. Note, however, from the discussions of target temperatures that the lower mass-to-volume ratio tanks will have higher target teperatures and, thus, a lesser tank chilldown mass. CRYOCHIL will prompt the user for the input of the tank's mass, volume, initial temperature, and a target temperature.

Since the avoidance of tank overpressurization is a major concern, the tank's maximum pressure is an important input. Likewise, in order to calculate the available thermal capacity of given charge, the injected liquid enthalpy must be known. It is calculated from the input value of the supply tank saturation pressure, thus neglecting energy inputs from the transfer line, pressurization system, or transfer pumps. In an actual system the liquid state would be measured just prior to the liquid injection system.

Lastly, CRYOCHIL will prompt the user for a "vent stage pressure drop." This will cause the VENTDN subroutine to perform multiple vent cycles if any value less than the input maximum pressure is given. This is desirable because the venting can be more efficiently accomplished in small stages down to intermediate pressures at which the vapor can be held once again. This will allow for the isentropic expansion of the remaining vapor to cool the vapor and, consequently, the tank wall. Reference 3 used CRYOCHIL to demonstrate that a 23% fluid mass savings is possible for a quarter-scale model of an OTV tank when one 60 psi vent stage is replaced with many 1 psi vent stages. The limit to decreasing the magnitude of the vent stages becomes an infinite number of infinitely small stages which, of course, would be one slow vent stage at an optimized flow rate. This optimum flow rate has not yet been calculated at Lewis.

CRYOCHIL prompts the user for each input and then echoes this input to an output file. The calculations begin with an evaluation of the liquid enthalpy of the injected liquid based on the specified saturation pressure in the supply tank prior to its being pressurized; this value remains constant for the entire test case.

The code next uses the ALCP subroutine to determine the specific heat of aluminum at the initial wall temperature for the given cycle.

At this point CRYOCHIL must make a guess at the tank wall temperature prior to the initiation of the venting process. This temperature and the temperature at the completion of venting are both unknown. Rather than making an arbitrary guess at this temperature, an educated guess is made based on a parametric evaluation of tank chilldowns over a range of tank mass-to-volume ratios using liquid hydrogen. Guesses for the beginning of subsequent chilldown cycles are made based on information retained from the preceding cycle. The use of these educated guesses has significantly reduced the execution time of the code from the time required with the use of arbitrary guesses.

Since the tank temperature prior to venting is unknown, an iterative solution technique can be used by solving equation 32 from reference 6 based on the previously guessed value. The algorithm is iterative because the properties of the vapor are evaluated at the tank's maximum pressure and a temperature which is 95% of the tank temperature. (Again, this assumption is working toward a prediction of fluid masses for an optimum chilldown cycle; actual spray systems should be designed to achieve this goal.) Recently, however, the code has been modified to more accurately account for the compressibility of the vapor by eliminating the ideal gas law (equation 30) from the analysis. What results is a less complex algorithm using equation 31 instead of equation 32, (ref. 6). Once this calculated value is within the user specified error band (entered via terminal input), the code proceeds to calculate the mass injected by multiplying the vapor density by the tank volume.

Having calculated the wall temperature prior to venting, CRYOCHIL next calls the VENTDN subroutine to model the venting according to the description of reference 6. Since the temperature of the wall at the conclusion of the venting is unknown, an iterative process is once again used. When finished, the VENTDN subroutine returns the wall temperature and the number of vent cycles for the specified vent stage magnitude. The last venting stage will always be down to 2 psia, regardless of its magnitude. Any effects associated with venting the tank back to space vacuum are considered negligible. Note that VENTDN also uses the ALCP subroutine to evaluate wall specific heats and GASP to evaluate the fluid properties.

This charge-hold-vent procedure repeats for each chilldown cycle until the tank temperature, before or after venting, drops below the tank's target temperature. Since the objective of the modeling is to minimize the fluid consumption, this is undesirable. When this occurs, the CRYOCHIL code will call a subroutine, CALC, designed to chilldown the tank to within the user specified error band of the target temperature.

The CALC subroutine is not as straight forward as one might expect, even though the final temperature of this final cycle is known. This is because the cooling during the tank venting must be taken into account. Therefore, an iterative bisection algorithm, also known as "halving the interval," is used to calculate the tank temperature prior to venting until it is such that the resultant venting cools the tank to the target temperature. To accomplish this, CALC will call both the VENTDN and ALCP subroutines in addition to GASP. Since CALC should only be called when a complete "optimum" chilldown cycle is not possible or desirable, the maximum pressure due to the liquid evaporation should be below the tank's maximum pressure. For this reason, CALC will return the actual tank pressure to CRYOCHIL and print the value out with the number of vent cycles returned from VENTDN. If, however, the mass injected during this final cycle does not raise the tank pressure above 2 psia, VENTDN will not be called, and the number of vent cycles will be zero. This extra effort to hit the target temperature is made to assist in the conductance of trade studies with specified target temperatures. When CALC has found the proper injection mass to reach the target temperature, CRYOCHIL calculates the total mass injected and the total number of chilldown cycles.

Abnormal endings to CRYOCHIL can occur by several different ways: (1) One of the iterative solution techniques, in either the CRYOCHIL, VENTDN or CALC, exceeds the specified number of iterations, usually fifty; (2) the number of tank chilldown cycles exceeds fifty; (3) GASP returns to VENTDN or CALC with a thermodynamic state of the fluid different than expected; and (4) Any temperature in CRYOCHIL, VENTDN, or CALC is out of range for ALCP. If any of these failures occur, the execution will terminate and an error message will be given, usually specifying which failure stopped the execution. Abnormal endings 3 and 4 are most likely to occur if the specified target temperature is excessively low for a given tank and operation conditions.

Code Specifics:

CRYOCHIL also can be run for any fluid for which the property data exists. It is currently configured to run liquids hydrogen, oxygen, and nitrogen. This will be the first input made by the user. The user should not try to chilldown a tank too close to the fluid's boiling point since the original assumption of all the liquid evaporating will be violated.

Input data is shown in table A-5.
Output data is shown in table A-6.

```
THIS PROGRAM DETERMINES THERMODYNAMIC PROPERTIES FOR
PARAHYDROGEN FROM THE SUBROUTINE GASP
ENTER TANK VOLUME (FT**3)
?
23.6
ENTER TANK MASS TO VOLUME RATIO (LBM/FT**2)
?
3.0
ENTER LIQUID INFLOW RATE (LBM/HR)
?
500.
ENTER HEAT TRANSFER COEFIENT (BTU/FT**2 HR R)
?
40.0
ENTER INCOMING LIQUID TEMPERATURE (R)
?
36.6
ENTER CHILLDOWN TEMPERATURE (R)
?
102.5
TANK 95% FULL
FINAL PRESSURE = 29.04
FINAL GAS TEMPERATURE = 62.36
FINAL LIQUID TEMPERATURE = 38.81
```

Table A-1

NO VENT FILL TWO STEP MODEL
ADIABATIC COMPRESION FOLLOWED BY ISOBARIC MASS TRANSFER

TANK VOLUME = 23.60 CU FT
LIQUID INFLOW RATE = 500.00 LBM/HR
LIQUID TEMPERATURE = 36.60 R
INTERFACE-LIQUID HEAT TRANSFER COEFFICIENT = 40.0000
CHILLDOWN TEMP = 102.50 R
MASS TO VOLUME RATIO = 3.000 LBM/CU FT

TIME HR	PRESS PSIA	FILL %	GAS T R	LIQ T R	M GAS LBM	V GAS CU FT	M LIQ LBM	V LIQ CU FT
0.000	2.00	0.00	102.50	36.60	0.09	23.60	0.00	0.00
0.001	9.56	0.00	72.95	36.60	0.59	23.60	0.00	0.00
0.002	14.79	0.00	61.81	36.60	1.09	23.60	0.00	0.00
0.003	20.09	0.00	58.34	36.60	1.59	23.60	0.00	0.00
0.004	22.68	0.00	57.33	36.60	1.84	23.60	0.25	0.00
WARNING BULK BOILING X=0.0050								
0.005	22.40	0.76	56.74	39.30	1.82	23.42	0.77	0.18
0.006	22.42	1.23	56.48	38.41	1.82	23.31	1.26	0.29
WARNING BULK BOILING X=0.0020								
0.007	22.27	1.76	56.45	39.22	1.80	23.19	1.79	0.41
0.008	22.34	2.24	56.33	38.79	1.80	23.07	2.28	0.53
0.009	22.33	2.74	56.39	38.89	1.79	22.95	2.80	0.65
0.010	22.33	3.24	56.38	38.87	1.78	22.83	3.30	0.77
0.011	22.32	3.74	56.37	38.87	1.77	22.72	3.81	0.88
0.012	22.31	4.24	56.37	38.87	1.76	22.60	4.32	1.00
0.013	22.31	4.74	56.36	38.86	1.75	22.48	4.83	1.12
0.014	22.30	5.24	56.35	38.86	1.74	22.36	5.34	1.24
0.015	22.29	5.74	56.34	38.86	1.73	22.25	5.85	1.35
0.016	22.28	6.24	56.34	38.86	1.72	22.13	6.36	1.47
0.017	22.28	6.74	56.33	38.85	1.71	22.01	6.87	1.59
0.018	22.27	7.24	56.32	38.85	1.71	21.89	7.38	1.71
0.019	22.26	7.74	56.32	38.85	1.70	21.77	7.89	1.83
0.020	22.26	8.24	56.31	38.85	1.69	21.66	8.40	1.94
0.021	22.25	8.74	56.30	38.84	1.68	21.54	8.91	2.06
0.022	22.25	9.24	56.30	38.84	1.67	21.42	9.42	2.18
0.023	22.24	9.74	56.29	38.84	1.66	21.30	9.93	2.30
0.024	22.24	10.24	56.29	38.84	1.65	21.18	10.44	2.42
0.025	22.24	10.73	56.28	38.84	1.64	21.07	10.95	2.53
0.026	22.23	11.23	56.28	38.83	1.63	20.95	11.46	2.65
0.027	22.23	11.73	56.28	38.83	1.62	20.83	11.97	2.77
0.028	22.22	12.23	56.27	38.83	1.61	20.71	12.48	2.89
0.029	22.22	12.73	56.27	38.83	1.60	20.60	12.98	3.00
0.030	22.22	13.23	56.27	38.83	1.59	20.48	13.49	3.12
0.031	22.22	13.73	56.26	38.83	1.58	20.36	14.00	3.24
0.032	22.21	14.23	56.26	38.82	1.57	20.24	14.51	3.36
0.033	22.21	14.73	56.26	38.82	1.57	20.12	15.02	3.48
0.034	22.21	15.23	56.26	38.82	1.56	20.01	15.53	3.59
0.035	22.21	15.73	56.25	38.82	1.55	19.89	16.04	3.71
0.036	22.21	16.22	56.25	38.82	1.54	19.77	16.55	3.83
0.037	22.20	16.72	56.25	38.82	1.53	19.65	17.06	3.95
0.038	22.20	17.22	56.25	38.82	1.52	19.54	17.57	4.06
0.039	22.20	17.72	56.25	38.81	1.51	19.42	18.08	4.18
0.040	22.20	18.22	56.25	38.81	1.50	19.30	18.59	4.30

Table A-2
(1 of 4)

0.041	22.20	18.72	56.25	38.81	1.49	19.18	19.10	4.42
0.042	22.20	19.22	56.25	38.81	1.48	19.06	19.60	4.54
0.043	22.20	19.72	56.25	38.81	1.47	18.95	20.11	4.65
0.044	22.20	20.22	56.24	38.81	1.46	18.83	20.62	4.77
0.045	22.20	20.72	56.24	38.81	1.45	18.71	21.13	4.89
0.046	22.20	21.21	56.24	38.80	1.45	18.59	21.64	5.01
0.047	22.20	21.71	56.24	38.80	1.44	18.48	22.15	5.12
0.048	22.20	22.21	56.25	38.80	1.43	18.36	22.66	5.24
0.049	22.20	22.71	56.25	38.80	1.42	18.24	23.17	5.36
0.050	22.20	23.21	56.25	38.80	1.41	18.12	23.68	5.48
0.051	22.20	23.71	56.25	38.80	1.40	18.00	24.19	5.60
0.052	22.20	24.21	56.25	38.80	1.39	17.89	24.70	5.71
0.053	22.21	24.71	56.25	38.80	1.38	17.77	25.20	5.83
0.054	22.21	25.20	56.25	38.80	1.37	17.65	25.71	5.95
0.055	22.21	25.70	56.25	38.80	1.36	17.53	26.22	6.07
0.056	22.21	26.20	56.25	38.79	1.35	17.42	26.73	6.18
0.057	22.21	26.70	56.26	38.79	1.35	17.30	27.24	6.30
0.058	22.21	27.20	56.26	38.79	1.34	17.18	27.75	6.42
0.059	22.22	27.70	56.26	38.79	1.33	17.06	28.26	6.54
0.060	22.22	28.20	56.26	38.79	1.32	16.95	28.77	6.65
0.061	22.22	28.70	56.26	38.79	1.31	16.83	29.28	6.77
0.062	22.22	29.19	56.27	38.79	1.30	16.71	29.79	6.89
0.063	22.23	29.69	56.27	38.79	1.29	16.59	30.30	7.01
0.064	22.23	30.19	56.27	38.79	1.28	16.47	30.80	7.13
0.065	22.23	30.69	56.27	38.79	1.27	16.36	31.31	7.24
0.066	22.23	31.19	56.28	38.79	1.26	16.24	31.82	7.36
0.067	22.24	31.69	56.28	38.79	1.25	16.12	32.33	7.48
0.068	22.24	32.19	56.28	38.79	1.25	16.00	32.84	7.60
0.069	22.24	32.68	56.29	38.78	1.24	15.89	33.35	7.71
0.070	22.25	33.18	56.29	38.78	1.23	15.77	33.86	7.83
0.071	22.25	33.68	56.29	38.78	1.22	15.65	34.37	7.95
0.072	22.25	34.18	56.30	38.78	1.21	15.53	34.88	8.07
0.073	22.26	34.68	56.30	38.78	1.20	15.42	35.39	8.18
0.074	22.26	35.18	56.31	38.78	1.19	15.30	35.89	8.30
0.075	22.27	35.68	56.31	38.78	1.18	15.18	36.40	8.42
0.076	22.27	36.17	56.31	38.78	1.17	15.06	36.91	8.54
0.077	22.28	36.67	56.32	38.78	1.16	14.95	37.42	8.65
0.078	22.28	37.17	56.32	38.78	1.16	14.83	37.93	8.77
0.079	22.29	37.67	56.33	38.78	1.15	14.71	38.44	8.89
0.080	22.29	38.17	56.33	38.78	1.14	14.59	38.95	9.01
0.081	22.30	38.67	56.34	38.78	1.13	14.47	39.46	9.13
0.082	22.30	39.17	56.34	38.78	1.12	14.36	39.97	9.24
0.083	22.31	39.67	56.35	38.78	1.11	14.24	40.48	9.36
0.084	22.31	40.16	56.35	38.78	1.10	14.12	40.99	9.48
0.085	22.32	40.66	56.36	38.78	1.09	14.00	41.49	9.60
0.086	22.32	41.16	56.36	38.77	1.08	13.89	42.00	9.71
0.087	22.33	41.66	56.37	38.77	1.07	13.77	42.51	9.83
0.088	22.34	42.16	56.38	38.77	1.07	13.65	43.02	9.95
0.089	22.34	42.66	56.38	38.77	1.06	13.53	43.53	10.07
0.090	22.35	43.15	56.39	38.77	1.05	13.42	44.04	10.18
0.091	22.35	43.65	56.40	38.77	1.04	13.30	44.55	10.30
0.092	22.36	44.15	56.40	38.77	1.03	13.18	45.06	10.42
0.093	22.37	44.65	56.41	38.77	1.02	13.06	45.57	10.54
0.094	22.38	45.15	56.42	38.77	1.01	12.94	46.08	10.66
0.095	22.38	45.65	56.42	38.77	1.00	12.83	46.58	10.77

Table A-2
(2 of 4)

0.096	22.39	46.15	56.43	38.77	0.99	12.71	47.09	10.89
0.097	22.40	46.64	56.44	38.77	0.98	12.59	47.60	11.01
0.098	22.41	47.14	56.45	38.77	0.98	12.47	48.11	11.13
0.099	22.41	47.64	56.45	38.77	0.97	12.36	48.62	11.24
0.100	22.42	48.14	56.46	38.77	0.96	12.24	49.13	11.36
0.101	22.43	48.64	56.47	38.77	0.95	12.12	49.64	11.48
0.102	22.44	49.14	56.48	38.77	0.94	12.00	50.15	11.60
0.103	22.45	49.64	56.49	38.77	0.93	11.89	50.66	11.71
0.104	22.46	50.13	56.50	38.77	0.92	11.77	51.17	11.83
0.105	22.47	50.63	56.51	38.77	0.91	11.65	51.67	11.95
0.106	22.47	51.13	56.51	38.77	0.90	11.53	52.18	12.07
0.107	22.48	51.63	56.52	38.77	0.89	11.42	52.69	12.18
0.108	22.49	52.13	56.53	38.77	0.89	11.30	53.20	12.30
0.109	22.50	52.63	56.54	38.77	0.88	11.18	53.71	12.42
0.110	22.51	53.13	56.55	38.77	0.87	11.06	54.22	12.54
0.111	22.52	53.62	56.56	38.77	0.86	10.94	54.73	12.66
0.112	22.54	54.12	56.58	38.77	0.85	10.83	55.24	12.77
0.113	22.55	54.62	56.59	38.77	0.84	10.71	55.75	12.89
0.114	22.56	55.12	56.60	38.77	0.83	10.59	56.25	13.01
0.115	22.57	55.62	56.61	38.77	0.82	10.47	56.76	13.13
0.116	22.58	56.12	56.62	38.77	0.81	10.36	57.27	13.24
0.117	22.59	56.61	56.63	38.77	0.80	10.24	57.78	13.36
0.118	22.61	57.11	56.64	38.76	0.80	10.12	58.29	13.48
0.119	22.62	57.61	56.66	38.76	0.79	10.00	58.80	13.60
0.120	22.63	58.11	56.67	38.76	0.78	9.89	59.31	13.71
0.121	22.64	58.61	56.68	38.76	0.77	9.77	59.82	13.83
0.122	22.66	59.11	56.70	38.76	0.76	9.65	60.33	13.95
0.123	22.67	59.61	56.71	38.76	0.75	9.53	60.84	14.07
0.124	22.69	60.10	56.72	38.76	0.74	9.42	61.34	14.18
0.125	22.70	60.60	56.74	38.76	0.73	9.30	61.85	14.30
0.126	22.72	61.10	56.75	38.76	0.72	9.18	62.36	14.42
0.127	22.73	61.60	56.77	38.76	0.71	9.06	62.87	14.54
0.128	22.75	62.10	56.78	38.76	0.71	8.94	63.38	14.66
0.129	22.76	62.60	56.80	38.76	0.70	8.83	63.89	14.77
0.130	22.78	63.10	56.82	38.76	0.69	8.71	64.40	14.89
0.131	22.80	63.59	56.83	38.76	0.68	8.59	64.91	15.01
0.132	22.81	64.09	56.85	38.76	0.67	8.47	65.42	15.13
0.133	22.83	64.59	56.87	38.76	0.66	8.36	65.93	15.24
0.134	22.85	65.09	56.88	38.76	0.65	8.24	66.43	15.36
0.135	22.87	65.59	56.90	38.76	0.64	8.12	66.94	15.48
0.136	22.89	66.09	56.92	38.76	0.63	8.00	67.45	15.60
0.137	22.91	66.58	56.94	38.76	0.62	7.89	67.96	15.71
0.138	22.93	67.08	56.96	38.76	0.62	7.77	68.47	15.83
0.139	22.95	67.58	56.98	38.76	0.61	7.65	68.98	15.95
0.140	22.97	68.08	57.00	38.76	0.60	7.53	69.49	16.07
0.141	22.99	68.58	57.03	38.76	0.59	7.42	70.00	16.18
0.142	23.02	69.08	57.05	38.76	0.58	7.30	70.51	16.30
0.143	23.04	69.57	57.07	38.76	0.57	7.18	71.02	16.42
0.144	23.06	70.07	57.09	38.76	0.56	7.06	71.52	16.54
0.145	23.09	70.57	57.12	38.76	0.55	6.95	72.03	16.65
0.146	23.12	71.07	57.14	38.76	0.54	6.83	72.54	16.77
0.147	23.14	71.57	57.17	38.76	0.54	6.71	73.05	16.89
0.148	23.17	72.07	57.20	38.76	0.53	6.59	73.56	17.01
0.149	23.20	72.57	57.22	38.76	0.52	6.47	74.07	17.13
0.150	23.23	73.06	57.25	38.76	0.51	6.36	74.58	17.24

Table A-2
(3 of 4)

0.151	23.26	73.56	57.28	38.76	0.50	6.24	75.09	17.36
0.152	23.29	74.06	57.31	38.76	0.49	6.12	75.60	17.48
0.153	23.32	74.56	57.35	38.76	0.48	6.00	76.11	17.60
0.154	23.36	75.06	57.38	38.76	0.47	5.89	76.61	17.71
0.155	23.39	75.56	57.41	38.76	0.46	5.77	77.12	17.83
0.156	23.43	76.05	57.45	38.76	0.45	5.65	77.63	17.95
0.157	23.47	76.55	57.48	38.77	0.44	5.53	78.14	18.07
0.158	23.51	77.05	57.52	38.77	0.44	5.42	78.65	18.18
0.159	23.55	77.55	57.56	38.77	0.43	5.30	79.16	18.30
0.160	23.59	78.05	57.60	38.77	0.42	5.18	79.67	18.42
0.161	23.63	78.55	57.64	38.77	0.41	5.06	80.18	18.54
0.162	23.68	79.04	57.69	38.77	0.40	4.95	80.69	18.65
0.163	23.73	79.54	57.73	38.77	0.39	4.83	81.20	18.77
0.164	23.78	80.04	57.78	38.77	0.38	4.71	81.70	18.89
0.165	23.83	80.54	57.83	38.77	0.37	4.59	82.21	19.01
0.166	23.89	81.04	57.88	38.77	0.36	4.48	82.72	19.12
0.167	23.94	81.54	57.94	38.77	0.35	4.36	83.23	19.24
0.168	24.01	82.03	58.00	38.77	0.35	4.24	83.74	19.36
0.169	24.07	82.53	58.06	38.77	0.34	4.12	84.25	19.48
0.170	24.14	83.03	58.12	38.77	0.33	4.00	84.76	19.60
0.171	24.21	83.53	58.19	38.77	0.32	3.89	85.27	19.71
0.172	24.28	84.03	58.26	38.77	0.31	3.77	85.78	19.83
0.173	24.36	84.53	58.33	38.77	0.30	3.65	86.29	19.95
0.174	24.45	85.02	58.41	38.77	0.29	3.53	86.80	20.07
0.175	24.53	85.52	58.49	38.77	0.28	3.42	87.30	20.18
0.176	24.63	86.02	58.58	38.77	0.27	3.30	87.81	20.30
0.177	24.73	86.52	58.67	38.77	0.26	3.18	88.32	20.42
0.178	24.84	87.02	58.77	38.78	0.26	3.06	88.83	20.54
0.179	24.95	87.51	58.88	38.78	0.25	2.95	89.34	20.65
0.180	25.08	88.01	58.99	38.78	0.24	2.83	89.85	20.77
0.181	25.21	88.51	59.11	38.78	0.23	2.71	90.36	20.89
0.182	25.36	89.01	59.24	38.78	0.22	2.59	90.87	21.01
0.183	25.52	89.51	59.38	38.78	0.21	2.48	91.38	21.12
0.184	25.69	90.00	59.54	38.78	0.20	2.36	91.89	21.24
0.185	25.88	90.50	59.71	38.78	0.19	2.24	92.40	21.36
0.186	26.08	91.00	59.89	38.78	0.18	2.12	92.90	21.48
0.187	26.31	91.50	60.09	38.79	0.17	2.01	93.41	21.59
0.188	26.57	91.99	60.31	38.79	0.16	1.89	93.92	21.71
0.189	26.85	92.49	60.55	38.79	0.15	1.77	94.43	21.83
0.190	27.17	92.99	60.83	38.79	0.15	1.66	94.94	21.94
0.191	27.54	93.48	61.14	38.80	0.14	1.54	95.45	22.06
0.192	27.96	93.98	61.49	38.80	0.13	1.42	95.96	22.18
0.193	28.45	94.47	61.89	38.80	0.12	1.30	96.47	22.30
0.194	29.04	94.97	62.36	38.81	0.11	1.19	96.98	22.41
0.195	29.04	95.46	62.36	38.81	0.11	1.19	97.49	22.53

Table A-2
(4 of 4)

Example of TARGET Terminal Input Session

DMSLI0740I EXECUTION BEGINS...

Enter the appropriate number to select a fluid
0.....Hydrogen
1.....Oxygen
2.....Nitrogen
0

Enter the final receiver tank pressure in psia
30.0

Enter the final receiver tank filling in %
95.0

Enter the receiver tank mass in Lbm.

150.0

Enter the receiver tank volume in cu. ft.
50.0

AFB002I STOP Normal ending - TI > 540

Table A-3

Example of TARGET Output

****
******** LIQUID HYDROGEN TEST FLUID ********
****

The final tank condition is P = 30.0 psia

with a percent filling of 95.00 %

The receiver tank mass is 150.00 Lbm.

The receiver tank volume is 50.00 cu. ft.

The receiver tank m/V = 3.000 Lbm./cu. ft.

The total mass injected is 200.37 Lbm.

The final fluid temperature is 41.30 Deg. R
****

Table A-4
(1 of 2)

T-INIT. (R)	ENTHALPY INJ. (Btu/Lbm)	DELP (psid)
51.00	-98.163	1.51
61.00	-98.227	1.60
71.00	-98.333	1.75
81.00	-98.491	1.98
91.00	-98.712	2.29
101.00	-99.004	2.70
111.00	-99.372	3.22
121.00	-99.816	3.83
131.00	-100.329	4.53
141.00	-100.909	5.31
151.00	-101.553	6.17
161.00	-102.258	7.09
171.00	-103.020	8.07
181.00	-103.838	9.10
191.00	-104.708	10.16
201.00	-105.627	11.25
211.00	-106.593	12.37
221.00	-107.602	13.49
231.00	-108.651	14.62
241.00	-109.739	15.75
251.00	-110.862	16.85
261.00	-112.018	17.94
271.00	-113.205	19.00
281.00	-114.419	20.02
291.00	-115.659	21.00
301.00	-116.923	21.93
311.00	-118.208	22.82
321.00	-119.512	23.65
331.00	-120.834	24.43
341.00	-122.172	25.15
351.00	-123.524	25.82
361.00	-124.889	26.42
371.00	-126.265	26.98
381.00	-127.651	27.48
391.00	-129.047	27.92
401.00	-130.452	2.70
411.00	-131.864	2.70
421.00	-133.283	2.70
431.00	-134.710	2.70
441.00	-136.144	2.70
451.00	-137.585	2.70
461.00	-139.033	2.70
471.00	-140.490	2.70
481.00	-141.956	2.70
491.00	-143.431	2.70
501.00	-144.918	2.70
511.00	-146.417	2.70
521.00	-147.931	2.70
531.00	-149.462	2.70

Table A-4
(2 of 2)

Example of CRYOCHIL Terminal Input Session

```
DMSLI0740I EXECUTION BEGINS...

Enter the appropriate number to select a fluid
    0.....Hydrogen
    1.....Oxygen
    2.....Nitrogen
0

 Enter the max. receiver tank pressure in psia
30.0

 Enter the supply tank saturation pressure in psia
14.696

 Enter the vent stage pressure pressure drop in psia
10.0

 Enter the receiver tank mass in Lbm.
150.0

Enter the receiver tank volume in Ft**3
50.0

 Enter the initial tank temperature in deg. R
540.0

 Enter the TARGET temperature in deg. R
235.0

 Enter the TARGET temperature error band
0.5
 ***** NORMAL ENDING IN CALC; NG =  2*********

AFB002I STOP      Normal ending in CRYOCHIL
```

Table A-5

Example of CRYOCHIL Output

```
*********************************************
     ***** LIQUID HYDROGEN TEST FLUID *****
**********************************************

       ***** ECHO TERMINAL INPUT*****

 Enter the max. receiver tank pressure in psia
   30.00000

 Enter the supply tank saturation pressure in psia
   14.69600

 Enter the vent stage pressure pressure drop in psia
   10.00000

 Enter the receiver tank mass in Lbm.
  150.00000

Enter the receiver tank volume in Ft**3
   50.00000

The tank mass-to-volume ratio is  3.00 Lbm/Ft**3
```

Table A-6
(1 of 4)

1***
Initial temperature for cycle 1 is 540.000 R

Tank temperature before venting is 516.615 R

Mass injected in cycle 1 is 0.57329 Lbm.

Tank vented 4 times

Tank temperature after venting is 511.123 R
****
Initial temperature for cycle 2 is 511.123 R

Tank temperature before venting is 487.100 R

Mass injected in cycle 2 is 0.60757 Lbm.

Tank vented 4 times

Tank temperature after venting is 481.482 R
****
Initial temperature for cycle 3 is 481.482 R

Tank temperature before venting is 457.034 R

Mass injected in cycle 3 is 0.64766 Lbm.

Tank vented 4 times

Tank temperature after venting is 451.328 R
****
Initial temperature for cycle 4 is 451.328 R

Tank temperature before venting is 426.615 R

Mass injected in cycle 3 is 0.69396 Lbm.

Tank vented 4 times

Tank temperature after venting is 420.838 R
****

Table A-6
(2 of 4)

1***

Initial temperature for cycle 5 is 420.838 R

Tank temperature before venting is 395.940 R

Mass injected in cycle 5 is 0.74780 Lbm.

Tank vented 4 times

Tank temperature after venting is 390.088 R

****

Initial temperature for cycle 6 is 390.088 R

Tank temperature before venting is 365.002 R

Mass injected in cycle 6 is 0.81123 Lbm.

Tank vented 4 times

Tank temperature after venting is 359.047 R

****

Initial temperature for cycle 7 is 359.047 R

Tank temperature before venting is 333.677 R

Mass injected in cycle 7 is 0.88737 Lbm.

Tank vented 4 times

Tank temperature after venting is 327.566 R

****

Initial temperature for cycle 8 is 327.566 R

Tank temperature before venting is 301.715 R

Mass injected in cycle 8 is 0.98125 Lbm.

Tank vented 4 times

Tank temperature after venting is 295.359 R

****

Table A-6
(3 of 4)

```
Initial temperature for cycle  9 is 295.359 R

Tank temperature before venting is 268.650 R

Mass injected in cycle  9 is   1.10154 Lbm.

Tank vented   4 times

Tank temperature after venting is 261.905 R
*********************************************

1********************************************
Initial temperature for cycle  10 is 261.905 R
*********************************************
TFNEW < TARGET -- BEGIN NEW CYCLE


1********************************************

Initial temperature for cycle  10 is 261.905 R

Tank temperature before venting is 240.059 R

Mass injected in cycle  10 is   0.95703 Lbm.

Tank vented   3 times

Final tank temperature is 235.0000 +/- 0.500 R
*********************************************
*********************************************
Total mass after 10 cycle(s) is   8.00870 Lbm.
```

Table A-6
(4 of 4)

APPENDIX B

Input Screens for Sample Problems

The following are samples of the screens that the user would see after logging on to the VM computer and beginning execution of CRYOTRAN. The user responses for these sample runs are marked with a "*" to the right of the input line. In most cases the VM system responses are in Capital letters and user responses are in lower case.

Sample 1, Sinda model of a sphere, all 5 regions defined

```
Ready; T=0.01/0.01 13:07:13
link cryolib 200 222 rr                  *
Ready; T=0.01/0.01 13:07:27
access 222 m                             *
M (222) R/O
Ready; T=0.01/0.01 13:07:35
runcryo                                  *
C (301) R/O
D (302) R/O
No filetype specified
CONNECT= 00:30:42 VIRTCPU= 000:00.71 TOTCPU= 000:01.56
CONNECT= 00:00:01 VIRTCPU= 000:00.00 TOTCPU= 000:00.01

Assigning temporary storage destination to disk  E

DASD is being cleared
DASD 303 DEFINED 0010 CYL
DASD 304 LINKED R/O; R/W BY VVUSO; R/O BY    5 USERS
DMSACP723I F (304) R/O
DMSLIO201W The following names are undefined:
 CYLNDR   SFEERE   MATMNU   CYLNDS   SPHNDS   ULLGET   ULL1G    AREACYL
 CYLCDS   SPHCDS   PRPTBL   DUNPLT   PLTCYL   PLTSPH   CHILL    NVFILL
 TARGET
DMSLIO201W The following names are undefined:
 CYLNDR   MATMNU   CYLNDS   ULL1G    AREACYL  CYLCDS   PRPTBL   DUNPLT
 PLTCYL   PLTSPH   CHILL    NVFILL   TARGET
DMSLIO201W The following names are undefined:
 DUNPLT   PLTCYL   PLTSPH   CHILL    NVFILL   TARGET
DMSLIO201W The following names are undefined:
 DUNPLT   PLTCYL   PLTSPH
DMSLIO740I Execution begins...


  WELCOME TO CRYOTRAN
  YOU WILL BE PROMPTED FOR ALL NECESSARY INPUT.
  READ THE INSTRUCTIONS CAREFULLY.
  TYPE IN THE INPUT DATA CAREFULLY TO AVOID TROUBLE,
  YOU MAY QUIT THE PROGRAM AT ANY INPUT PROMPT BY TYPING A  "Q"  (QUIT)


 ENTER THE NUMBER FOR THE DESIRED PROBLEM TYPE
  THE PROBLEM TYPES ARE AS FOLLOWS:

 1 -  THERMO/THERMAL SINDA ANALYSIS ON A SPHERE.
 2 -  THERMO/THERMAL SINDA ANALYSIS ON A CYLINDER.
 3 -  RUN A PRESTORED ANALYSIS PROGRAM
1                                        *


    CHOOSE THE ANALYSIS PROGRAM YOU WISH TO USE.
```

```
    TYPE IN THE NUMBER OF THE DESIRED ANALYSIS.
    1     2D WEDGE WITH INSIDE OF TANK NODALIZED
    2     2D WEDGE SHELL - NO NODES INSIDE OF TANK
    3     2D WEDGE SHELL - THICK WALL FILL ANALYSIS
1                                                        *


  NOW A TITLE FOR THIS PROBLEM.

  THE TITLE LINE MAY BE UP TO 80 CHARACTERS LONG.
  TYPE IN THE TITLE.
sample model sphere1                                     *


   THIS TASK IS BEING SET UP FOR THE CRAY,
   NOW INPUT NECESSARY CRAY INFO.


  WHICH CRAY SYSTEM  COS  OR  UNICOS
    TYPE IN   C   OR   U
u                                                        *

   TYPE IN YOUR  CRAY  USERID.
userid                                                   *


   TYPE IN YOUR  CRAY  PASSWORD.
password                                                 *

   TYPE IN NO. OF CRAY CPU SECONDS TO BE USED.
  IF NUMBER OF SECONDS REQUESTED IS < 10,   60 WILL BE USED.
59                                                       *

   TYPE AMOUNT OF CRAY MEMORYTO BE REQUESTED,
   IF AMOUNT REQUESTED IS < 1,500,000,   1,500,000 WILL BE  USED.
1                                                        *

   NOW GIVE YOUR JOB A NAME, TYPE IN THE NAME,
    1 - 7 ALPHEBETIC CHARACTERS.
sphere1                                                  *


  THE CRAY JCL THAT WAS INPUT IS AS FOLLOWS:
  USERID            = vvglenn
  PASSWORD          = password
  CPU TIME REQUEST =        59 SECS.
  MEMORY REQUEST   =   1500000  words
  JOB  NAME         = sphere1

  ARE THESE ALL CORRECT?  TYPE   Y   OR   N   OR   Q    TO QUIT
y                                                        *


     NOW INPUT SPECIFIC DATA FOR THIS SPHERE.
      INPUT DATA TO DEFINE THE SPHERE MAY BE ANY ONE OF:
```

```
   1     RIN (IN.)          AND   ROUT (IN.)
   2     TNK VOL.(CU.FT.)   AND   WALL THICKNESS (IN.)
   3     TNK VOL.(CU.FT.)   AND   ROUT (IN.)
   4     RIN (IN.)          AND   WALL THICKNESS (IN.)
   5     ROUT (IN.)         AND   WALL THICKNESS (IN.)

   ENTER A NUMBER  1  -  5
4                                             *

   ENTER INSIDE TANK RADIUS,  RIN(IN.).
20                                            *

   ENTER WALL THICKNESS  (IN.).
.5                                            *



   THE GEOMETRY FOR THIS ANALYSIS IS A SPHERE WITH
    VOL=  19.393 FT**3,   RIN= 20.000 IN.,    AND      WALL THICKNESS= 0.5000 IN.



  TYPE IN NUMBER OF NODES ALONG CIRCUMFERENCE OF THE SPHERE.
  SOUTH POLE TO NORTH POLE.
  IF VALUE INPUT IS < 10,  20 WILL BE USED AS A DEFAULT.
25                                            *



  THIS IS A 2D ANALYSIS, THE WEDGE ANGLE = 1 RAD.



  INPUTTING DATA FOR REGION  1,    TANKWALL

  TYPE IN THE NO. OF LAYERS OF NODES THRU REGION 1
3                                             *

   TEMPERATURES MAY BE IN DEGF OR DEGR IF NO RADIATION IS PRESENT.
   THE TEMPERATURES WILL BE INPUT IN WHAT UNITS  F  OR  R?
   TYPE IN   F  OR  R
r                                             *

  TYPE IN THE INITIAL TEMPERATURE FOR THIS REGION  (DEG R)
550                                           *


ENTER MATERIAL NUMBER FOR REGION
101      LIQUID HYDROGEN
102      LIQUID METHANE
103      LIQUID NITROGEN
104      LIQUID OXYGEN
201      STAINLESS 304A
202      STAINLESS 347
203      ALUMINUM 6061
204      ALUMINUM 2219
205      ALUMINUM 7075
206      ALUMINUM OXIDE
207      INCONEL X-750
```

```
208      NICKEL
301      GAS HYDROGEN
302      GAS METHANE
303      GAS NITROGEN
304      GAS OXYGEN
999      USER DEFINED
204                                          *


 IS THERE TO BE A REGION ON THE OUTSIDE OF THE TANKWALL?
  EG. INSULATION.
   TYPE IN Y OR N
                                             *
Y


  INPUTTING DATA FOR REGION  2,    OUTSIDE LAYER 1


  NOW NEED TO SPECIFY THICKNESS OF REGION 2
  AND THE NUMBER OF LAYERS THRU THE REGION.
  TO DEFINE THE REGION THICKNESS THE INPUT MAY BE:
     1.  THE REGION THICKNESS (IN.)
OR   2.  THE THICKNESS OF EACH LAYER IN THE REGION
     TYPE IN    1    OR    2
                                             *
1

  TYPE IN THICKNESS (WIDTH) OF REGION  2 (IN.)
                                             *
.25

  TYPE IN THE NO. OF LAYERS OF NODES THRU REGION 2
                                             *
1

  TYPE IN THE INITIAL TEMPERATURE FOR THIS REGION  (DEG R)
                                             *
550


ENTER MATERIAL NUMBER FOR REGION
101      LIQUID HYDROGEN
102      LIQUID METHANE
103      LIQUID NITROGEN
104      LIQUID OXYGEN
201      STAINLESS 304A
202      STAINLESS 347
203      ALUMINUM 6061
204      ALUMINUM 2219
205      ALUMINUM 7075
206      ALUMINUM OXIDE
207      INCONEL X-750
208      NICKEL
301      GAS HYDROGEN
302      GAS METHANE
303      GAS NITROGEN
304      GAS OXYGEN
999      USER DEFINED
204                                          *
```

```
 IS THERE TO BE A 2ND REGION OUTSIDE OF THE TANKWALL?
  EG. MORE OR DIFFERENT INSULATION.
   TYPE IN Y OR N
y                                                         *


  INPUTTING DATA FOR REGION  3,    OUTSIDE LAYER 2


  NOW NEED TO SPECIFY THICKNESS OF REGION 3
  AND THE NUMBER OF LAYERS THRU THE REGION.
  TO DEFINE THE REGION THICKNESS THE INPUT MAY BE:
     1.  THE REGION THICKNESS (IN.)
OR   2.  THE THICKNESS OF EACH LAYER IN THE REGION
     TYPE IN    1   OR   2
2                                                         *

  TYPE IN THICKNESS (WIDTH) OF EACH LAYER OF REGION  3 (IN.)
.1                                                        *

  TYPE IN THE NO. OF LAYERS OF NODES THRU REGION 3
2                                                         *

  TYPE IN THE INITIAL TEMPERATURE FOR THIS REGION  (DEG R)
540                                                       *


ENTER MATERIAL NUMBER FOR REGION
101      LIQUID HYDROGEN
102      LIQUID METHANE
103      LIQUID NITROGEN
104      LIQUID OXYGEN
201      STAINLESS 304A
202      STAINLESS 347
203      ALUMINUM 6061
204      ALUMINUM 2219
205      ALUMINUM 7075
206      ALUMINUM OXIDE
207      INCONEL X-750
208      NICKEL
301      GAS HYDROGEN
302      GAS METHANE
303      GAS NITROGEN
304      GAS OXYGEN
999      USER DEFINED
202                                                       *


 FOR THIS ANALYSIS THE INSIDE OF THE TANK WILL BE NODALIZED
 HOW MANY REGIONS INSIDE OF THE TANK ?   1  OR  2
2                                                         *


 INPUTTING DATA FOR REGION  4,    INSIDE TANK AT WALL

 REGION 4 IS PART OF THE DISTANCE INSIDE THE SPHERE  ALONG THE RADIUS,
 FROM THE INSIDE TANK WALL TOWARD THE CENTER OF THE SPHERE
```

```
WHERE RIN, (THE INSIDE SPHERE   RADIUS) =  20.000


NOW NEED TO SPECIFY THICKNESS OF REGION 4
AND THE NUMBER OF LAYERS THRU THE REGION.
TO DEFINE THE REGION THICKNESS THE INPUT MAY BE:
   1.  THE REGION THICKNESS (IN.)
OR 2.  THE THICKNESS OF EACH LAYER IN THE REGION
   TYPE IN    1   OR   2
1                                          *

 TYPE IN THICKNESS (WIDTH) OF REGION  4 (IN.)
5                                          *

 TYPE IN THE NO. OF LAYERS OF NODES THRU REGION 4
4                                          *

 TYPE IN THE INITIAL TEMPERATURE FOR THIS REGION  (DEG R)
40                                         *


ENTER MATERIAL NUMBER FOR REGION
101     LIQUID HYDROGEN
102     LIQUID METHANE
103     LIQUID NITROGEN
104     LIQUID OXYGEN
201     STAINLESS 304A
202     STAINLESS 347
203     ALUMINUM 6061
204     ALUMINUM 2219
205     ALUMINUM 7075
206     ALUMINUM OXIDE
207     INCONEL X-750
208     NICKEL
301     GAS HYDROGEN
302     GAS METHANE
303     GAS NITROGEN
304     GAS OXYGEN
999     USER DEFINED
101                                        *


 INPUTTING DATA FOR REGION  5,    INSIDE TANK AT CENTER

 TYPE IN THE NO. OF LAYERS OF NODES THRU REGION 5
15                                         *

 TYPE IN THE INITIAL TEMPERATURE FOR THIS REGION  (DEG R)
40                                         *


ENTER MATERIAL NUMBER FOR REGION
101     LIQUID HYDROGEN
102     LIQUID METHANE
103     LIQUID NITROGEN
104     LIQUID OXYGEN
201     STAINLESS 304A
202     STAINLESS 347
203     ALUMINUM 6061
```

```
 204      ALUMINUM 2219
 205      ALUMINUM 7075
 206      ALUMINUM OXIDE
 207      INCONEL X-750
 208      NICKEL
 301      GAS HYDROGEN
 302      GAS METHANE
 303      GAS NITROGEN
 304      GAS OXYGEN
 999      USER DEFINED
 101                                            *


    THE HEAT TRANSFER MECHANISM INSIDE THE TANK,
       I.E. REGIONS 4 AND 5,  IS TO BE:
    1.   CONDUCTION ONLY
    2.   CONVECTION ONLY
    3.   CONDUCTION AND CONVECTION
      TYPE IN   1    2     OR   3
1                                               *



  TYPE IN % TANK IS FULL OF LIQUID.
75                                              *

   IS THIS ANALYSIS A LOW-G  OR  1-G ANALYSIS?
   TYPE IN   0   OR   1
1                                               *



   ARE THERE TO BE ANY HEAT EXCHANGERS?
    TYPE IN Y OR N
y                                               *



   HEAT EXCHANGER INFO, MAX NO. =10
  INPUT FOR HEAT EXCHANGER NO. 1
    TYPE IN THE REGION NUMBER WHERE THE HEAT EXCHANGER GOES.
4                                               *
    THE HEAT EXCHANGER IS ON TOP OF WHICH LAYER OF REGION  4?
    TYPE IN THE LAYER NO., COUNT LAYERS FROM OUTSIDE
    TOWARD THE CENTER.
1                                               *
    TYPE IN THE THETA ANGLE WHERE THE HEAT EXCHANGER STARTS
   COUNT UP FROM THE SOUTH POLE.
2                                               *
    TYPE IN THE NUMBER OF THETAS THAT THE HEAT EXCHANGER COVERS.
4                                               *
    TYPE IN THE HEAT EXCHANGER TEMPERATURE (DEG R)
36                                              *



    HEAT EXCHANGER NO.  1 SPECIFIED
    ON TOP OF LAYER  1 OF REGION 4    STARTING AT THETA ANGLE  2 FOR   4 NODES,  WITH TEMPERATURE
 =  36.00
    IS THIS CORRECT?
    TYPE IN Y OR N
```

```
y                                                  *
   MORE HEAT EXCHANGERS?   TYPE      Y   OR   N
y                                                  *


  HEAT EXCHANGER INFO, MAX NO. =10
 INPUT FOR HEAT EXCHANGER NO. 2
   TYPE IN THE REGION NUMBER WHERE THE HEAT EXCHANGER GOES.
4                                                  *
   THE HEAT EXCHANGER IS ON TOP OF WHICH LAYER OF REGION  4?
   TYPE IN THE LAYER NO., COUNT LAYERS FROM OUTSIDE
   TOWARD THE CENTER.
3                                                  *
   TYPE IN THE THETA ANGLE WHERE THE HEAT EXCHANGER STARTS
  COUNT UP FROM THE SOUTH POLE.
17                                                 *
   TYPE IN THE NUMBER OF THETAS THAT THE HEAT EXCHANGER COVERS.
3                                                  *
   TYPE IN THE HEAT EXCHANGER TEMPERATURE (DEG R)
36                                                 *


   HEAT EXCHANGER NO.  2 SPECIFIED
   ON TOP OF LAYER  3 OF REGION 4    STARTING AT THETA ANGLE 17 FOR   3 NODES,  WITH TEMPERATURE
=  36.00
   IS THIS CORRECT?
   TYPE IN Y OR N
y                                                  *
   MORE HEAT EXCHANGERS?   TYPE      Y   OR   N
y                                                  *


  HEAT EXCHANGER INFO, MAX NO. =10
 INPUT FOR HEAT EXCHANGER NO. 3
   TYPE IN THE REGION NUMBER WHERE THE HEAT EXCHANGER GOES.
3                                                  *
   THE HEAT EXCHANGER IS ON TOP OF WHICH LAYER OF REGION  3?
   TYPE IN THE LAYER NO., COUNT LAYERS FROM OUTSIDE
TOWARD THE CENTER.
1                                                  *
   TYPE IN THE THETA ANGLE WHERE THE HEAT EXCHANGER STARTS
  COUNT UP FROM THE SOUTH POLE.
10                                                 *
   TYPE IN THE NUMBER OF THETAS THAT THE HEAT EXCHANGER COVERS.
3                                                  *
   TYPE IN THE HEAT EXCHANGER TEMPERATURE (DEG R)
60                                                 *


   HEAT EXCHANGER NO.  3 SPECIFIED
   ON TOP OF LAYER  1 OF REGION 3    STARTING AT THETA ANGLE 10 FOR   3 NODES,  WITH TEMPERATURE
=  60.00
   IS THIS CORRECT?
   TYPE IN Y OR N
y                                                  *
   MORE HEAT EXCHANGERS?   TYPE      Y   OR   N
n                                                  *
```

```
 THERE MAY BE UP TO TWO BOUNDARY NODES ON THE  OUTSIDE OF THE TANKWALL.
  EG. OUTSIDE ATMOSPHERE.
  DO YOU WANT ONE OR MORE OF THESE BOUNDARY NODES?
   TYPE IN Y OR N
y                                              *
  TYPE IN THE OUTSIDE ATMOSPHERE TEMPERATURE (DEG R)
600                                            *
 THE HEAT TRANSFER TO THIS OUTSIDE TEMPERATURE IS TO BE
          CONVECTION OR RADIATION?
  TYPE IN    C         OR   R
c                                              *

  TYPE IN THE CONVECTION COEFFICIENT, (BTU/HR-FT2-DEG)
200                                            *


  DO YOU WANT A 2ND OUTSIDE BOUNDARY NODE?
   TYPE IN Y OR N
y                       .                      *
  TYPE IN THE OUTSIDE ATMOSPHERE TEMPERATURE (DEG R)
900                                            *
 THE HEAT TRANSFER TO THIS OUTSIDE TEMPERATURE IS TO BE
          CONVECTION OR RADIATION?
  TYPE IN    C         OR   R
r                                              *

  TYPE IN  THE RADIATION FACTOR  (EPS*F)
.2                                             *


  ONE OR MORE OF THE OUTSIDE BOUNDARY CONDUCTORS  IS A RADIATION CONDUCTOR,
  ALL TEMPERATURES  HAVE BEEN CONVERTED TO DEG F.


  IS THERE TO BE A CONSTANT Q INPUT, (SOURCE TERM)
  INTO THE OUTSIDE SURFACE OF THE MODEL?
   TYPE  Y  OR  N
y                                              *
   THE VALUE OF Q MAY BE SPECIFIED IN 3 WAYS:
 1  CONSTANT Q PER UNIT AREA,  (BTU/(HR-FT2)
 2  CONSTANT Q PER UNIT AREA,  (BTU/(HR-IN2)
 3  Q BASED ON BTU/HR OVER THE ENTIRE SPHERE SURFACE
  TYPE 1,  2,  OR  3
3                                              *
  TYPE IN THE VALUE OF Q IN BTU/HR ON SPHERE
12.5                                           *
  NOW INPUT THE SPECIFIC DATA FOR SINDA
  THIS SINDA ANALYSIS MAY BE:
  1   A STEADY STATE ANALYSIS
  2   A TRANSIENT ANALYSIS
  3   STEADY STATE FOLLOWED BY A TRANSIENT
  4   A TRANSIENT FOLLOWED BY STEADY STATE
    TYPE IN  1,  2,  3,  OR 4
2                                              *
  A TRANSIENT ANALYSIS IS TO BE DONE,
  THE EXECUTION SUBROUTINE WILL BE EITHER  FWDBCK  OR CNFRDL
  THIS WILL BE DETERMINED BY THE VALUE OF THE TIME STEP, (DELTIME),
  WHICH WILL BE INPUT BELOW.
```

```
  THE NEXT 4 INPUT VALUES INVOLVE PROBLEM TIME,
  THESE 4 VALUES MAY BE INPUT IN UNITS OF
                SECONDS,    MINUTES,   OR   HOURS
  NOW TYPE IN     S            M        OR        H
                                                    *
m


  NOW TYPE IN THE PROBLEM START TIME (MIN)
                                                    *
0

  NOW TYPE IN THE PROBLEM END TIME (MIN)
                                                    *
120

  TYPE IN THE TIME STEP,(DELTIME),(MIN) TO BE USED.
  IF DELTIME IS UNKNOWN, OR IF YOU TYPE ZERO ( 0 ),
  THE SINDA FORWARD DIFFERENCE METHOD, (CNFRDL),
  WILL BE USED AND DELTIME WILL BE COMPUTED BY THE PROGRAM
                                                    *
.001

  TYPE IN THE OUTPUT INTERVAL  DTOUT  (MIN)   TEMPERATURES WILL BE PRINTED EVERY DT MIN.
  IF INPUT VALUE .LE. 0, >>>  .25 HRS. WILL BE USED
                                                    *
.25


  TYPE IN THE CONVERGENCE CRITERIA, DELTA TEMPERATURE
   SUGGESTED VALUE RANGE  .01  TO .001
   IF INPUT VALUE .LE. 0 >>>  .005 WILL BE USED.
                                                    *
.001


  TYPE IN NLOOP, THE NUMBER OF ITERATION LOOPS  ALLOWED
  SUGGESTED RANGE OF VALUES  100  TO 1000
  IF INPUT VALUE  IS .LE. 0 >>>  100 WILL BE USED.
  NOTE: SOME STEADY STATE CASES MAY NEED NLOOP > 1000
                                                    *
500

THE FOLLOWING IS THE RANGE OF PRESSURES IN THE
MATERIAL DBASE FOR HYDROGEN          IN REGION #4:



STARTING PRESSURE =        5.00

ENDING PRESSURE   =       81.00

INCREMENT         =        2.00



ENTER THE DESIRED PRESSURE FOR THAT REGION
                                                    *
49


  IN THE PLOTTING ROUTINE, NTYP=1; 2D SPHERE WEDGE
  DO YOU WANT A PLOT OF THIS GEOMETRY?
   TYPE  Y  OR  N
                                                    *
y
```

```
   IN THE SPHERE PLOTTING ROUTINE
   SEND THE GRAPH TO
   1.  THE QMS PRINTER
   2.  THE TERMINAL SCREEN
   3.  SOME OTHER DEVICE
   TYPE IN  1      2   OR   3
 1                                         *

 PLOT-- RADMAX,RSTEP=  23.9499969       5.32222080
    END OF CRYOTRAN PREPROCESSOR PROGRAM,
     ON TO ANALYSIS PROGRAM
    THE OUTPUT FILE IS CALLED "CRYOTRAN MODEL".
    THIS "CRYOTRAN MODEL" FILE IS A SINDA        MODEL.

    USER MAY NOW SUBMIT THE FILE   "CRYOTRAN MODEL"
     TO THE CRAY COMPUTER FOR EXECUTION,
     OR MAKE ANY DESIRED MODIFICATIONS WITH AN EDITOR
     PRIOR TO SUBMITTING IT TO THE CRAY.

    TO SUBMIT THE FILE TO CRAY,
     ON THE VM SYSTEM TYPE:       CRSUBMIT CRYOTRAN MODEL

   DO YOU WANT TO GO TO BEGINNING OF CRYOTRAN OR  QUIT?
      TYPE  Y  TO GO BACK TO BEGINNING OF CRYOTRAN,
   OR TYPE  N  TO QUIT CRYOTRAN.
 n                                         *

     ON TO ANALYSIS PROGRAM
    THE OUTPUT FILE IS CALLED "CRYOTRAN MODEL".
    THIS "CRYOTRAN MODEL" FILE IS A SINDA        MODEL.

    USER MAY NOW SUBMIT THE FILE   "CRYOTRAN MODEL"
     TO THE CRAY COMPUTER FOR EXECUTION,
     OR MAKE ANY DESIRED MODIFICATIONS WITH AN EDITOR
     PRIOR TO SUBMITTING IT TO THE CRAY.

    TO SUBMIT THE FILE TO CRAY,
     ON THE VM SYSTEM TYPE:       CRSUBMIT CRYOTRAN MODEL

   IF USER HAS REQUESTED A GEOMETRY PLOT OF THE SINDA MODEL
   THE PLOT DATA IS IN FILE NAMED  "QMS PLOTDATA"

   USER MAY PLOT THESE RESULTS BY TYPING:    PLOTQA
END OF DISSPLA 11.0 -- 27876 VECTORS IN 1 PLOTS.
RUN ON 12/8/89 USING SERIAL NUMBER 2312 AT NASA LEWIS RESEARCH
CENTER
PROPRIETARY SOFTWARE PRODUCT OF COMPUTER ASSOCIATES, INC.
2729 VIRTUAL STORAGE REFERENCES; 17 READS; 4 WRITES.
AFB240I VABEX : ABEND OCCURRED IN FORTRAN PROCESSING OF ORIGINAL ABEND.
DMSFRE161T Invalid DMSFRET call from F3570C, error number 6
CMS
FILEL
DMSABN150W 255 (HEX 0000FF) doublewords of system storage were not recovered
Ready; T=*.**/*.** 07:28:23
```

```
plotqa                                                      *
Which QMS printer would you like to have your output sent to?
  1) ANALEX
  2) RAC
  3) ERB
  4) DEB
Enter the number of your choice:
1                                                           *
PRT FILE 8336  TO  RSCS     COPY 001   NOHOLD
Ready; T=0.13/0.56 07:28:34
```

This ends the CryoTran input prompts and the responses to a sample case 1.

Sample 2 and 3

Sinda model of sphere with subroutines called, followed by sphere with inside of tank not nodalized. As in the previous sample screens the lines containing user responses are marked with a *.

```
Ready; T=0.01/0.01 11:16:52
link cryolib 200 222 rr                                     *
DASD 222 LINKED R/O; R/W BY CRYOLIB
Ready; T=0.01/0.01 11:17:09
access 222 m                                                *
M (222) R/O
Ready; T=0.01/0.01 11:17:20
runcry                                                      *
No filetype specified
C (301) R/O
The following names are undefined:
 CYLNDR    SFEERE    MATMNU    CYLNDS    SPHNDS    ULLGET    ULL1G     AREACYL
 CYLCDS    SPHCDS    PRPTBL    DUNPLT    PLTCYL    PLTSPH    CHILL     NVFILL
 TARGET
The following names are undefined:
 CYLNDR    MATMNU    CYLNDS    ULL1G     AREACYL   CYLCDS    PRPTBL    DUNPLT
 PLTCYL    PLTSPH    CHILL     NVFILL    TARGET
The following names are undefined:
 DUNPLT    PLTCYL    PLTSPH    CHILL     NVFILL    TARGET
The following names are undefined:
 DUNPLT    PLTCYL    PLTSPH
The following names are undefined:
 ANGLE     AREA2D    BASALF    CURVE     DONEPL    ENDPL     HEIGHT    IBM52
 INTNO     MARKER    MESSAG    PAGE      PDEV      POLAR     QMS2      REALNO
 RESET     RLINT     RLMESS    RLVEC     THKCRV    TRIPLX    VECTOR    XPOSN
 YPOSN     GRAF      QMS
Execution begins...

  WELCOME TO CRYOTRAN
  YOU WILL BE PROMPTED FOR ALL NECESSARY INPUT.
  READ THE INSTRUCTIONS CAREFULLY.
  TYPE IN THE INPUT DATA CAREFULLY TO AVOID TROUBLE.
  YOU MAY QUIT THE PROGRAM AT ANY INPUT PROMPT BY TYPING A  "Q"  (QUIT)


 ENTER THE NUMBER FOR THE DESIRED PROBLEM TYPE
```

```
  THE PROBLEM TYPES ARE AS FOLLOWS:

 1 -  THERMO/THERMAL SINDA ANALYSIS ON A SPHERE.
 2 -  THERMO/THERMAL SINDA ANALYSIS ON A CYLINDER.
 3 -  RUN A PRESTORED ANALYSIS PROGRAM
1                                                   *



    CHOOSE THE ANALYSIS PROGRAM YOU WISH TO USE.
    TYPE IN THE NUMBER OF THE DESIRED ANALYSIS.
    1     2D WEDGE WITH INSIDE OF TANK NODALIZED
    2     2D WEDGE SHELL - NO NODES INSIDE OF TANK
    3     2D WEDGE SHELL - THICK WALL FILL ANALYSIS
3                                                   *



  NOW A TITLE FOR THIS PROBLEM.

  THE TITLE LINE MAY BE UP TO 80 CHARACTERS LONG.
  TYPE IN THE TITLE.
sample run of no nodes in tank, calling subroutines *



   THIS TASK IS BEING SET UP FOR THE CRAY,
   NOW INPUT NECESSARY CRAY INFO.


  WHICH CRAY SYSTEM  COS   OR   UNICOS
    TYPE IN    C    OR    U
u                                                   *

   TYPE IN YOUR  CRAY  USERID.
userid                                              *



   TYPE IN YOUR  CRAY  PASSWORD.
password                                            *

   TYPE IN NO. OF CRAY CPU SECONDS TO BE USED.
  IF NUMBER OF SECONDS REQUESTED IS < 10,    60 WILL BE USED.
59                                                  *

   TYPE AMOUNT OF CRAY MEMORYTO BE REQUESTED,
   IF AMOUNT REQUESTED IS < 1,500,000,    1,500,000 WILL BE  USED.
1                                                   *

   NOW GIVE YOUR JOB A NAME, TYPE IN THE NAME,
    1 - 7 ALPHEBETIC CHARACTERS.
sphere2                                             *



  THE CRAY JCL THAT WAS INPUT IS AS FOLLOWS:
  USERID           = userid
  PASSWORD         = password
```

```
CPU TIME REQUEST =          59 SECS.
MEMORY REQUEST   =    1500000  words
JOB  NAME        = sphere2

ARE THESE ALL CORRECT?  TYPE    Y   OR    N    OR    Q     TO QUIT
                                                *
y


  NOW INPUT SPECIFIC DATA FOR THIS SPHERE.
   INPUT DATA TO DEFINE THE SPHERE MAY BE ANY ONE OF:
 1     RIN (IN.)           AND    ROUT (IN.)
 2     TNK VOL.(CU.FT.)    AND    WALL THICKNESS (IN.)
 3     TNK VOL.(CU.FT.)    AND    ROUT (IN.)
 4     RIN (IN.)           AND    WALL THICKNESS (IN.)
 5     ROUT (IN.)          AND    WALL THICKNESS (IN.)

  ENTER A NUMBER  1  -  5
                                                *
4

  ENTER INSIDE TANK RADIUS,  RIN(IN.).
                                                *
24

  ENTER WALL THICKNESS   (IN.).
                                                *
2



  THE GEOMETRY FOR THIS ANALYSIS IS A SPHERE WITH
   VOL=  33.510 FT**3,   RIN= 24.000 IN.,    AND      WALL THICKNESS= 2.0000 IN.



  TYPE IN NUMBER OF NODES ALONG CIRCUMFERENCE OF THE SPHERE.
  SOUTH POLE TO NORTH POLE.
  IF VALUE INPUT IS < 10,  20 WILL BE USED AS A DEFAULT.
                                                *
25



  THIS IS A 2D ANALYSIS, THE WEDGE ANGLE = 1 RAD.



  INPUTTING DATA FOR REGION  1,     TANKWALL

  TYPE IN THE NO. OF LAYERS OF NODES THRU REGION 1
                                                *
4

   TEMPERATURES MAY BE IN DEGF OR DEGR IF NO RADIATION IS PRESENT.
   THE TEMPERATURES WILL BE INPUT IN WHAT UNITS  F  OR  R?
   TYPE IN    F  OR  R
                                                *
r

  TYPE IN THE INITIAL TEMPERATURE FOR THIS REGION  (DEG R)
                                                *
540


ENTER MATERIAL NUMBER FOR REGION
```

```
 101      LIQUID HYDROGEN
 102      LIQUID METHANE
 103      LIQUID NITROGEN
 104      LIQUID OXYGEN
 201      STAINLESS 304A
 202      STAINLESS 347
 203      ALUMINUM 6061
 204      ALUMINUM 2219
 205      ALUMINUM 7075
 206      ALUMINUM OXIDE
 207      INCONEL X-750
 208      NICKEL
 301      GAS HYDROGEN
 302      GAS METHANE
 303      GAS NITROGEN
 304      GAS OXYGEN
 999      USER DEFINED
 201                                              *


 IS THERE TO BE A REGION ON THE OUTSIDE OF THE TANKWALL?
  EG. INSULATION.
   TYPE IN Y OR N
n                                                 *


  ARE THERE TO BE ANY HEAT EXCHANGERS?
   TYPE IN Y OR N
n                                                 *


 THERE MAY BE UP TO TWO BOUNDARY NODES ON THE  OUTSIDE OF THE TANKWALL.
  EG. OUTSIDE ATMOSPHERE.
  DO YOU WANT ONE OR MORE OF THESE BOUNDARY NODES?
   TYPE IN Y OR N
n                                                 *


  IS THERE TO BE A CONSTANT Q INPUT, (SOURCE TERM)
  INTO THE OUTSIDE SURFACE OF THE MODEL?
   TYPE  Y  OR  N
n                                                 *
  NOW INPUT THE SPECIFIC DATA FOR SINDA
  THIS SINDA ANALYSIS MAY BE:
  1   A STEADY STATE ANALYSIS
  2   A TRANSIENT ANALYSIS
  3   STEADY STATE FOLLOWED BY A TRANSIENT
  4   A TRANSIENT FOLLOWED BY STEADY STATE
    TYPE IN  1,  2,  3,  OR 4
2                                                 *
 A TRANSIENT ANALYSIS IS TO BE DONE,
 THE EXECUTION SUBROUTINE WILL BE EITHER  FWDBCK  OR CNFRDL
 THIS WILL BE DETERMINED BY THE VALUE OF THE TIME STEP, (DELTIME),
 WHICH WILL BE INPUT BELOW.

 THE NEXT 4 INPUT VALUES INVOLVE PROBLEM TIME,
 THESE 4 VALUES MAY BE INPUT IN UNITS OF
             SECONDS,   MINUTES,  OR  HOURS
```

```
  NOW TYPE IN     S           M       OR       H
m                                                 *


  NOW TYPE IN THE PROBLEM START TIME (MIN)
0                                                 *

  NOW TYPE IN THE PROBLEM END TIME (MIN)
360                                               *

  TYPE IN THE TIME STEP,(DELTIME),(MIN) TO BE USED.
  IF DELTIME IS UNKNOWN, OR IF YOU TYPE ZERO ( 0 ),
  THE SINDA FORWARD DIFFERENCE METHOD, (CNFRDL),
  WILL BE USED AND DELTIME WILL BE COMPUTED BY THE PROGRAM
.0125                                             *

  TYPE IN THE OUTPUT INTERVAL  DTOUT  (MIN)   TEMPERATURES WILL BE PRINTED EVERY DT MIN.
  IF INPUT VALUE .LE. 0, >>>  .25 HRS. WILL BE USED
.25                                               *


  TYPE IN THE CONVERGENCE CRITERIA, DELTA TEMPERATURE
   SUGGESTED VALUE RANGE  .01  TO .001
   IF INPUT VALUE .LE. 0 >>>  .005 WILL BE USED.
.001                                              *


  TYPE IN NLOOP, THE NUMBER OF ITERATION LOOPS  ALLOWED
  SUGGESTED RANGE OF VALUES  100  TO 1000
  IF INPUT VALUE  IS .LE. 0 >>>  100 WILL BE USED.
  NOTE: SOME STEADY STATE CASES MAY NEED NLOOP > 1000
300                                               *
  SPECIAL INPUT FOR TANKFILL PROCEDURES
  TYPE IN FLUID FLOW RATE  (LB/HR)
.5                                                *
  TYPE IN FLUID TEMPERATURE  (DEG R)
  NOTE:  TEMPERATURE UNITS MUST BE DEG R.
40                                                *
  TYPE IN VAPOR TEMPERATURE  (DEG R)
60                                                *
  FILL THE TANK HOW FULL?  TYPE IN PERCENT TO FILL
95                                                *
  DO YOU NEED MATERIAL PROPERTIES FOR THE LIQUID?
   TYPE   Y   OR  N
y                                                 *


ENTER MATERIAL NUMBER FOR REGION
101      LIQUID HYDROGEN
102      LIQUID METHANE
103      LIQUID NITROGEN
104      LIQUID OXYGEN
201      STAINLESS 304A
202      STAINLESS 347
203      ALUMINUM 6061
204      ALUMINUM 2219
205      ALUMINUM 7075
206      ALUMINUM OXIDE
207      INCONEL X-750
208      NICKEL
301      GAS HYDROGEN
```

```
302     GAS METHANE
303     GAS NITROGEN
304     GAS OXYGEN
999     USER DEFINED
101                                            *

THE FOLLOWING IS THE RANGE OF PRESSURES IN THE
MATERIAL DBASE FOR HYDROGEN         IN REGION #6:


STARTING PRESSURE =        5.00

ENDING PRESSURE   =       81.00

INCREMENT         =        2.00


ENTER THE DESIRED PRESSURE FOR THAT REGION

49                                             *
JCL COMMAND - IRC=FILEDEF CRYSUBS DISK CRYOSUBS THWSE1 M               0
JCL COMMAND - IRC=FILEDEF CRYSUBS CLEAR          0


 IN THE PLOTTING ROUTINE, NTYP=1; 2D SPHERE WEDGE
 DO YOU WANT A PLOT OF THIS GEOMETRY?
  TYPE  Y  OR  N
n                                              *
   END OF CRYOTRAN PREPROCESSOR PROGRAM,
    ON TO ANALYSIS PROGRAM
   THE OUTPUT FILE IS CALLED "CRYOTRAN MODEL".
   THIS "CRYOTRAN MODEL" FILE IS A SINDA        MODEL.


   USER MAY NOW SUBMIT THE FILE   "CRYOTRAN MODEL"
    TO THE CRAY COMPUTER FOR EXECUTION,
    OR MAKE ANY DESIRED MODIFICATIONS WITH AN EDITOR
    PRIOR TO SUBMITTING IT TO THE CRAY.


   TO SUBMIT THE FILE TO CRAY,
    ON THE VM SYSTEM TYPE:       CRSUBMIT CRYOTRAN MODEL

  DO YOU WANT TO GO TO BEGINNING OF CRYOTRAN OR  QUIT?
     TYPE  Y  TO GO BACK TO BEGINNING OF CRYOTRAN,
  OR TYPE  N  TO QUIT CRYOTRAN.
y                                              *
 BEFORE CONTINUING YOU MAY WANT TO CHANGE THE NAME
 OF SOME OF THE OUTPUT FILES. IF YOU DO NOT CHANGE THE NAME
 OF THE MODEL FILE, THE NEW MODEL OUTPUT OF THE NEW RUN
 WILL OVERWRITE THE MODEL OUTPUT OF THE PREVIOUS RUN.

 DO YOU WANT TO CHANGE THE NAME OF ANY OF YOUR OUTPUT
 FILES FROM THIS RUN BEFORE CONTINUING?

    TYPE IN   Y   OR   N
y                                              *
  CHANGE THE NAME OF THE FILE   "CRYOTRAN INPUTEKO"?
```

```
   TYPE IN    Y    OR    N
                                                   *
n
  CHANGE THE NAME OF THE FILE    "CRYOTRAN MODEL"?

   TYPE IN    Y    OR    N
                                                   *
y

TYPE IN THE NEW    FILE NAME;  FILE TYPE;  FILE MODE
 YOU MUST TYPE IN ALL THREE PARTS OF NAME        FN FT FM
                                                   *
sphere2 thkw a
JCL COMMAND - IRC=RENAME CRYOTRAN MODEL A    SPHERE2 THKW A                 0


  WELCOME TO CRYOTRAN
  YOU WILL BE PROMPTED FOR ALL NECESSARY INPUT.
  READ THE INSTRUCTIONS CAREFULLY.
  TYPE IN THE INPUT DATA CAREFULLY TO AVOID TROUBLE,
  YOU MAY QUIT THE PROGRAM AT ANY INPUT PROMPT BY TYPING A  "Q"  (QUIT)


 ENTER THE NUMBER FOR THE DESIRED PROBLEM TYPE
  THE PROBLEM TYPES ARE AS FOLLOWS:

 1 -  THERMO/THERMAL SINDA ANALYSIS ON A SPHERE.
 2 -  THERMO/THERMAL SINDA ANALYSIS ON A CYLINDER.
 3 -  RUN A PRESTORED ANALYSIS PROGRAM
                                                    *
 1


    CHOOSE THE ANALYSIS PROGRAM YOU WISH TO USE.
    TYPE IN THE NUMBER OF THE DESIRED ANALYSIS.
    1     2D WEDGE WITH INSIDE OF TANK NODALIZED
    2     2D WEDGE SHELL - NO NODES INSIDE OF TANK
    3     2D WEDGE SHELL - THICK WALL FILL ANALYSIS
                                                    *
 2


   NOW A TITLE FOR THIS PROBLEM.

   THE TITLE LINE MAY BE UP TO 80 CHARACTERS LONG.
   TYPE IN THE TITLE.
 sample of sphere not nodalized in tank          *


    THIS TASK IS BEING SET UP FOR THE CRAY,
    NOW INPUT NECESSARY CRAY INFO.


   WHICH CRAY SYSTEM  COS  OR  UNICOS
     TYPE IN   C   OR   U
                                                     *
  u

    TYPE IN YOUR  CRAY  USERID.
                                                     *
  userid
```

```
   TYPE IN YOUR  CRAY  PASSWORD.
password                                          *

   TYPE IN NO. OF CRAY CPU SECONDS TO BE USED.
  IF NUMBER OF SECONDS REQUESTED IS < 10,   60 WILL BE USED.
59                                                *

   TYPE AMOUNT OF CRAY MEMORYTO BE REQUESTED,
   IF AMOUNT REQUESTED IS < 1,500,000,   1,500,000 WILL BE  USED.
1                                                 *

   NOW GIVE YOUR JOB A NAME, TYPE IN THE NAME,
    1 - 7 ALPHEBETIC CHARACTERS.
sphere3                                           *



  THE CRAY JCL THAT WAS INPUT IS AS FOLLOWS:
  USERID            = userid
  PASSWORD          = password
  CPU TIME REQUEST =         59 SECS.
  MEMORY REQUEST    =   1500000  words
  JOB  NAME         = sphere3

  ARE THESE ALL CORRECT?  TYPE   Y   OR   N   OR   Q    TO QUIT
y                                                 *



    NOW INPUT SPECIFIC DATA FOR THIS SPHERE.
     INPUT DATA TO DEFINE THE SPHERE MAY BE ANY ONE OF:
   1    RIN (IN.)          AND   ROUT (IN.)
   2    TNK VOL.(CU.FT.)   AND   WALL THICKNESS (IN.)
   3    TNK VOL.(CU.FT.)   AND   ROUT (IN.)
   4    RIN (IN.)          AND   WALL THICKNESS (IN.)
   5    ROUT (IN.)         AND   WALL THICKNESS (IN.)

  ENTER A NUMBER  1  -  5
2                                                 *

  ENTER TANK VOLUME (CU.FT.).
200                                               *

  ENTER WALL THICKNESS  (IN.).
.2                                                *



  THE GEOMETRY FOR THIS ANALYSIS IS A SPHERE WITH
   VOL= 200.000 FT**3,    RIN= 43.534 IN.,    AND      WALL THICKNESS= 0.2000 IN.


 TYPE IN NUMBER OF NODES ALONG CIRCUMFERENCE OF THE SPHERE.
 SOUTH POLE TO NORTH POLE .
 IF VALUE INPUT IS < 10,  20 WILL BE USED AS A DEFAULT.
40                                                *
```

```
THIS IS A 2D ANALYSIS, THE WEDGE ANGLE = 1 RAD.


INPUTTING DATA FOR REGION  1,     TANKWALL

TYPE IN THE NO. OF LAYERS OF NODES THRU REGION 1
                                                  *
2

TEMPERATURES MAY BE IN DEGF OR DEGR IF NO RADIATION IS PRESENT.
THE TEMPERATURES WILL BE INPUT IN WHAT UNITS  F  OR  R?
TYPE IN   F  OR  R
                                                  *
r

TYPE IN THE INITIAL TEMPERATURE FOR THIS REGION  (DEG R)
540                                               *


ENTER MATERIAL NUMBER FOR REGION
101      LIQUID HYDROGEN
102      LIQUID METHANE
103      LIQUID NITROGEN
104      LIQUID OXYGEN
201      STAINLESS 304A
202      STAINLESS 347
203      ALUMINUM 6061
204      ALUMINUM 2219
205      ALUMINUM 7075
206      ALUMINUM OXIDE
207      INCONEL X-750
208      NICKEL
301      GAS HYDROGEN
302      GAS METHANE
303      GAS NITROGEN
304      GAS OXYGEN
999      USER DEFINED
204                                               *


IS THERE TO BE A REGION ON THE OUTSIDE OF THE TANKWALL?
 EG. INSULATION.
  TYPE IN Y OR N
                                                  *
n


ARE THERE TO BE ANY HEAT EXCHANGERS?
 TYPE IN Y OR N
                                                  *
n


THERE MAY BE UP TO TWO BOUNDARY NODES ON THE  OUTSIDE OF THE TANKWALL.
 EG. OUTSIDE ATMOSPHERE.
 DO YOU WANT ONE OR MORE OF THESE BOUNDARY NODES?
  TYPE IN Y OR N
                                                  *
n
```

```
 FOR THIS MODEL, REGION 4 (INSIDE OF TANK),
 IS NOT NODALIZED WITH SINDA NODES;
  DO YOU WANT CONSTANT TEMPERATURE BOUNDARY NODES
  TO CONNECT TO INSIDE OF TANK WALL, OR NOT?
  YOU MAY HAVE:
   1.    NO CONSTANT TEMPERATURE BOUNDARY NODES.
   2.    A SINGLE SET OF CONSTANT TEMPERATURE NODES.
   3.    2 SETS OF CONSTANT TEMPERATURE NODES TO
           TO SIMULATE LIQUID AND VAPOR IN  1-G.

      TYPE IN  1   2   OR  3
3                                            *

  TYPE IN THE TEMPERATURE OF THE LIQUID BNDY NODES  DEG(R)
36                                           *

  TYPE IN THE TEMPERATURE OF THE VAPOR BNDY NODES  DEG(R)
45                                           *

  TYPE IN % TANK IS FULL OF LIQUID.
80                                           *


  IS THERE TO BE A CONSTANT Q INPUT, (SOURCE TERM)
  INTO THE OUTSIDE SURFACE OF THE MODEL?
   TYPE  Y  OR  N
n                                            *
  NOW INPUT THE SPECIFIC DATA FOR SINDA
  THIS SINDA ANALYSIS MAY BE:
  1   A STEADY STATE ANALYSIS
  2   A TRANSIENT ANALYSIS
  3   STEADY STATE FOLLOWED BY A TRANSIENT
  4   A TRANSIENT FOLLOWED BY STEADY STATE
    TYPE IN  1,  2,  3,  OR 4
1                                            *


  TYPE IN THE CONVERGENCE CRITERIA, DELTA TEMPERATURE
   SUGGESTED VALUE RANGE   .01   TO .001
   IF INPUT VALUE .LE. 0 >>>  .005 WILL BE USED.
.001                                         *


  TYPE IN NLOOP, THE NUMBER OF ITERATION LOOPS  ALLOWED
  SUGGESTED RANGE OF VALUES  100  TO 1000
  IF INPUT VALUE  IS .LE. 0 >>>  100 WILL BE USED.
  NOTE: SOME STEADY STATE CASES MAY NEED NLOOP > 1000
2000                                         *


 TEMPERATURES INSIDE OF TANK ARE DEFINED TL=   36.00 DEG R  AND  TV=   45.00 DEG R
 WANT TO INPUT HL AND HV TO COMPUTE CONVECTION COEFICIENTS G=H*A?

 TYPE IN   Y   OR   N
y                                            *


 TYPE IN  FILM COEFFICIENT  HL   (BTU/HR-FT2-R)
```

```
2400                                                   *

 TYPE IN  FILM COEFFICIENT  HV   (BTU/HR-FT2-R)
200                                                    *


 IN THE PLOTTING ROUTINE, NTYP=1; 2D SPHERE WEDGE
 DO YOU WANT A PLOT OF THIS GEOMETRY?
  TYPE  Y  OR  N
n                                                      *
   END OF CRYOTRAN PREPROCESSOR PROGRAM,
    ON TO ANALYSIS PROGRAM
   THE OUTPUT FILE IS CALLED "CRYOTRAN MODEL".
   THIS "CRYOTRAN MODEL" FILE IS A SINDA        MODEL.


   USER MAY NOW SUBMIT THE FILE   "CRYOTRAN MODEL"
    TO THE CRAY COMPUTER FOR EXECUTION,
    OR MAKE ANY DESIRED MODIFICATIONS WITH AN EDITOR
    PRIOR TO SUBMITTING IT TO THE CRAY.


   TO SUBMIT THE FILE TO CRAY,
    ON THE VM SYSTEM TYPE:       CRSUBMIT CRYOTRAN MODEL

  DO YOU WANT TO GO TO BEGINNING OF CRYOTRAN OR  QUIT?
     TYPE  Y  TO GO BACK TO BEGINNING OF CRYOTRAN,
  OR TYPE  N  TO QUIT CRYOTRAN.
n                                                      *
    ON TO ANALYSIS PROGRAM
   THE OUTPUT FILE IS CALLED "CRYOTRAN MODEL".
   THIS "CRYOTRAN MODEL" FILE IS A SINDA        MODEL.


   USER MAY NOW SUBMIT THE FILE   "CRYOTRAN MODEL"
    TO THE CRAY COMPUTER FOR EXECUTION,
    OR MAKE ANY DESIRED MODIFICATIONS WITH AN EDITOR
    PRIOR TO SUBMITTING IT TO THE CRAY.


   TO SUBMIT THE FILE TO CRAY,
    ON THE VM SYSTEM TYPE:       CRSUBMIT CRYOTRAN MODEL


  IF USER HAS REQUESTED A GEOMETRY PLOT OF THE SINDA MODEL
  THE PLOT DATA IS IN FILE NAMED  "QMS PLOTDATA"

  USER MAY PLOT THESE RESULTS BY TYPING:    PLOTQA
Ready; T=2.77/4.95 11:28:47
```

This ends the CryoTran input prompts and the responses to a sample cases 2 and 3.

APPENDIX C

Sample Problems

Sample sphere model with 5 regions, regions 4 and 5 are nodalized, Q on outside surface, 3 heat exchangers and 2 outside boundary nodes. Figure 7 is a plot of this sample model.

```
# USER=vvglenn            PW=password
# QSUB -r sphere1                  # jobname
# QSUB -eo                 # Combine error andstandard output
# QSUB -lT       59          # CPU time
# QSUB -lM  1.5Mw      # Memory requested
#      @$                  # End NQS statements
set  -x                    # set echo
ja
cat  >  model  << EOF      # SINDA MODEL TO FOLLOW

      BCD 3THERMAL LPCS
C     REM  THIS SINDA MODEL WAS GENERATED BY CRYOTRAN
C     REM  SPHERE   --- 2D WEDGE WITH INSIDE OF TANK NODALIZED
C     REM              WEDGE ANGLE=BETA = 1.0 RADIANS
      BCD 9SAMPLE MODEL SPHERE1
      BCD 9
      END
      BCD 3NODE DATA
      REM  NODE TEMPERATURES ARE IN (DEG F)
      REM  DIMENSIONS ARE IN (IN.),  TIME IS IN (SECS)
      REM  SURFACE NODES, INSIDE TANK WALL
            1001,           90.0,   -1.000000        $ SURFACE NODES
      REM HEAT EXCHANGER NO.  1, REPLACES NODES 1002 THRU  1005
      GEN   1006, 20,  1,    90.0,            -1.000000 $ SURFACE NODES
      REM  DIFFUSION NODES, REGION  1, TANKWALL
      REM   REGION  1,  LAYER NO.   1
      SIM   2001,  2, 24,    90.0, A1204,     0.547099 $ ALUMINUM 2219
      SIM   2002,  2, 22,    90.0, A1204,     1.632664 $ ALUMINUM 2219
      SIM   2003,  2, 20,    90.0, A1204,     2.692478 $ ALUMINUM 2219
      SIM   2004,  2, 18,    90.0, A1204,     3.709835 $ ALUMINUM 2219
      SIM   2005,  2, 16,    90.0, A1204,     4.668679 $ ALUMINUM 2219
      SIM   2006,  2, 14,    90.0, A1204,     5.553900 $ ALUMINUM 2219
      SIM   2007,  2, 12,    90.0, A1204,     6.351530 $ ALUMINUM 2219
      SIM   2008,  2, 10,    90.0, A1204,     7.048999 $ ALUMINUM 2219
      SIM   2009,  2,  8,    90.0, A1204,     7.635290 $ ALUMINUM 2219
      SIM   2010,  2,  6,    90.0, A1204,     8.101176 $ ALUMINUM 2219
      SIM   2011,  2,  4,    90.0, A1204,     8.439301 $ ALUMINUM 2219
      SIM   2012,  2,  2,    90.0, A1204,     8.644333 $ ALUMINUM 2219
      SIV   2013,            90.0, A1204,     8.713038 $ ALUMINUM 2219
      REM   REGION  1,  LAYER NO.   2
      SIM   2026,  2, 24,    90.0, A1204,     0.538204 $ ALUMINUM 2219
      SIM   2027,  2, 22,    90.0, A1204,     1.606119 $ ALUMINUM 2219
      SIM   2028,  2, 20,    90.0, A1204,     2.648705 $ ALUMINUM 2219
      SIM   2029,  2, 18,    90.0, A1204,     3.649517 $ ALUMINUM 2219
      SIM   2030,  2, 16,    90.0, A1204,     4.592772 $ ALUMINUM 2219
      SIM   2031,  2, 14,    90.0, A1204,     5.463598 $ ALUMINUM 2219
      SIM   2032,  2, 12,    90.0, A1204,     6.248263 $ ALUMINUM 2219
      SIM   2033,  2, 10,    90.0, A1204,     6.934390 $ ALUMINUM 2219
      SIM   2034,  2,  8,    90.0, A1204,     7.511152 $ ALUMINUM 2219
      SIM   2035,  2,  6,    90.0, A1204,     7.969460 $ ALUMINUM 2219
      SIM   2036,  2,  4,    90.0, A1204,     8.302086 $ ALUMINUM 2219
      SIM   2037,  2,  2,    90.0, A1204,     8.503784 $ ALUMINUM 2219
      SIV   2038,            90.0, A1204,     8.571373 $ ALUMINUM 2219
      REM   REGION  1,  LAYER NO.   3
      SIM   2051,  2, 24,    90.0, A1204,     0.529381 $ ALUMINUM 2219
      SIM   2052,  2, 22,    90.0, A1204,     1.579787 $ ALUMINUM 2219
      SIM   2053,  2, 20,    90.0, A1204,     2.605281 $ ALUMINUM 2219
      SIM   2054,  2, 18,    90.0, A1204,     3.589687 $ ALUMINUM 2219
      SIM   2055,  2, 16,    90.0, A1204,     4.517477 $ ALUMINUM 2219
      SIM   2056,  2, 14,    90.0, A1204,     5.374026 $ ALUMINUM 2219
      SIM   2057,  2, 12,    90.0, A1204,     6.145826 $ ALUMINUM 2219
      SIM   2058,  2, 10,    90.0, A1204,     6.820707 $ ALUMINUM 2219
      SIM   2059,  2,  8,    90.0, A1204,     7.388011 $ ALUMINUM 2219
```

```
SIM   2060,  2,  6,    90.0, A1204,      7.838806 $ ALUMINUM 2219
SIM   2061,  2,  4,    90.0, A1204,      8.165982 $ ALUMINUM 2219
SIM   2062,  2,  2,    90.0, A1204,      8.364372 $ ALUMINUM 2219
SIV   2063,            90.0, A1204,      8.430852 $ ALUMINUM 2219
REM  SURFACE NODES, OUTSIDE SURFACE, REGION  1, TANKWALL
GEN   3001, 25,  1,    90.0,            -1.000000 $ SURFACE NODES
  REM  DIFFUSION NODES, REGION  2, OUTSIDE LAYER 1
REM   REGION  2,  LAYER NO.   1
SIM   4001,  2, 24,    90.0, A1204,      0.837483 $ ALUMINUM 2219
SIM   4002,  2, 22,    90.0, A1204,      2.499235 $ ALUMINUM 2219
SIM   4003,  2, 20,    90.0, A1204,      4.121567 $ ALUMINUM 2219
SIM   4004,  2, 18,    90.0, A1204,      5.678905 $ ALUMINUM 2219
SIM   4005,  2, 16,    90.0, A1204,      7.146675 $ ALUMINUM 2219
SIM   4006,  2, 14,    90.0, A1204,      8.501743 $ ALUMINUM 2219
SIM   4007,  2, 12,    90.0, A1204,      9.722736 $ ALUMINUM 2219
SIM   4008,  2, 10,    90.0, A1204,     10.790398 $ ALUMINUM 2219
SIM   4009,  2,  8,    90.0, A1204,     11.687881 $ ALUMINUM 2219
SIM   4010,  2,  6,    90.0, A1204,     12.401039 $ ALUMINUM 2219
SIM   4011,  2,  4,    90.0, A1204,     12.918633 $ ALUMINUM 2219
SIM   4012,  2,  2,    90.0, A1204,     13.232487 $ ALUMINUM 2219
SIV   4013,            90.0, A1204,     13.337662 $ ALUMINUM 2219
REM  SURFACE NODES, OUTSIDE SURFACE, REGION  2, OUTSIDE LAYER 1
GEN   5001, 25,  1,    90.0,            -1.000000 $ SURFACE NODES
REM  DIFFUSION NODES, REGION  3, OUTSIDE LAYER 2
REM   REGION  3,  LAYER NO.   1
SIM   6001,  2, 24,    80.0, A1202,      0.343986 $ STAINLESS 347
SIM   6002,  2, 22,    80.0, A1202,      1.026528 $ STAINLESS 347
SIM   6003,  2, 20,    80.0, A1202,      1.692882 $ STAINLESS 347
SIM   6004,  2, 18,    80.0, A1202,      2.332538 $ STAINLESS 347
SIM   6005,  2, 16,    80.0, A1202,      2.935409 $ STAINLESS 347
SIM   6006,  2, 14,    80.0, A1202,      3.491985 $ STAINLESS 347
SIM   6007,  2, 12,    80.0, A1202,      3.993491 $ STAINLESS 347
SIM   6008,  2, 10,    80.0, A1202,      4.432021 $ STAINLESS 347
SIM   6009,  2,  8,    80.0, A1202,      4.800650 $ STAINLESS 347
SIM   6010,  2,  6,    80.0, A1202,      5.093573 $ STAINLESS 347
SIM   6011,  2,  4,    80.0, A1202,      5.306167 $ STAINLESS 347
SIM   6012,  2,  2,    80.0, A1202,      5.435080 $ STAINLESS 347
SIV   6013,            80.0, A1202,      5.478277 $ STAINLESS 347
REM   REGION  3,  LAYER NO.   2
SIM   6026,  2, 24,    80.0, A1202,      0.340702 $ STAINLESS 347
SIM   6027,  2, 22,    80.0, A1202,      1.016728 $ STAINLESS 347
SIM   6028,  2, 20,    80.0, A1202,      1.676720 $ STAINLESS 347
SIM   6029,  2, 18,    80.0, A1202,      2.310270 $ STAINLESS 347
SIM   6030,  2, 16,    80.0, A1202,      2.907384 $ STAINLESS 347
SIM   6031,  2, 14,    80.0, A1202,      3.458648 $ STAINLESS 347
SIM   6032,  2, 12,    80.0, A1202,      3.955365 $ STAINLESS 347
SIM   6033,  2, 10,    80.0, A1202,      4.389710 $ STAINLESS 347
SIM   6034,  2,  8,    80.0, A1202,      4.754818 $ STAINLESS 347
SIM   6035,  2,  6,    80.0, A1202,      5.044944 $ STAINLESS 347
SIM   6036,  2,  4,    80.0, A1202,      5.255507 $ STAINLESS 347
SIM   6037,  2,  2,    80.0, A1202,      5.383190 $ STAINLESS 347
SIV   6038,            80.0, A1202,      5.425976 $ STAINLESS 347
REM  SURFACE NODES, OUTSIDE SURFACE, REGION  3, OUTSIDE LAYER 2
GEN   7001,  9,  1,    80.0,            -1.000000 $ SURFACE NODES
REM HEAT EXCHANGER NO.  3, REPLACES NODES 7010 THRU  7012
GEN   7013, 13,  1,    80.0,            -1.000000 $ SURFACE NODES
REM  DIFFUSION NODES, REGION  4, INSIDE TANK AT WALL
REM  THIS MODEL; TANK IS  75.% FULL, A 1-G  CASE, ULLAGE AT TOP & FLAT
REM  ULLAGE STARTS AT TANK WALL AT THETA POSITION NO.  16
REM   (COUNTING FROM SOUTH POLE)
REM   REGION  4,  LAYER NO.   1
SIV   8001,           -420.0, A1101,      3.695231 $ L-HYDROGEN
SIV   8025,           -420.0, A1301,      3.695231 $ G-HYDROGEN
SIV   8002,           -420.0, A1101,     11.027384 $ L-HYDROGEN
SIV   8024,           -420.0, A1301,     11.027384 $ G-HYDROGEN
SIV   8003,           -420.0, A1101,     18.185623 $ L-HYDROGEN
SIV   8023,           -420.0, A1301,     18.185623 $ G-HYDROGEN
SIV   8004,           -420.0, A1101,     25.057068 $ L-HYDROGEN
SIV   8022,           -420.0, A1301,     25.057068 $ G-HYDROGEN
SIV   8005,           -420.0, A1101,     31.533310 $ L-HYDROGEN
```

```
SIV   8021,          -420.0, A1301,     31.533310 $ G-HYDROGEN
SIV   8006,          -420.0, A1101,     37.512283 $ L-HYDROGEN
SIV   8020,          -420.0, A1301,     37.512283 $ G-HYDROGEN
SIV   8007,          -420.0, A1101,     42.899673 $ L-HYDROGEN
SIV   8019,          -420.0, A1301,     42.899673 $ G-HYDROGEN
SIV   8008,          -420.0, A1101,     47.610519 $ L-HYDROGEN
SIV   8018,          -420.0, A1301,     47.610519 $ G-HYDROGEN
SIV   8009,          -420.0, A1101,     51.570480 $ L-HYDROGEN
SIV   8017,          -420.0, A1301,     51.570480 $ G-HYDROGEN
SIV   8010,          -420.0, A1101,     54.717178 $ L-HYDROGEN
SIV   8016,          -420.0, A1301,     54.717178 $ G-HYDROGEN
SIV   8011,          -420.0, A1101,     57.000931 $ L-HYDROGEN
SIV   8015,          -420.0, A1101,     57.000931 $ L-HYDROGEN
SIV   8012,          -420.0, A1101,     58.385773 $ L-HYDROGEN
SIV   8014,          -420.0, A1101,     58.385773 $ L-HYDROGEN
SIV   8013,          -420.0, A1101,     58.849808 $ L-HYDROGEN
REM   REGION   4,  LAYER NO.   2
SIV   8026,          -420.0, A1101,      3.233808 $ L-HYDROGEN
SIV   8050,          -420.0, A1301,      3.233808 $ G-HYDROGEN
SIV   8027,          -420.0, A1101,      9.650397 $ L-HYDROGEN
SIV   8049,          -420.0, A1301,      9.650397 $ G-HYDROGEN
SIV   8028,          -420.0, A1101,     15.914793 $ L-HYDROGEN
SIV   8048,          -420.0, A1301,     15.914793 $ G-HYDROGEN
SIV   8029,          -420.0, A1101,     21.928192 $ L-HYDROGEN
SIV   8047,          -420.0, A1301,     21.928192 $ G-HYDROGEN
SIV   8030,          -420.0, A1101,     27.595749 $ L-HYDROGEN
SIV   8046,          -420.0, A1301,     27.595749 $ G-HYDROGEN
SIV   8031,          -420.0, A1101,     32.828140 $ L-HYDROGEN
SIV   8045,          -420.0, A1301,     32.828140 $ G-HYDROGEN
SIV   8032,          -420.0, A1101,     37.542770 $ L-HYDROGEN
SIV   8044,          -420.0, A1301,     37.542770 $ G-HYDROGEN
SIV   8033,          -420.0, A1101,     41.665390 $ L-HYDROGEN
SIV   8043,          -420.0, A1301,     41.665390 $ G-HYDROGEN
SIV   8034,          -420.0, A1101,     45.130859 $ L-HYDROGEN
SIV   8042,          -420.0, A1301,     45.130859 $ G-HYDROGEN
SIV   8035,          -420.0, A1101,     47.884628 $ L-HYDROGEN
SIV   8041,          -420.0, A1301,     47.884628 $ G-HYDROGEN
SIV   8036,          -420.0, A1101,     49.883224 $ L-HYDROGEN
SIV   8040,          -420.0, A1101,     49.883224 $ L-HYDROGEN
SIV   8037,          -420.0, A1101,     51.095139 $ L-HYDROGEN
SIV   8039,          -420.0, A1101,     51.095139 $ L-HYDROGEN
SIV   8038,          -420.0, A1101,     51.501236 $ L-HYDROGEN
REM   REGION   4,  LAYER NO.   3
SIV   8051,          -420.0, A1101,      2.803146 $ L-HYDROGEN
SIV   8075,          -420.0, A1301,      2.803146 $ G-HYDROGEN
SIV   8052,          -420.0, A1101,      8.365207 $ L-HYDROGEN
SIV   8074,          -420.0, A1301,      8.365207 $ G-HYDROGEN
SIV   8053,          -420.0, A1101,     13.795338 $ L-HYDROGEN
SIV   8073,          -420.0, A1301,     13.795338 $ G-HYDROGEN
SIV   8054,          -420.0, A1101,     19.007904 $ L-HYDROGEN
SIV   8072,          -420.0, A1301,     19.007904 $ G-HYDROGEN
SIV   8055,          -420.0, A1101,     23.920685 $ L-HYDROGEN
SIV   8071,          -420.0, A1301,     23.920685 $ G-HYDROGEN
SIV   8056,          -420.0, A1101,     28.456238 $ L-HYDROGEN
SIV   8070,          -420.0, A1301,     28.456238 $ G-HYDROGEN
SIV   8057,          -420.0, A1101,     32.543030 $ L-HYDROGEN
SIV   8069,          -420.0, A1301,     32.543030 $ G-HYDROGEN
SIV   8058,          -420.0, A1101,     36.116608 $ L-HYDROGEN
SIV   8068,          -420.0, A1301,     36.116608 $ G-HYDROGEN
SIV   8059,          -420.0, A1101,     39.120575 $ L-HYDROGEN
SIV   8067,          -420.0, A1301,     39.120575 $ G-HYDROGEN
SIV   8060,          -420.0, A1101,     41.507599 $ L-HYDROGEN
SIV   8066,          -420.0, A1301,     41.507599 $ G-HYDROGEN
SIV   8061,          -420.0, A1101,     43.240051 $ L-HYDROGEN
SIV   8065,          -420.0, A1101,     43.240051 $ L-HYDROGEN
SIV   8062,          -420.0, A1101,     44.290558 $ L-HYDROGEN
SIV   8064,          -420.0, A1101,     44.290558 $ L-HYDROGEN
SIV   8063,          -420.0, A1101,     44.642563 $ L-HYDROGEN
REM   REGION   4,  LAYER NO.   4
SIV   8076,          -420.0, A1101,      2.403246 $ L-HYDROGEN
```

```
SIV   8100,           -420.0, A1301,      2.403246 $ G-HYDROGEN
SIV   8077,           -420.0, A1101,      7.171817 $ L-HYDROGEN
SIV   8099,           -420.0, A1301,      7.171817 $ G-HYDROGEN
SIV   8078,           -420.0, A1101,     11.827278 $ L-HYDROGEN
SIV   8098,           -420.0, A1301,     11.827278 $ G-HYDROGEN
SIV   8079,           -420.0, A1101,     16.296219 $ L-HYDROGEN
SIV   8097,           -420.0, A1301,     16.296219 $ G-HYDROGEN
SIV   8080,           -420.0, A1101,     20.508133 $ L-HYDROGEN
SIV   8096,           -420.0, A1301,     20.508133 $ G-HYDROGEN
SIV   8081,           -420.0, A1101,     24.396637 $ L-HYDROGEN
SIV   8095,           -420.0, A1301,     24.396637 $ G-HYDROGEN
SIV   8082,           -420.0, A1101,     27.900406 $ L-HYDROGEN
SIV   8094,           -420.0, A1301,     27.900406 $ G-HYDROGEN
SIV   8083,           -420.0, A1101,     30.964172 $ L-HYDROGEN
SIV   8093,           -420.0, A1301,     30.964172 $ G-HYDROGEN
SIV   8084,           -420.0, A1101,     33.539597 $ L-HYDROGEN
SIV   8092,           -420.0, A1301,     33.539597 $ G-HYDROGEN
SIV   8085,           -420.0, A1101,     35.586060 $ L-HYDROGEN
SIV   8091,           -420.0, A1101,     35.586060 $ L-HYDROGEN
SIV   8086,           -420.0, A1101,     37.071350 $ L-HYDROGEN
SIV   8090,           -420.0, A1101,     37.071350 $ L-HYDROGEN
SIV   8087,           -420.0, A1101,     37.972000 $ L-HYDROGEN
SIV   8089,           -420.0, A1101,     37.972000 $ L-HYDROGEN
SIV   8088,           -420.0, A1101,     38.273804 $ L-HYDROGEN
REM  SURFACE NODES, OUTSIDE SURFACE, REGION  5, INSIDE TANK AT CENTER
GEN  9001, 25,  1, -420.0,               -1.000000 $ SURFACE NODES
REM  DIFFUSION NODES, REGION  5, INSIDE TANK AT CENTER
REM   REGION  5,  LAYER NO.   1
SIV  10001,           -420.0, A1101,      1.655709 $ L-HYDROGEN
SIV  10025,           -420.0, A1301,      1.655709 $ G-HYDROGEN
SIV  10002,           -420.0, A1101,      4.941003 $ L-HYDROGEN
SIV  10024,           -420.0, A1301,      4.941003 $ G-HYDROGEN
SIV  10003,           -420.0, A1101,      8.148369 $ L-HYDROGEN
SIV  10023,           -420.0, A1301,      8.148369 $ G-HYDROGEN
SIV  10004,           -420.0, A1101,     11.227234 $ L-HYDROGEN
SIV  10022,           -420.0, A1301,     11.227234 $ G-HYDROGEN
SIV  10005,           -420.0, A1101,     14.129028 $ L-HYDROGEN
SIV  10021,           -420.0, A1301,     14.129028 $ G-HYDROGEN
SIV  10006,           -420.0, A1101,     16.807999 $ L-HYDROGEN
SIV  10020,           -420.0, A1301,     16.807999 $ G-HYDROGEN
SIV  10007,           -420.0, A1101,     19.221909 $ L-HYDROGEN
SIV  10019,           -420.0, A1301,     19.221909 $ G-HYDROGEN
SIV  10008,           -420.0, A1101,     21.332672 $ L-HYDROGEN
SIV  10018,           -420.0, A1301,     21.332672 $ G-HYDROGEN
SIV  10009,           -420.0, A1101,     23.107010 $ L-HYDROGEN
SIV  10017,           -420.0, A1301,     23.107010 $ G-HYDROGEN
SIV  10010,           -420.0, A1101,     24.516937 $ L-HYDROGEN
SIV  10016,           -420.0, A1101,     24.516937 $ L-HYDROGEN
SIV  10011,           -420.0, A1101,     25.540222 $ L-HYDROGEN
SIV  10015,           -420.0, A1101,     25.540222 $ L-HYDROGEN
SIV  10012,           -420.0, A1101,     26.160721 $ L-HYDROGEN
SIV  10014,           -420.0, A1101,     26.160721 $ L-HYDROGEN
SIV  10013,           -420.0, A1101,     26.368637 $ L-HYDROGEN
REM   REGION  5,  LAYER NO.   2
SIV  10026,           -420.0, A1101,      1.435211 $ L-HYDROGEN
SIV  10050,           -420.0, A1301,      1.435211 $ G-HYDROGEN
SIV  10027,           -420.0, A1101,      4.282986 $ L-HYDROGEN
SIV  10049,           -420.0, A1301,      4.282986 $ G-HYDROGEN
SIV  10028,           -420.0, A1101,      7.063215 $ L-HYDROGEN
SIV  10048,           -420.0, A1301,      7.063215 $ G-HYDROGEN
SIV  10029,           -420.0, A1101,      9.732048 $ L-HYDROGEN
SIV  10047,           -420.0, A1301,      9.732048 $ G-HYDROGEN
SIV  10030,           -420.0, A1101,     12.247398 $ L-HYDROGEN
SIV  10046,           -420.0, A1301,     12.247398 $ G-HYDROGEN
SIV  10031,           -420.0, A1101,     14.569603 $ L-HYDROGEN
SIV  10045,           -420.0, A1301,     14.569603 $ G-HYDROGEN
SIV  10032,           -420.0, A1101,     16.662033 $ L-HYDROGEN
SIV  10044,           -420.0, A1301,     16.662033 $ G-HYDROGEN
SIV  10033,           -420.0, A1101,     18.491699 $ L-HYDROGEN
SIV  10043,           -420.0, A1301,     18.491699 $ G-HYDROGEN
```

```
SIV  10034,        -420.0, A1101,    20.029724 $ L-HYDROGEN
SIV  10042,        -420.0, A1301,    20.029724 $ G-HYDROGEN
SIV  10035,        -420.0, A1101,    21.251877 $ L-HYDROGEN
SIV  10041,        -420.0, A1101,    21.251877 $ L-HYDROGEN
SIV  10036,        -420.0, A1101,    22.138885 $ L-HYDROGEN
SIV  10040,        -420.0, A1101,    22.138885 $ L-HYDROGEN
SIV  10037,        -420.0, A1101,    22.676758 $ L-HYDROGEN
SIV  10039,        -420.0, A1101,    22.676758 $ L-HYDROGEN
SIV  10038,        -420.0, A1101,    22.856995 $ L-HYDROGEN
REM   REGION  5,  LAYER NO.   3
SIV  10051,        -420.0, A1101,     1.230462 $ L-HYDROGEN
SIV  10075,        -420.0, A1301,     1.230462 $ G-HYDROGEN
SIV  10052,        -420.0, A1101,     3.671969 $ L-HYDROGEN
SIV  10074,        -420.0, A1301,     3.671969 $ G-HYDROGEN
SIV  10053,        -420.0, A1101,     6.055569 $ L-HYDROGEN
SIV  10073,        -420.0, A1301,     6.055569 $ G-HYDROGEN
SIV  10054,        -420.0, A1101,     8.343666 $ L-HYDROGEN
SIV  10072,        -420.0, A1301,     8.343666 $ G-HYDROGEN
SIV  10055,        -420.0, A1101,    10.500168 $ L-HYDROGEN
SIV  10071,        -420.0, A1301,    10.500168 $ G-HYDROGEN
SIV  10056,        -420.0, A1101,    12.491089 $ L-HYDROGEN
SIV  10070,        -420.0, A1301,    12.491089 $ G-HYDROGEN
SIV  10057,        -420.0, A1101,    14.285011 $ L-HYDROGEN
SIV  10069,        -420.0, A1301,    14.285011 $ G-HYDROGEN
SIV  10058,        -420.0, A1101,    15.853661 $ L-HYDROGEN
SIV  10068,        -420.0, A1301,    15.853661 $ G-HYDROGEN
SIV  10059,        -420.0, A1101,    17.172256 $ L-HYDROGEN
SIV  10067,        -420.0, A1101,    17.172256 $ L-HYDROGEN
SIV  10060,        -420.0, A1101,    18.220062 $ L-HYDROGEN
SIV  10066,        -420.0, A1101,    18.220062 $ L-HYDROGEN
SIV  10061,        -420.0, A1101,    18.980530 $ L-HYDROGEN
SIV  10065,        -420.0, A1101,    18.980530 $ L-HYDROGEN
SIV  10062,        -420.0, A1101,    19.441666 $ L-HYDROGEN
SIV  10064,        -420.0, A1101,    19.441666 $ L-HYDROGEN
SIV  10063,        -420.0, A1101,    19.596176 $ L-HYDROGEN
REM   REGION  5,  LAYER NO.   4
SIV  10076,        -420.0, A1101,     1.041463 $ L-HYDROGEN
SIV  10100,        -420.0, A1301,     1.041463 $ G-HYDROGEN
SIV  10077,        -420.0, A1101,     3.107956 $ L-HYDROGEN
SIV  10099,        -420.0, A1301,     3.107956 $ G-HYDROGEN
SIV  10078,        -420.0, A1101,     5.125433 $ L-HYDROGEN
SIV  10098,        -420.0, A1301,     5.125433 $ G-HYDROGEN
SIV  10079,        -420.0, A1101,     7.062079 $ L-HYDROGEN
SIV  10097,        -420.0, A1301,     7.062079 $ G-HYDROGEN
SIV  10080,        -420.0, A1101,     8.887344 $ L-HYDROGEN
SIV  10096,        -420.0, A1301,     8.887344 $ G-HYDROGEN
SIV  10081,        -420.0, A1101,    10.572456 $ L-HYDROGEN
SIV  10095,        -420.0, A1301,    10.572456 $ G-HYDROGEN
SIV  10082,        -420.0, A1101,    12.090836 $ L-HYDROGEN
SIV  10094,        -420.0, A1301,    12.090836 $ G-HYDROGEN
SIV  10083,        -420.0, A1101,    13.418541 $ L-HYDROGEN
SIV  10093,        -420.0, A1301,    13.418541 $ G-HYDROGEN
SIV  10084,        -420.0, A1101,    14.534615 $ L-HYDROGEN
SIV  10092,        -420.0, A1101,    14.534615 $ L-HYDROGEN
SIV  10085,        -420.0, A1101,    15.421478 $ L-HYDROGEN
SIV  10091,        -420.0, A1101,    15.421478 $ L-HYDROGEN
SIV  10086,        -420.0, A1101,    16.065125 $ L-HYDROGEN
SIV  10090,        -420.0, A1101,    16.065125 $ L-HYDROGEN
SIV  10087,        -420.0, A1101,    16.455414 $ L-HYDROGEN
SIV  10089,        -420.0, A1101,    16.455414 $ L-HYDROGEN
SIV  10088,        -420.0, A1101,    16.586212 $ L-HYDROGEN
REM   REGION  5,  LAYER NO.   5
SIV  10101,        -420.0, A1101,     0.868214 $ L-HYDROGEN
SIV  10125,        -420.0, A1301,     0.868214 $ G-HYDROGEN
SIV  10102,        -420.0, A1101,     2.590941 $ L-HYDROGEN
SIV  10124,        -420.0, A1301,     2.590941 $ G-HYDROGEN
SIV  10103,        -420.0, A1101,     4.272809 $ L-HYDROGEN
SIV  10123,        -420.0, A1301,     4.272809 $ G-HYDROGEN
SIV  10104,        -420.0, A1101,     5.887291 $ L-HYDROGEN
SIV  10122,        -420.0, A1301,     5.887291 $ G-HYDROGEN
```

```
SIV  10105,        -420.0, A1101,     7.408922 $ L-HYDROGEN
SIV  10121,        -420.0, A1301,     7.408922 $ G-HYDROGEN
SIV  10106,        -420.0, A1101,     8.813713 $ L-HYDROGEN
SIV  10120,        -420.0, A1301,     8.813713 $ G-HYDROGEN
SIV  10107,        -420.0, A1101,    10.079506 $ L-HYDROGEN
SIV  10119,        -420.0, A1301,    10.079506 $ G-HYDROGEN
SIV  10108,        -420.0, A1101,    11.186348 $ L-HYDROGEN
SIV  10118,        -420.0, A1101,    11.186348 $ L-HYDROGEN
SIV  10109,        -420.0, A1101,    12.116753 $ L-HYDROGEN
SIV  10117,        -420.0, A1101,    12.116753 $ L-HYDROGEN
SIV  10110,        -420.0, A1101,    12.856087 $ L-HYDROGEN
SIV  10116,        -420.0, A1101,    12.856087 $ L-HYDROGEN
SIV  10111,        -420.0, A1101,    13.392670 $ L-HYDROGEN
SIV  10115,        -420.0, A1101,    13.392670 $ L-HYDROGEN
SIV  10112,        -420.0, A1101,    13.718040 $ L-HYDROGEN
SIV  10114,        -420.0, A1101,    13.718040 $ L-HYDROGEN
SIV  10113,        -420.0, A1101,    13.827072 $ L-HYDROGEN
REM   REGION  5,  LAYER NO.  6
SIV  10126,        -420.0, A1101,     0.710715 $ L-HYDROGEN
SIV  10150,        -420.0, A1301,     0.710715 $ G-HYDROGEN
SIV  10127,        -420.0, A1101,     2.120929 $ L-HYDROGEN
SIV  10149,        -420.0, A1301,     2.120929 $ G-HYDROGEN
SIV  10128,        -420.0, A1101,     3.497696 $ L-HYDROGEN
SIV  10148,        -420.0, A1301,     3.497696 $ G-HYDROGEN
SIV  10129,        -420.0, A1101,     4.819302 $ L-HYDROGEN
SIV  10147,        -420.0, A1301,     4.819302 $ G-HYDROGEN
SIV  10130,        -420.0, A1101,     6.064899 $ L-HYDROGEN
SIV  10146,        -420.0, A1301,     6.064899 $ G-HYDROGEN
SIV  10131,        -420.0, A1101,     7.214853 $ L-HYDROGEN
SIV  10145,        -420.0, A1301,     7.214853 $ G-HYDROGEN
SIV  10132,        -420.0, A1101,     8.251022 $ L-HYDROGEN
SIV  10144,        -420.0, A1301,     8.251022 $ G-HYDROGEN
SIV  10133,        -420.0, A1101,     9.157074 $ L-HYDROGEN
SIV  10143,        -420.0, A1101,     9.157074 $ L-HYDROGEN
SIV  10134,        -420.0, A1101,     9.918701 $ L-HYDROGEN
SIV  10142,        -420.0, A1101,     9.918701 $ L-HYDROGEN
SIV  10135,        -420.0, A1101,    10.523918 $ L-HYDROGEN
SIV  10141,        -420.0, A1101,    10.523918 $ L-HYDROGEN
SIV  10136,        -420.0, A1101,    10.963158 $ L-HYDROGEN
SIV  10140,        -420.0, A1101,    10.963158 $ L-HYDROGEN
SIV  10137,        -420.0, A1101,    11.229507 $ L-HYDROGEN
SIV  10139,        -420.0, A1101,    11.229507 $ L-HYDROGEN
SIV  10138,        -420.0, A1101,    11.318764 $ L-HYDROGEN
REM   REGION  5,  LAYER NO.  7
SIV  10151,        -420.0, A1101,     0.568965 $ L-HYDROGEN
SIV  10175,        -420.0, A1301,     0.568965 $ G-HYDROGEN
SIV  10152,        -420.0, A1101,     1.697919 $ L-HYDROGEN
SIV  10174,        -420.0, A1301,     1.697919 $ G-HYDROGEN
SIV  10153,        -420.0, A1101,     2.800095 $ L-HYDROGEN
SIV  10173,        -420.0, A1301,     2.800095 $ G-HYDROGEN
SIV  10154,        -420.0, A1101,     3.858111 $ L-HYDROGEN
SIV  10172,        -420.0, A1301,     3.858111 $ G-HYDROGEN
SIV  10155,        -420.0, A1101,     4.855280 $ L-HYDROGEN
SIV  10171,        -420.0, A1301,     4.855280 $ G-HYDROGEN
SIV  10156,        -420.0, A1101,     5.775880 $ L-HYDROGEN
SIV  10170,        -420.0, A1301,     5.775880 $ G-HYDROGEN
SIV  10157,        -420.0, A1101,     6.605392 $ L-HYDROGEN
SIV  10169,        -420.0, A1101,     6.605392 $ L-HYDROGEN
SIV  10158,        -420.0, A1101,     7.330735 $ L-HYDROGEN
SIV  10168,        -420.0, A1101,     7.330735 $ L-HYDROGEN
SIV  10159,        -420.0, A1101,     7.940461 $ L-HYDROGEN
SIV  10167,        -420.0, A1101,     7.940461 $ L-HYDROGEN
SIV  10160,        -420.0, A1101,     8.424965 $ L-HYDROGEN
SIV  10166,        -420.0, A1101,     8.424965 $ L-HYDROGEN
SIV  10161,        -420.0, A1101,     8.776604 $ L-HYDROGEN
SIV  10165,        -420.0, A1101,     8.776604 $ L-HYDROGEN
SIV  10162,        -420.0, A1101,     8.989830 $ L-HYDROGEN
SIV  10164,        -420.0, A1101,     8.989830 $ L-HYDROGEN
SIV  10163,        -420.0, A1101,     9.061279 $ L-HYDROGEN
REM   REGION  5,  LAYER NO.  8
```

```
SIV  10176,          -420.0, A1101,      0.442967 $ L-HYDROGEN
SIV  10200,          -420.0, A1301,      0.442967 $ G-HYDROGEN
SIV  10177,          -420.0, A1101,      1.321908 $ L-HYDROGEN
SIV  10199,          -420.0, A1301,      1.321908 $ G-HYDROGEN
SIV  10178,          -420.0, A1101,      2.180004 $ L-HYDROGEN
SIV  10198,          -420.0, A1301,      2.180004 $ G-HYDROGEN
SIV  10179,          -420.0, A1101,      3.003719 $ L-HYDROGEN
SIV  10197,          -420.0, A1301,      3.003719 $ G-HYDROGEN
SIV  10180,          -420.0, A1101,      3.780062 $ L-HYDROGEN
SIV  10196,          -420.0, A1101,      3.780062 $ L-HYDROGEN
SIV  10181,          -420.0, A1101,      4.496792 $ L-HYDROGEN
SIV  10195,          -420.0, A1101,      4.496792 $ L-HYDROGEN
SIV  10182,          -420.0, A1101,      5.142606 $ L-HYDROGEN
SIV  10194,          -420.0, A1101,      5.142606 $ L-HYDROGEN
SIV  10183,          -420.0, A1101,      5.707319 $ L-HYDROGEN
SIV  10193,          -420.0, A1101,      5.707319 $ L-HYDROGEN
SIV  10184,          -420.0, A1101,      6.182019 $ L-HYDROGEN
SIV  10192,          -420.0, A1101,      6.182019 $ L-HYDROGEN
SIV  10185,          -420.0, A1101,      6.559229 $ L-HYDROGEN
SIV  10191,          -420.0, A1101,      6.559229 $ L-HYDROGEN
SIV  10186,          -420.0, A1101,      6.832996 $ L-HYDROGEN
SIV  10190,          -420.0, A1101,      6.832996 $ L-HYDROGEN
SIV  10187,          -420.0, A1101,      6.999003 $ L-HYDROGEN
SIV  10189,          -420.0, A1101,      6.999003 $ L-HYDROGEN
SIV  10188,          -420.0, A1101,      7.054631 $ L-HYDROGEN
REM   REGION   5,  LAYER NO.   9
SIV  10201,          -420.0, A1101,      0.332717 $ L-HYDROGEN
SIV  10225,          -420.0, A1301,      0.332717 $ G-HYDROGEN
SIV  10202,          -420.0, A1101,      0.992901 $ L-HYDROGEN
SIV  10224,          -420.0, A1101,      0.992901 $ L-HYDROGEN
SIV  10203,          -420.0, A1101,      1.637425 $ L-HYDROGEN
SIV  10223,          -420.0, A1101,      1.637425 $ L-HYDROGEN
SIV  10204,          -420.0, A1101,      2.256126 $ L-HYDROGEN
SIV  10222,          -420.0, A1101,      2.256126 $ L-HYDROGEN
SIV  10205,          -420.0, A1101,      2.839247 $ L-HYDROGEN
SIV  10221,          -420.0, A1101,      2.839247 $ L-HYDROGEN
SIV  10206,          -420.0, A1101,      3.377590 $ L-HYDROGEN
SIV  10220,          -420.0, A1101,      3.377590 $ L-HYDROGEN
SIV  10207,          -420.0, A1101,      3.862667 $ L-HYDROGEN
SIV  10219,          -420.0, A1101,      3.862667 $ L-HYDROGEN
SIV  10208,          -420.0, A1101,      4.286831 $ L-HYDROGEN
SIV  10218,          -420.0, A1101,      4.286831 $ L-HYDROGEN
SIV  10209,          -420.0, A1101,      4.643383 $ L-HYDROGEN
SIV  10217,          -420.0, A1101,      4.643383 $ L-HYDROGEN
SIV  10210,          -420.0, A1101,      4.926710 $ L-HYDROGEN
SIV  10216,          -420.0, A1101,      4.926710 $ L-HYDROGEN
SIV  10211,          -420.0, A1101,      5.132339 $ L-HYDROGEN
SIV  10215,          -420.0, A1101,      5.132339 $ L-HYDROGEN
SIV  10212,          -420.0, A1101,      5.257029 $ L-HYDROGEN
SIV  10214,          -420.0, A1101,      5.257029 $ L-HYDROGEN
SIV  10213,          -420.0, A1101,      5.298812 $ L-HYDROGEN
REM   REGION   5,  LAYER NO.   10
SIV  10226,          -420.0, A1301,      0.238218 $ G-HYDROGEN
SIV  10250,          -420.0, A1301,      0.238218 $ G-HYDROGEN
SIV  10227,          -420.0, A1301,      0.710893 $ G-HYDROGEN
SIV  10249,          -420.0, A1301,      0.710893 $ G-HYDROGEN
SIV  10228,          -420.0, A1301,      1.172358 $ G-HYDROGEN
SIV  10248,          -420.0, A1301,      1.172358 $ G-HYDROGEN
SIV  10229,          -420.0, A1301,      1.615333 $ G-HYDROGEN
SIV  10247,          -420.0, A1301,      1.615333 $ G-HYDROGEN
SIV  10230,          -420.0, A1301,      2.032833 $ G-HYDROGEN
SIV  10246,          -420.0, A1301,      2.032833 $ G-HYDROGEN
SIV  10231,          -420.0, A1301,      2.418274 $ G-HYDROGEN
SIV  10245,          -420.0, A1301,      2.418274 $ G-HYDROGEN
SIV  10232,          -420.0, A1301,      2.765579 $ G-HYDROGEN
SIV  10244,          -420.0, A1301,      2.765579 $ G-HYDROGEN
SIV  10233,          -420.0, A1301,      3.069269 $ G-HYDROGEN
SIV  10243,          -420.0, A1301,      3.069269 $ G-HYDROGEN
SIV  10234,          -420.0, A1301,      3.324553 $ G-HYDROGEN
SIV  10242,          -420.0, A1301,      3.324553 $ G-HYDROGEN
```

```
SIV  10235,        -420.0, A1301,     3.527408 $ G-HYDROGEN
SIV  10241,        -420.0, A1301,     3.527408 $ G-HYDROGEN
SIV  10236,        -420.0, A1301,     3.674633 $ G-HYDROGEN
SIV  10240,        -420.0, A1301,     3.674633 $ G-HYDROGEN
SIV  10237,        -420.0, A1301,     3.763907 $ G-HYDROGEN
SIV  10239,        -420.0, A1301,     3.763907 $ G-HYDROGEN
SIV  10238,        -420.0, A1301,     3.793823 $ G-HYDROGEN
REM   REGION  5,  LAYER NO.  11
SIV  10251,        -420.0, A1301,     0.159468 $ G-HYDROGEN
SIV  10275,        -420.0, A1301,     0.159468 $ G-HYDROGEN
SIV  10252,        -420.0, A1301,     0.475887 $ G-HYDROGEN
SIV  10274,        -420.0, A1301,     0.475887 $ G-HYDROGEN
SIV  10253,        -420.0, A1301,     0.784801 $ G-HYDROGEN
SIV  10273,        -420.0, A1301,     0.784801 $ G-HYDROGEN
SIV  10254,        -420.0, A1301,     1.081338 $ G-HYDROGEN
SIV  10272,        -420.0, A1301,     1.081338 $ G-HYDROGEN
SIV  10255,        -420.0, A1301,     1.360822 $ G-HYDROGEN
SIV  10271,        -420.0, A1301,     1.360822 $ G-HYDROGEN
SIV  10256,        -420.0, A1301,     1.618845 $ G-HYDROGEN
SIV  10270,        -420.0, A1301,     1.618845 $ G-HYDROGEN
SIV  10257,        -420.0, A1301,     1.851336 $ G-HYDROGEN
SIV  10269,        -420.0, A1301,     1.851336 $ G-HYDROGEN
SIV  10258,        -420.0, A1301,     2.054634 $ G-HYDROGEN
SIV  10268,        -420.0, A1301,     2.054634 $ G-HYDROGEN
SIV  10259,        -420.0, A1301,     2.225527 $ G-HYDROGEN
SIV  10267,        -420.0, A1301,     2.225527 $ G-HYDROGEN
SIV  10260,        -420.0, A1301,     2.361322 $ G-HYDROGEN
SIV  10266,        -420.0, A1301,     2.361322 $ G-HYDROGEN
SIV  10261,        -420.0, A1301,     2.459879 $ G-HYDROGEN
SIV  10265,        -420.0, A1301,     2.459879 $ G-HYDROGEN
SIV  10262,        -420.0, A1301,     2.519641 $ G-HYDROGEN
SIV  10264,        -420.0, A1301,     2.519641 $ G-HYDROGEN
SIV  10263,        -420.0, A1301,     2.539666 $ G-HYDROGEN
REM   REGION  5,  LAYER NO.  12
SIV  10276,        -420.0, A1301,     0.096468 $ G-HYDROGEN
SIV  10300,        -420.0, A1301,     0.096468 $ G-HYDROGEN
SIV  10277,        -420.0, A1301,     0.287883 $ G-HYDROGEN
SIV  10299,        -420.0, A1301,     0.287883 $ G-HYDROGEN
SIV  10278,        -420.0, A1301,     0.474757 $ G-HYDROGEN
SIV  10298,        -420.0, A1301,     0.474757 $ G-HYDROGEN
SIV  10279,        -420.0, A1301,     0.654143 $ G-HYDROGEN
SIV  10297,        -420.0, A1301,     0.654143 $ G-HYDROGEN
SIV  10280,        -420.0, A1301,     0.823214 $ G-HYDROGEN
SIV  10296,        -420.0, A1301,     0.823214 $ G-HYDROGEN
SIV  10281,        -420.0, A1301,     0.979301 $ G-HYDROGEN
SIV  10295,        -420.0, A1301,     0.979301 $ G-HYDROGEN
SIV  10282,        -420.0, A1301,     1.119945 $ G-HYDROGEN
SIV  10294,        -420.0, A1301,     1.119945 $ G-HYDROGEN
SIV  10283,        -420.0, A1301,     1.242927 $ G-HYDROGEN
SIV  10293,        -420.0, A1301,     1.242927 $ G-HYDROGEN
SIV  10284,        -420.0, A1301,     1.346305 $ G-HYDROGEN
SIV  10292,        -420.0, A1301,     1.346305 $ G-HYDROGEN
SIV  10285,        -420.0, A1301,     1.428453 $ G-HYDROGEN
SIV  10291,        -420.0, A1301,     1.428453 $ G-HYDROGEN
SIV  10286,        -420.0, A1301,     1.488074 $ G-HYDROGEN
SIV  10290,        -420.0, A1301,     1.488074 $ G-HYDROGEN
SIV  10287,        -420.0, A1301,     1.524227 $ G-HYDROGEN
SIV  10289,        -420.0, A1301,     1.524227 $ G-HYDROGEN
SIV  10288,        -420.0, A1301,     1.536342 $ G-HYDROGEN
REM   REGION  5,  LAYER NO.  13
SIV  10301,        -420.0, A1301,     0.049218 $ G-HYDROGEN
SIV  10325,        -420.0, A1301,     0.049218 $ G-HYDROGEN
SIV  10302,        -420.0, A1301,     0.146879 $ G-HYDROGEN
SIV  10324,        -420.0, A1301,     0.146879 $ G-HYDROGEN
SIV  10303,        -420.0, A1301,     0.242223 $ G-HYDROGEN
SIV  10323,        -420.0, A1301,     0.242223 $ G-HYDROGEN
SIV  10304,        -420.0, A1301,     0.333747 $ G-HYDROGEN
SIV  10322,        -420.0, A1301,     0.333747 $ G-HYDROGEN
SIV  10305,        -420.0, A1301,     0.420007 $ G-HYDROGEN
SIV  10321,        -420.0, A1301,     0.420007 $ G-HYDROGEN
```

```
SIV  10306,         -420.0, A1301,     0.499644 $ G-HYDROGEN
SIV  10320,         -420.0, A1301,     0.499644 $ G-HYDROGEN
SIV  10307,         -420.0, A1301,     0.571401 $ G-HYDROGEN
SIV  10319,         -420.0, A1301,     0.571401 $ G-HYDROGEN
SIV  10308,         -420.0, A1301,     0.634147 $ G-HYDROGEN
SIV  10318,         -420.0, A1301,     0.634147 $ G-HYDROGEN
SIV  10309,         -420.0, A1301,     0.686891 $ G-HYDROGEN
SIV  10317,         -420.0, A1301,     0.686891 $ G-HYDROGEN
SIV  10310,         -420.0, A1301,     0.728803 $ G-HYDROGEN
SIV  10316,         -420.0, A1301,     0.728803 $ G-HYDROGEN
SIV  10311,         -420.0, A1301,     0.759222 $ G-HYDROGEN
SIV  10315,         -420.0, A1301,     0.759222 $ G-HYDROGEN
SIV  10312,         -420.0, A1301,     0.777667 $ G-HYDROGEN
SIV  10314,         -420.0, A1301,     0.777667 $ G-HYDROGEN
SIV  10313,         -420.0, A1301,     0.783848 $ G-HYDROGEN
REM   REGION  5,  LAYER NO.  14
SIV  10326,         -420.0, A1301,     0.017719 $ G-HYDROGEN
SIV  10350,         -420.0, A1301,     0.017719 $ G-HYDROGEN
SIV  10327,         -420.0, A1301,     0.052876 $ G-HYDROGEN
SIV  10349,         -420.0, A1301,     0.052876 $ G-HYDROGEN
SIV  10328,         -420.0, A1301,     0.087200 $ G-HYDROGEN
SIV  10348,         -420.0, A1301,     0.087200 $ G-HYDROGEN
SIV  10329,         -420.0, A1301,     0.120149 $ G-HYDROGEN
SIV  10347,         -420.0, A1301,     0.120149 $ G-HYDROGEN
SIV  10330,         -420.0, A1301,     0.151202 $ G-HYDROGEN
SIV  10346,         -420.0, A1301,     0.151202 $ G-HYDROGEN
SIV  10331,         -420.0, A1301,     0.179872 $ G-HYDROGEN
SIV  10345,         -420.0, A1301,     0.179872 $ G-HYDROGEN
SIV  10332,         -420.0, A1301,     0.205704 $ G-HYDROGEN
SIV  10344,         -420.0, A1301,     0.205704 $ G-HYDROGEN
SIV  10333,         -420.0, A1301,     0.228293 $ G-HYDROGEN
SIV  10343,         -420.0, A1301,     0.228293 $ G-HYDROGEN
SIV  10334,         -420.0, A1301,     0.247281 $ G-HYDROGEN
SIV  10342,         -420.0, A1301,     0.247281 $ G-HYDROGEN
SIV  10335,         -420.0, A1301,     0.262369 $ G-HYDROGEN
SIV  10341,         -420.0, A1301,     0.262369 $ G-HYDROGEN
SIV  10336,         -420.0, A1301,     0.273320 $ G-HYDROGEN
SIV  10340,         -420.0, A1301,     0.273320 $ G-HYDROGEN
SIV  10337,         -420.0, A1301,     0.279960 $ G-HYDROGEN
SIV  10339,         -420.0, A1301,     0.279960 $ G-HYDROGEN
SIV  10338,         -420.0, A1301,     0.282185 $ G-HYDROGEN
REM   REGION  5,  LAYER NO.  15
SIV  10351,         -420.0, A1301,     0.001969 $ G-HYDROGEN
SIV  10375,         -420.0, A1301,     0.001969 $ G-HYDROGEN
SIV  10352,         -420.0, A1301,     0.005875 $ G-HYDROGEN
SIV  10374,         -420.0, A1301,     0.005875 $ G-HYDROGEN
SIV  10353,         -420.0, A1301,     0.009689 $ G-HYDROGEN
SIV  10373,         -420.0, A1301,     0.009689 $ G-HYDROGEN
SIV  10354,         -420.0, A1301,     0.013350 $ G-HYDROGEN
SIV  10372,         -420.0, A1301,     0.013350 $ G-HYDROGEN
SIV  10355,         -420.0, A1301,     0.016800 $ G-HYDROGEN
SIV  10371,         -420.0, A1301,     0.016800 $ G-HYDROGEN
SIV  10356,         -420.0, A1301,     0.019986 $ G-HYDROGEN
SIV  10370,         -420.0, A1301,     0.019986 $ G-HYDROGEN
SIV  10357,         -420.0, A1301,     0.022856 $ G-HYDROGEN
SIV  10369,         -420.0, A1301,     0.022856 $ G-HYDROGEN
SIV  10358,         -420.0, A1301,     0.025366 $ G-HYDROGEN
SIV  10368,         -420.0, A1301,     0.025366 $ G-HYDROGEN
SIV  10359,         -420.0, A1301,     0.027476 $ G-HYDROGEN
SIV  10367,         -420.0, A1301,     0.027476 $ G-HYDROGEN
SIV  10360,         -420.0, A1301,     0.029152 $ G-HYDROGEN
SIV  10366,         -420.0, A1301,     0.029152 $ G-HYDROGEN
SIV  10361,         -420.0, A1301,     0.030369 $ G-HYDROGEN
SIV  10365,         -420.0, A1301,     0.030369 $ G-HYDROGEN
SIV  10362,         -420.0, A1301,     0.031107 $ G-HYDROGEN
SIV  10364,         -420.0, A1301,     0.031107 $ G-HYDROGEN
SIV  10363,         -420.0, A1301,     0.031354 $ G-HYDROGEN
    -20001,         -424.0,      1.000000            $ HEAT EXCHANGER 1
    -20002,         -424.0,      1.000000            $ HEAT EXCHANGER 2
    -20003,         -400.0,      1.000000            $ HEAT EXCHANGER 3
```

```
    -20301,            140.0,     1.000000            $ OUTSIDE ATMOS 1
    -20302,            440.0,     1.000000            $ OUTSIDE ATMOS 2
END
BCD 3SOURCE DATA
GEN  7001, 2,24, 7.8334E-03 $ Q(BTU/HR) BASED ON  12.50BTU/HR ON SPHERE
GEN  7002, 2,22, 2.3376E-02 $ Q(BTU/HR) BASED ON  12.50BTU/HR ON SPHERE
GEN  7003, 2,20, 3.8551E-02 $ Q(BTU/HR) BASED ON  12.50BTU/HR ON SPHERE
GEN  7004, 2,18, 5.3117E-02 $ Q(BTU/HR) BASED ON  12.50BTU/HR ON SPHERE
GEN  7005, 2,16, 6.6846E-02 $ Q(BTU/HR) BASED ON  12.50BTU/HR ON SPHERE
GEN  7006, 2,14, 7.9521E-02 $ Q(BTU/HR) BASED ON  12.50BTU/HR ON SPHERE
GEN  7007, 2,12, 9.0941E-02 $ Q(BTU/HR) BASED ON  12.50BTU/HR ON SPHERE
GEN  7008, 2,10, 1.0093E-01 $ Q(BTU/HR) BASED ON  12.50BTU/HR ON SPHERE
GEN  7009, 2, 8, 1.0932E-01 $ Q(BTU/HR) BASED ON  12.50BTU/HR ON SPHERE
GEN  7010, 2, 6, 1.1599E-01 $ Q(BTU/HR) BASED ON  12.50BTU/HR ON SPHERE
GEN  7011, 2, 4, 1.2083E-01 $ Q(BTU/HR) BASED ON  12.50BTU/HR ON SPHERE
GEN  7012, 2, 2, 1.2377E-01 $ Q(BTU/HR) BASED ON  12.50BTU/HR ON SPHERE
     7013,            1.2475E-01 $ Q(BTU/HR) BASED ON 12.50BTU/HR ON SPHERE
END
BCD 3CONDUCTOR DATA
REM  RADIAL CONDUCTORS,  CONDUCTION
REM  RADIAL CONDUCTORS REGION 1, LAYER  1 TO BOUNDARY   1- 4
SIV     1,         1001,     2001,     A6204, 3.795743E+01
SIV     2,         1025,     2025,     A6204, 3.795743E+01
SIV     3,        20001,     2002,     A6204, 1.132733E+02
SIV     4,         1024,     2024,     A6204, 1.132733E+02
SIV     5,        20001,     2003,     A6204, 1.868028E+02
SIV     6,         1023,     2023,     A6204, 1.868028E+02
SIV     7,        20001,     2004,     A6204, 2.573862E+02
SIV     8,         1022,     2022,     A6204, 2.573862E+02
SIV     9,        20001,     2005,     A6204, 3.239102E+02
SIV    10,         1021,     2021,     A6204, 3.239102E+02
SIV    11,         1006,     2006,     A6204, 3.853262E+02
SIV    12,         1020,     2020,     A6204, 3.853262E+02
SIV    13,         1007,     2007,     A6204, 4.406655E+02
SIV    14,         1019,     2019,     A6204, 4.406655E+02
SIV    15,         1008,     2008,     A6204, 4.890552E+02
SIV    16,         1018,     2018,     A6204, 4.890552E+02
SIV    17,         1009,     2009,     A6204, 5.297319E+02
SIV    18,         1017,     2017,     A6204, 5.297319E+02
SIV    19,         1010,     2010,     A6204, 5.620549E+02
SIV    20,         1016,     2016,     A6204, 5.620549E+02
SIV    21,         1011,     2011,     A6204, 5.855137E+02
SIV    22,         1015,     2015,     A6204, 5.855137E+02
SIV    23,         1012,     2012,     A6204, 5.997388E+02
SIV    24,         1014,     2014,     A6204, 5.997388E+02
SIV    25,         1013,     2013,     A6204, 6.045054E+02
REM  RADIAL CONDUCTORS REGION 1, LAYER  1 TO LAYER  2
DIM    26,  2,1, 2001,24,  2026,24,A6204, 3.827370E+01,A6204, 3.859138E+01
DIM    28,  2,1, 2002,22,  2027,22,A6204, 1.142172E+02,A6204, 1.151651E+02
DIM    30,  2,1, 2003,20,  2028,20,A6204, 1.883593E+02,A6204, 1.899227E+02
DIM    32,  2,1, 2004,18,  2029,18,A6204, 2.595308E+02,A6204, 2.616851E+02
DIM    34,  2,1, 2005,16,  2030,16,A6204, 3.266091E+02,A6204, 3.293198E+02
DIM    36,  2,1, 2006,14,  2031,14,A6204, 3.885371E+02,A6204, 3.917617E+02
DIM    38,  2,1, 2007,12,  2032,12,A6204, 4.443372E+02,A6204, 4.480251E+02
DIM    40,  2,1, 2008,10,  2033,10,A6204, 4.931304E+02,A6204, 4.972234E+02
DIM    42,  2,1, 2009, 8,  2034, 8,A6204, 5.341462E+02,A6204, 5.385793E+02
DIM    44,  2,1, 2010, 6,  2035, 6,A6204, 5.667383E+02,A6204, 5.714419E+02
DIM    46,  2,1, 2011, 4,  2036, 4,A6204, 5.903926E+02,A6204, 5.952927E+02
DIM    48,  2,1, 2012, 2,  2037, 2,A6204, 6.047361E+02,A6204, 6.097551E+02
DIM    50,  1,1, 2013, 0,  2038, 0,A6204, 6.095425E+02,A6204, 6.146016E+02
REM  RADIAL CONDUCTORS REGION 1, LAYER  2 TO LAYER  3
DIM    51,  2,1, 2026,24,  2051,24,A6204, 3.891029E+01,A6204, 3.923051E+01
DIM    53,  2,1, 2027,22,  2052,22,A6204, 1.161168E+02,A6204, 1.170724E+02
DIM    55,  2,1, 2028,20,  2053,20,A6204, 1.914922E+02,A6204, 1.930679E+02
DIM    57,  2,1, 2029,18,  2054,18,A6204, 2.638474E+02,A6204, 2.660188E+02
DIM    59,  2,1, 2030,16,  2055,16,A6204, 3.320415E+02,A6204, 3.347742E+02
DIM    61,  2,1, 2031,14,  2056,14,A6204, 3.949993E+02,A6204, 3.982502E+02
DIM    63,  2,1, 2032,12,  2057,12,A6204, 4.517275E+02,A6204, 4.554451E+02
DIM    65,  2,1, 2033,10,  2058,10,A6204, 5.013323E+02,A6204, 5.054583E+02
DIM    67,  2,1, 2034, 8,  2059, 8,A6204, 5.430303E+02,A6204, 5.474993E+02
```

```
DIM    69,  2,1, 2035, 6, 2060, 6,A6204, 5.761646E+02,A6204, 5.809060E+02
DIM    71,  2,1, 2036, 4, 2061, 4,A6204, 6.002122E+02,A6204, 6.051519E+02
DIM    73,  2,1, 2037, 2, 2062, 2,A6204, 6.147942E+02,A6204, 6.198540E+02
DIM    75,  1,1, 2038, 0, 2063, 0,A6204, 6.196807E+02,A6204, 6.247805E+02
REM  RADIAL CONDUCTORS REGION 1, LAYER  3 TO BOUNDARY   1- 2
SIM    76,  2,1, 2051,24, 3001,24, A6204, 3.955209E+01
SIM    78,  2,1, 2052,22, 3002,22, A6204, 1.180322E+02
SIM    80,  2,1, 2053,20, 3003,20, A6204, 1.946507E+02
SIM    82,  2,1, 2054,18, 3004,18, A6204, 2.681995E+02
SIM    84,  2,1, 2055,16, 3005,16, A6204, 3.375186E+02
SIM    86,  2,1, 2056,14, 3006,14, A6204, 4.015146E+02
SIM    88,  2,1, 2057,12, 3007,12, A6204, 4.591790E+02
SIM    90,  2,1, 2058,10, 3008,10, A6204, 5.096018E+02
SIM    92,  2,1, 2059, 8, 3009, 8, A6204, 5.519873E+02
SIM    94,  2,1, 2060, 6, 3010, 6, A6204, 5.856682E+02
SIM    96,  2,1, 2061, 4, 3011, 4, A6204, 6.101125E+02
SIM    98,  2,1, 2062, 2, 3012, 2, A6204, 6.249351E+02
SIM   100,  1,1, 2063, 0, 3013, 0, A6204, 6.299023E+02
REM  CIRCUMFERENTIAL CONDUCTORS; Y- DIRECTION,  CONDUCTION
REM  CIRCUMFERENTIAL CONDUCTORS REGION 1, LAYER NUMBER  1
DIM   101,  2,1, 2001,23, 2002,23,A6204, 1.662292E-01,A6204, 4.960644E-01
DIM   103,  2,1, 2002,21, 2003,21,A6204, 4.960644E-01,A6204, 8.180760E-01
DIM   105,  2,1, 2003,19, 2004,19,A6204, 8.180760E-01,A6204, 1.127185E+00
DIM   107,  2,1, 2004,17, 2005,17,A6204, 1.127185E+00,A6204, 1.418519E+00
DIM   109,  2,1, 2005,15, 2006,15,A6204, 1.418519E+00,A6204, 1.687482E+00
DIM   111,  2,1, 2006,13, 2007,13,A6204, 1.687482E+00,A6204, 1.929832E+00
DIM   113,  2,1, 2007,11, 2008,11,A6204, 1.929832E+00,A6204, 2.141749E+00
DIM   115,  2,1, 2008, 9, 2009, 9,A6204, 2.141749E+00,A6204, 2.319886E+00
DIM   117,  2,1, 2009, 7, 2010, 7,A6204, 2.319886E+00,A6204, 2.461440E+00
DIM   119,  2,1, 2010, 5, 2011, 5,A6204, 2.461440E+00,A6204, 2.564175E+00
DIM   121,  2,1, 2011, 3, 2012, 3,A6204, 2.564175E+00,A6204, 2.626471E+00
DIM   123,  2,1, 2012, 1, 2013, 1,A6204, 2.626471E+00,A6204, 2.647346E+00
REM  CIRCUMFERENTIAL CONDUCTORS REGION 1, LAYER NUMBER  2
DIM   125,  2,1, 2026,23, 2027,23,A6204, 1.662292E-01,A6204, 4.960645E-01
DIM   127,  2,1, 2027,21, 2028,21,A6204, 4.960645E-01,A6204, 8.180764E-01
DIM   129,  2,1, 2028,19, 2029,19,A6204, 8.180764E-01,A6204, 1.127187E+00
DIM   131,  2,1, 2029,17, 2030,17,A6204, 1.127187E+00,A6204, 1.418519E+00
DIM   133,  2,1, 2030,15, 2031,15,A6204, 1.418519E+00,A6204, 1.687482E+00
DIM   135,  2,1, 2031,13, 2032,13,A6204, 1.687482E+00,A6204, 1.929832E+00
DIM   137,  2,1, 2032,11, 2033,11,A6204, 1.929832E+00,A6204, 2.141749E+00
DIM   139,  2,1, 2033, 9, 2034, 9,A6204, 2.141749E+00,A6204, 2.319886E+00
DIM   141,  2,1, 2034, 7, 2035, 7,A6204, 2.319886E+00,A6204, 2.461439E+00
DIM   143,  2,1, 2035, 5, 2036, 5,A6204, 2.461439E+00,A6204, 2.564175E+00
DIM   145,  2,1, 2036, 3, 2037, 3,A6204, 2.564175E+00,A6204, 2.626471E+00
DIM   147,  2,1, 2037, 1, 2038, 1,A6204, 2.626471E+00,A6204, 2.647346E+00
REM  CIRCUMFERENTIAL CONDUCTORS REGION 1, LAYER NUMBER  3
DIM   149,  2,1, 2051,23, 2052,23,A6204, 1.662292E-01,A6204, 4.960643E-01
DIM   151,  2,1, 2052,21, 2053,21,A6204, 4.960643E-01,A6204, 8.180760E-01
DIM   153,  2,1, 2053,19, 2054,19,A6204, 8.180760E-01,A6204, 1.127186E+00
DIM   155,  2,1, 2054,17, 2055,17,A6204, 1.127186E+00,A6204, 1.418519E+00
DIM   157,  2,1, 2055,15, 2056,15,A6204, 1.418519E+00,A6204, 1.687482E+00
DIM   159,  2,1, 2056,13, 2057,13,A6204, 1.687482E+00,A6204, 1.929832E+00
DIM   161,  2,1, 2057,11, 2058,11,A6204, 1.929832E+00,A6204, 2.141748E+00
DIM   163,  2,1, 2058, 9, 2059, 9,A6204, 2.141748E+00,A6204, 2.319886E+00
DIM   165,  2,1, 2059, 7, 2060, 7,A6204, 2.319886E+00,A6204, 2.461440E+00
DIM   167,  2,1, 2060, 5, 2061, 5,A6204, 2.461440E+00,A6204, 2.564175E+00
DIM   169,  2,1, 2061, 3, 2062, 3,A6204, 2.564175E+00,A6204, 2.626471E+00
DIM   171,  2,1, 2062, 1, 2063, 1,A6204, 2.626471E+00,A6204, 2.647346E+00
REM  RADIAL CONDUCTORS,  CONDUCTION
REM  RADIAL CONDUCTORS REGION 2, LAYER  1 TO BOUNDARY   2- 1
SIM   173,  2,1, 3001,24, 4001,24, A6204, 2.663728E+01
SIM   175,  2,1, 3002,22, 4002,22, A6204, 7.949152E+01
SIM   177,  2,1, 3003,20, 4003,20, A6204, 1.310920E+02
SIM   179,  2,1, 3004,18, 4004,18, A6204, 1.806254E+02
SIM   181,  2,1, 3005,16, 4005,16, A6204, 2.273097E+02
SIM   183,  2,1, 3006,14, 4006,14, A6204, 2.704094E+02
SIM   185,  2,1, 3007,12, 4007,12, A6204, 3.092446E+02
SIM   187,  2,1, 3008,10, 4008,10, A6204, 3.432031E+02
SIM   189,  2,1, 3009, 8, 4009, 8, A6204, 3.717488E+02
SIM   191,  2,1, 3010, 6, 4010, 6, A6204, 3.944319E+02
```

```
SIM   193,  2,1, 3011, 4, 4011, 4, A6204, 4.108945E+02
SIM   195,  2,1, 3012, 2, 4012, 2, A6204, 4.208772E+02
SIM   197,  1,1, 3013, 0, 4013, 0, A6204, 4.242222E+02
REM  RADIAL CONDUCTORS REGION 2, LAYER  1 TO BOUNDARY   2- 3
SIM   198,  2,1, 4001,24, 5001,24, A6204, 2.696213E+01
SIM   200,  2,1, 4002,22, 5002,22, A6204, 8.046094E+01
SIM   202,  2,1, 4003,20, 5003,20, A6204, 1.326908E+02
SIM   204,  2,1, 4004,18, 5004,18, A6204, 1.828280E+02
SIM   206,  2,1, 4005,16, 5005,16, A6204, 2.300818E+02
SIM   208,  2,1, 4006,14, 5006,14, A6204, 2.737070E+02
SIM   210,  2,1, 4007,12, 5007,12, A6204, 3.130161E+02
SIM   212,  2,1, 4008,10, 5008,10, A6204, 3.473887E+02
SIM   214,  2,1, 4009, 8, 5009, 8, A6204, 3.762822E+02
SIM   216,  2,1, 4010, 6, 5010, 6, A6204, 3.992419E+02
SIM   218,  2,1, 4011, 4, 5011, 4, A6204, 4.159053E+02
SIM   220,  2,1, 4012, 2, 5012, 2, A6204, 4.260098E+02
SIM   222,  1,1, 4013, 0, 5013, 0, A6204, 4.293958E+02
REM  CIRCUMFERENTIAL CONDUCTORS; Y- DIRECTION,  CONDUCTION
REM  CIRCUMFERENTIAL CONDUCTORS REGION 2, LAYER NUMBER  1
DIM   223,  2,1, 4001,23, 4002,23,A6204, 2.493440E-01,A6204, 7.440972E-01
DIM   225,  2,1, 4002,21, 4003,21,A6204, 7.440972E-01,A6204, 1.227115E+00
DIM   227,  2,1, 4003,19, 4004,19,A6204, 1.227115E+00,A6204, 1.690781E+00
DIM   229,  2,1, 4004,17, 4005,17,A6204, 1.690781E+00,A6204, 2.127781E+00
DIM   231,  2,1, 4005,15, 4006,15,A6204, 2.127781E+00,A6204, 2.531224E+00
DIM   233,  2,1, 4006,13, 4007,13,A6204, 2.531224E+00,A6204, 2.894751E+00
DIM   235,  2,1, 4007,11, 4008,11,A6204, 2.894751E+00,A6204, 3.212626E+00
DIM   237,  2,1, 4008, 9, 4009, 9,A6204, 3.212626E+00,A6204, 3.479833E+00
DIM   239,  2,1, 4009, 7, 4010, 7,A6204, 3.479833E+00,A6204, 3.692163E+00
DIM   241,  2,1, 4010, 5, 4011, 5,A6204, 3.692163E+00,A6204, 3.846264E+00
DIM   243,  2,1, 4011, 3, 4012, 3,A6204, 3.846264E+00,A6204, 3.939709E+00
DIM   245,  2,1, 4012, 1, 4013, 1,A6204, 3.939709E+00,A6204, 3.971023E+00
REM  RADIAL CONDUCTORS,  CONDUCTION
REM  RADIAL CONDUCTORS REGION 3, LAYER  1 TO BOUNDARY   3- 2
SIM   247,  2,1, 5001,24, 6001,24, A6202, 6.797668E+01
SIM   249,  2,1, 5002,22, 6002,22, A6202, 2.028573E+02
SIM   251,  2,1, 5003,20, 6003,20, A6202, 3.345383E+02
SIM   253,  2,1, 5004,18, 6004,18, A6202, 4.609441E+02
SIM   255,  2,1, 5005,16, 6005,16, A6202, 5.800801E+02
SIM   257,  2,1, 5006,14, 6006,14, A6202, 6.900679E+02
SIM   259,  2,1, 5007,12, 6007,12, A6202, 7.891729E+02
SIM   261,  2,1, 5008,10, 6008,10, A6202, 8.758328E+02
SIM   263,  2,1, 5009, 8, 6009, 8, A6202, 9.486792E+02
SIM   265,  2,1, 5010, 6, 6010, 6, A6202, 1.006565E+03
SIM   267,  2,1, 5011, 4, 6011, 4, A6202, 1.048577E+03
SIM   269,  2,1, 5012, 2, 6012, 2, A6202, 1.074052E+03
SIM   271,  1,1, 5013, 0, 6013, 0, A6202, 1.082588E+03
REM  RADIAL CONDUCTORS REGION 3, LAYER  1 TO LAYER  2
DIM   272,  2,1, 6001,24, 6026,24,A6202, 6.830429E+01,A6202, 6.863269E+01
DIM   274,  2,1, 6002,22, 6027,22,A6202, 2.038349E+02,A6202, 2.048150E+02
DIM   276,  2,1, 6003,20, 6028,20,A6202, 3.361506E+02,A6202, 3.377671E+02
DIM   278,  2,1, 6004,18, 6029,18,A6202, 4.631653E+02,A6202, 4.653926E+02
DIM   280,  2,1, 6005,16, 6030,16,A6202, 5.828757E+02,A6202, 5.856785E+02
DIM   282,  2,1, 6006,14, 6031,14,A6202, 6.933936E+02,A6202, 6.967273E+02
DIM   284,  2,1, 6007,12, 6032,12,A6202, 7.929763E+02,A6202, 7.967888E+02
DIM   286,  2,1, 6008,10, 6033,10,A6202, 8.800537E+02,A6202, 8.842852E+02
DIM   288,  2,1, 6009, 8, 6034, 8,A6202, 9.532512E+02,A6202, 9.578347E+02
DIM   290,  2,1, 6010, 6, 6035, 6,A6202, 1.011416E+03,A6202, 1.016279E+03
DIM   292,  2,1, 6011, 4, 6036, 4,A6202, 1.053630E+03,A6202, 1.058697E+03
DIM   294,  2,1, 6012, 2, 6037, 2,A6202, 1.079228E+03,A6202, 1.084417E+03
DIM   296,  1,1, 6013, 0, 6038, 0,A6202, 1.087806E+03,A6202, 1.093036E+03
REM  RADIAL CONDUCTORS REGION 3, LAYER  2 TO BOUNDARY   3- 4
SIV   297,        6026,     7001,     A6202, 6.896176E+01
SIV   298,        6050,     7025,     A6202, 6.896176E+01
SIV   299,        6027,     7002,     A6202, 2.057971E+02
SIV   300,        6049,     7024,     A6202, 2.057971E+02
SIV   301,        6028,     7003,     A6202, 3.393865E+02
SIV   302,        6048,     7023,     A6202, 3.393865E+02
SIV   303,        6029,     7004,     A6202, 4.676240E+02
SIV   304,        6047,     7022,     A6202, 4.676240E+02
SIV   305,        6030,     7005,     A6202, 5.884863E+02
```

```
SIV   306,         6046,     7021,      A6202, 5.884863E+02
SIV   307,         6031,     7006,      A6202, 7.000681E+02
SIV   308,         6045,     7020,      A6202, 7.000681E+02
SIV   309,         6032,     7007,      A6202, 8.006094E+02
SIV   310,         6044,     7019,      A6202, 8.006094E+02
SIV   311,         6033,     7008,      A6202, 8.885251E+02
SIV   312,         6043,     7018,      A6202, 8.885251E+02
SIV   313,         6034,     7009,      A6202, 9.624272E+02
SIV   314,         6042,     7017,      A6202, 9.624272E+02
SIV   315,         6035,    20003,      A6202, 1.021152E+03
SIV   316,         6041,     7016,      A6202, 1.021152E+03
SIV   317,         6036,    20003,      A6202, 1.063772E+03
SIV   318,         6040,     7015,      A6202, 1.063772E+03
SIV   319,         6037,    20003,      A6202, 1.089617E+03
SIV   320,         6039,     7014,      A6202, 1.089617E+03
SIV   321,         6038,     7013,      A6202, 1.098277E+03
REM  CIRCUMFERENTIAL CONDUCTORS; Y- DIRECTION,  CONDUCTION
REM  CIRCUMFERENTIAL CONDUCTORS REGION 3, LAYER NUMBER  1
DIM   322,  2,1,  6001,23,  6002,23,A6202,  9.973752E-02,A6202,  2.976390E-01
DIM   324,  2,1,  6002,21,  6003,21,A6202,  2.976390E-01,A6202,  4.908463E-01
DIM   326,  2,1,  6003,19,  6004,19,A6202,  4.908463E-01,A6202,  6.763121E-01
DIM   328,  2,1,  6004,17,  6005,17,A6202,  6.763121E-01,A6202,  8.511126E-01
DIM   330,  2,1,  6005,15,  6006,15,A6202,  8.511126E-01,A6202,  1.012489E+00
DIM   332,  2,1,  6006,13,  6007,13,A6202,  1.012489E+00,A6202,  1.157900E+00
DIM   334,  2,1,  6007,11,  6008,11,A6202,  1.157900E+00,A6202,  1.285050E+00
DIM   336,  2,1,  6008, 9,  6009, 9,A6202,  1.285050E+00,A6202,  1.391932E+00
DIM   338,  2,1,  6009, 7,  6010, 7,A6202,  1.391932E+00,A6202,  1.476865E+00
DIM   340,  2,1,  6010, 5,  6011, 5,A6202,  1.476865E+00,A6202,  1.538506E+00
DIM   342,  2,1,  6011, 3,  6012, 3,A6202,  1.538506E+00,A6202,  1.575884E+00
DIM   344,  2,1,  6012, 1,  6013, 1,A6202,  1.575884E+00,A6202,  1.588408E+00
REM  CIRCUMFERENTIAL CONDUCTORS REGION 3, LAYER NUMBER  2
DIM   346,  2,1,  6026,23,  6027,23,A6202,  9.973752E-02,A6202,  2.976389E-01
DIM   348,  2,1,  6027,21,  6028,21,A6202,  2.976389E-01,A6202,  4.908462E-01
DIM   350,  2,1,  6028,19,  6029,19,A6202,  4.908462E-01,A6202,  6.763124E-01
DIM   352,  2,1,  6029,17,  6030,17,A6202,  6.763124E-01,A6202,  8.511118E-01
DIM   354,  2,1,  6030,15,  6031,15,A6202,  8.511118E-01,A6202,  1.012489E+00
DIM   356,  2,1,  6031,13,  6032,13,A6202,  1.012489E+00,A6202,  1.157900E+00
DIM   358,  2,1,  6032,11,  6033,11,A6202,  1.157900E+00,A6202,  1.285049E+00
DIM   360,  2,1,  6033, 9,  6034, 9,A6202,  1.285049E+00,A6202,  1.391932E+00
DIM   362,  2,1,  6034, 7,  6035, 7,A6202,  1.391932E+00,A6202,  1.476865E+00
DIM   364,  2,1,  6035, 5,  6036, 5,A6202,  1.476865E+00,A6202,  1.538506E+00
DIM   366,  2,1,  6036, 3,  6037, 3,A6202,  1.538506E+00,A6202,  1.575884E+00
DIM   368,  2,1,  6037, 1,  6038, 1,A6202,  1.575884E+00,A6202,  1.588408E+00
REM  RADIAL CONDUCTORS,   CONDUCTION
REM  RADIAL CONDUCTORS REGION 4, LAYER  1 TO BOUNDARY    4- 1
SIV   370,         1001,     8001,      A6101, 4.883705E+00
SIV   371,         1025,     8025,      A6301, 4.883705E+00
SIV   372,        20001,     8002,      A6101, 1.457405E+01
SIV   373,         1024,     8024,      A6301, 1.457405E+01
SIV   374,        20001,     8003,      A6101, 2.403455E+01
SIV   375,         1023,     8023,      A6301, 2.403455E+01
SIV   376,        20001,     8004,      A6101, 3.311601E+01
SIV   377,         1022,     8022,      A6301, 3.311601E+01
SIV   378,        20001,     8005,      A6101, 4.167517E+01
SIV   379,         1021,     8021,      A6301, 4.167517E+01
SIV   380,         1006,     8006,      A6101, 4.957712E+01
SIV   381,         1020,     8020,      A6301, 4.957712E+01
SIV   382,         1007,     8007,      A6101, 5.669720E+01
SIV   383,         1019,     8019,      A6301, 5.669720E+01
SIV   384,         1008,     8008,      A6101, 6.292319E+01
SIV   385,         1018,     8018,      A6301, 6.292319E+01
SIV   386,         1009,     8009,      A6101, 6.815675E+01
SIV   387,         1017,     8017,      A6301, 6.815675E+01
SIV   388,         1010,     8010,      A6101, 7.231549E+01
SIV   389,         1016,     8016,      A6301, 7.231549E+01
SIV   390,         1011,     8011,      A6101, 7.533379E+01
SIV   391,         1015,     8015,      A6101, 7.533379E+01
SIV   392,         1012,     8012,      A6101, 7.716400E+01
SIV   393,         1014,     8014,      A6101, 7.716400E+01
SIV   394,         1013,     8013,      A6101, 7.777728E+01
```

```
REM   RADIAL CONDUCTORS REGION 4, LAYER  1 TO LAYER  2
DIM    395,   1,1, 8001,24, 8026,24,A6101, 4.578548E+00,A6101, 4.283237E+00
DIM    396,   1,1, 8025,24, 8050,24,A6301, 4.578548E+00,A6301, 4.283237E+00
DIM    397,   1,1, 8002,22, 8027,22,A6101, 1.366340E+01,A6101, 1.278213E+01
DIM    398,   1,1, 8024,22, 8049,22,A6301, 1.366340E+01,A6301, 1.278213E+01
DIM    399,   1,1, 8003,20, 8028,20,A6101, 2.253276E+01,A6101, 2.107942E+01
DIM    400,   1,1, 8023,20, 8048,20,A6301, 2.253276E+01,A6301, 2.107942E+01
DIM    401,   1,1, 8004,18, 8029,18,A6101, 3.104677E+01,A6101, 2.904428E+01
DIM    402,   1,1, 8022,18, 8047,18,A6301, 3.104677E+01,A6301, 2.904428E+01
DIM    403,   1,1, 8005,16, 8030,16,A6101, 3.907111E+01,A6101, 3.655109E+01
DIM    404,   1,1, 8021,16, 8046,16,A6301, 3.907111E+01,A6301, 3.655109E+01
DIM    405,   1,1, 8006,14, 8031,14,A6101, 4.647931E+01,A6101, 4.348146E+01
DIM    406,   1,1, 8020,14, 8045,14,A6301, 4.647931E+01,A6301, 4.348146E+01
DIM    407,   1,1, 8007,12, 8032,12,A6101, 5.315454E+01,A6101, 4.972612E+01
DIM    408,   1,1, 8019,12, 8044,12,A6301, 5.315454E+01,A6301, 4.972612E+01
DIM    409,   1,1, 8008,10, 8033,10,A6101, 5.899147E+01,A6101, 5.518658E+01
DIM    410,   1,1, 8018,10, 8043,10,A6301, 5.899147E+01,A6301, 5.518658E+01
DIM    411,   1,1, 8009, 8, 8034, 8,A6101, 6.389801E+01,A6101, 5.977667E+01
DIM    412,   1,1, 8017, 8, 8042, 8,A6301, 6.389801E+01,A6301, 5.977667E+01
DIM    413,   1,1, 8010, 6, 8035, 6,A6101, 6.779689E+01,A6101, 6.342407E+01
DIM    414,   1,1, 8016, 6, 8041, 6,A6301, 6.779689E+01,A6301, 6.342407E+01
DIM    415,   1,1, 8011, 4, 8036, 4,A6101, 7.062659E+01,A6101, 6.607126E+01
DIM    416,   1,1, 8015, 4, 8040, 4,A6101, 7.062659E+01,A6101, 6.607126E+01
DIM    417,   1,1, 8012, 2, 8037, 2,A6101, 7.234245E+01,A6101, 6.767645E+01
DIM    418,   1,1, 8014, 2, 8039, 2,A6101, 7.234245E+01,A6101, 6.767645E+01
DIM    419,   1,1, 8013, 0, 8038, 0,A6101, 7.291742E+01,A6101, 6.821432E+01
REM   RADIAL CONDUCTORS REGION 4, LAYER  2 TO LAYER  3
SIV    420,        8026,     8051,     A6101, 3.997772E+00
SIV    421,        8026,     8026,     A6101, 3.997772E+00
SIV    422,        8050,     8075,     A6301, 3.997772E+00
SIV    423,        8026,     8050,     A6301, 3.997772E+00
SIV    424,        8027,     8052,     A6101, 1.193023E+01
SIV    425,        8027,     8027,     A6101, 1.193023E+01
SIV    426,        8049,     8074,     A6301, 1.193023E+01
SIV    427,        8027,     8049,     A6301, 1.193023E+01
SIV    428,        8028,     8053,     A6101, 1.967453E+01
SIV    429,        8028,     8028,     A6101, 1.967453E+01
SIV    430,        8048,     8073,     A6301, 1.967453E+01
SIV    431,        8028,     8048,     A6301, 1.967453E+01
SIV    432,        8029,     8054,     A6101, 2.710854E+01
SIV    433,        8029,     8029,     A6101, 2.710854E+01
SIV    434,        8047,     8072,     A6301, 2.710854E+01
SIV    435,        8029,     8047,     A6301, 2.710854E+01
SIV    436,        8030,     8055,     A6101, 3.411504E+01
SIV    437,        8030,     8030,     A6101, 3.411504E+01
SIV    438,        8046,     8071,     A6301, 3.411504E+01
SIV    439,        8030,     8046,     A6301, 3.411504E+01
SIV    440,        8031,     8056,     A6101, 4.058351E+01
SIV    441,        8031,     8031,     A6101, 4.058351E+01
SIV    442,        8045,     8070,     A6301, 4.058351E+01
SIV    443,        8031,     8045,     A6301, 4.058351E+01
SIV    444,        8032,     8057,     A6101, 4.641199E+01
SIV    445,        8032,     8032,     A6101, 4.641199E+01
SIV    446,       20002,     8069,     A6101, 4.321216E+01
SIV    447,        8032,    20002,     A6301, 4.321216E+01
SIV    448,        8033,     8058,     A6101, 5.150851E+01
SIV    449,        8033,     8033,     A6101, 5.150851E+01
SIV    450,       20002,     8068,     A6101, 4.795732E+01
SIV    451,        8033,    20002,     A6301, 4.795732E+01
SIV    452,        8034,     8059,     A6101, 5.579269E+01
SIV    453,        8034,     8034,     A6101, 5.579269E+01
SIV    454,       20002,     8067,     A6101, 5.194611E+01
SIV    455,        8034,    20002,     A6301, 5.194611E+01
SIV    456,        8035,     8060,     A6101, 5.919704E+01
SIV    457,        8035,     8035,     A6101, 5.919704E+01
SIV    458,        8041,     8066,     A6301, 5.919704E+01
SIV    459,        8035,     8041,     A6301, 5.919704E+01
SIV    460,        8036,     8061,     A6101, 6.166777E+01
SIV    461,        8036,     8036,     A6101, 6.166777E+01
SIV    462,        8040,     8065,     A6101, 6.166777E+01
```

```
SIV  463,        8036,    8040,    A6101, 6.166777E+01
SIV  464,        8037,    8062,    A6101, 6.316599E+01
SIV  465,        8037,    8037,    A6101, 6.316599E+01
SIV  466,        8039,    8064,    A6101, 6.316599E+01
SIV  467,        8037,    8039,    A6101, 6.316599E+01
SIV  468,        8038,    8063,    A6101, 6.366803E+01
SIV  469,        8038,    8038,    A6101, 6.366803E+01
REM  RADIAL CONDUCTORS REGION 4, LAYER  3 TO LAYER  4
DIM  470,  1,1, 8051,24, 8076,24,A6101, 3.456367E+00,A6101, 3.200432E+00
DIM  471,  1,1, 8075,24, 8100,24,A6301, 3.456367E+00,A6301, 3.200432E+00
DIM  472,  1,1, 8052,22, 8077,22,A6101, 1.031456E+01,A6101, 9.550795E+00
DIM  473,  1,1, 8074,22, 8099,22,A6301, 1.031456E+01,A6301, 9.550795E+00
DIM  474,  1,1, 8053,20, 8078,20,A6101, 1.701007E+01,A6101, 1.575052E+01
DIM  475,  1,1, 8073,20, 8098,20,A6301, 1.701007E+01,A6301, 1.575052E+01
DIM  476,  1,1, 8054,18, 8079,18,A6101, 2.343735E+01,A6101, 2.170186E+01
DIM  477,  1,1, 8072,18, 8097,18,A6301, 2.343735E+01,A6301, 2.170186E+01
DIM  478,  1,1, 8055,16, 8080,16,A6101, 2.949496E+01,A6101, 2.731093E+01
DIM  479,  1,1, 8071,16, 8096,16,A6301, 2.949496E+01,A6301, 2.731093E+01
DIM  480,  1,1, 8056,14, 8081,14,A6101, 3.508745E+01,A6101, 3.248930E+01
DIM  481,  1,1, 8070,14, 8095,14,A6301, 3.508745E+01,A6301, 3.248930E+01
DIM  482,  1,1, 8057,12, 8082,12,A6101, 4.012659E+01,A6101, 3.715529E+01
DIM  483,  1,1, 8069,12, 8094,12,A6301, 4.012659E+01,A6301, 3.715529E+01
DIM  484,  1,1, 8058,10, 8083,10,A6101, 4.453290E+01,A6101, 4.123537E+01
DIM  485,  1,1, 8068,10, 8093,10,A6301, 4.453290E+01,A6301, 4.123537E+01
DIM  486,  1,1, 8059, 8, 8084, 8,A6101, 4.823691E+01,A6101, 4.466505E+01
DIM  487,  1,1, 8067, 8, 8092, 8,A6301, 4.823691E+01,A6301, 4.466505E+01
DIM  488,  1,1, 8060, 6, 8085, 6,A6101, 5.118018E+01,A6101, 4.739043E+01
DIM  489,  1,1, 8066, 6, 8091, 6,A6301, 5.118018E+01,A6101, 4.739043E+01
DIM  490,  1,1, 8061, 4, 8086, 4,A6101, 5.331635E+01,A6101, 4.936835E+01
DIM  491,  1,1, 8065, 4, 8090, 4,A6101, 5.331635E+01,A6101, 4.936835E+01
DIM  492,  1,1, 8062, 2, 8087, 2,A6101, 5.461166E+01,A6101, 5.056776E+01
DIM  493,  1,1, 8064, 2, 8089, 2,A6101, 5.461166E+01,A6101, 5.056776E+01
DIM  494,  1,1, 8063, 0, 8088, 0,A6101, 5.504570E+01,A6101, 5.096970E+01
REM  RADIAL CONDUCTORS REGION 4, LAYER  4 TO BOUNDARY   4- 5
SIM  495,  1,1, 8076,24, 9001,24, A6101, 2.954338E+00
SIM  496,  1,1, 8100,24, 9025,24, A6301, 2.954338E+00
SIM  497,  1,1, 8077,22, 9002,22, A6101, 8.816401E+00
SIM  498,  1,1, 8099,22, 9024,22, A6301, 8.816401E+00
SIM  499,  1,1, 8078,20, 9003,20, A6101, 1.453942E+01
SIM  500,  1,1, 8098,20, 9023,20, A6301, 1.453942E+01
SIM  501,  1,1, 8079,18, 9004,18, A6101, 2.003314E+01
SIM  502,  1,1, 8097,18, 9022,18, A6301, 2.003314E+01
SIM  503,  1,1, 8080,16, 9005,16, A6101, 2.521091E+01
SIM  504,  1,1, 8096,16, 9021,16, A6301, 2.521091E+01
SIM  505,  1,1, 8081,14, 9006,14, A6101, 2.999109E+01
SIM  506,  1,1, 8095,14, 9020,14, A6301, 2.999109E+01
SIM  507,  1,1, 8082,12, 9007,12, A6101, 3.429828E+01
SIM  508,  1,1, 8094,12, 9019,12, A6301, 3.429828E+01
SIM  509,  1,1, 8083,10, 9008,10, A6101, 3.806462E+01
SIM  510,  1,1, 8093,10, 9018,10, A6301, 3.806462E+01
SIM  511,  1,1, 8084, 8, 9009, 8, A6101, 4.123061E+01
SIM  512,  1,1, 8092, 8, 9017, 8, A6301, 4.123061E+01
SIM  513,  1,1, 8085, 6, 9010, 6, A6101, 4.374638E+01
SIM  514,  1,1, 8091, 6, 9016, 6, A6101, 4.374638E+01
SIM  515,  1,1, 8086, 4, 9011, 4, A6101, 4.557227E+01
SIM  516,  1,1, 8090, 4, 9015, 4, A6101, 4.557227E+01
SIM  517,  1,1, 8087, 2, 9012, 2, A6101, 4.667944E+01
SIM  518,  1,1, 8089, 2, 9014, 2, A6101, 4.667944E+01
SIM  519,  1,1, 8088, 0, 9013, 0, A6101, 4.705046E+01
REM  CIRCUMFERENTIAL CONDUCTORS; Y- DIRECTION,  CONDUCTION
REM  CIRCUMFERENTIAL CONDUCTORS REGION 4, LAYER NUMBER  1
DIV  520,        8001,    8002,    A6101, 1.246719E+00,A6101, 3.720487E+00
DIV  522,        8002,    8003,    A6101, 3.720487E+00,A6101, 6.135579E+00
DIV  524,        8003,    8004,    A6101, 6.135579E+00,A6101, 8.453903E+00
DIV  526,        8004,    8005,    A6101, 8.453903E+00,A6101, 1.063890E+01
DIV  528,        8005,    8006,    A6101, 1.063890E+01,A6101, 1.265613E+01
DIV  530,        8006,    8007,    A6101, 1.265613E+01,A6101, 1.447375E+01
DIV  532,        8007,    8008,    A6101, 1.447375E+01,A6101, 1.606313E+01
DIV  534,        8008,    8009,    A6101, 1.606313E+01,A6101, 1.739915E+01
DIV  536,        8009,    8010,    A6101, 1.739915E+01,A6101, 1.846080E+01
```

```
DIV   538,       8010,    8011,    A6101, 1.846080E+01,A6101, 1.923131E+01
DIV   540,       8011,    8012,    A6101, 1.923131E+01,A6101, 1.969855E+01
DIV   542,       8012,    8013,    A6101, 1.969855E+01,A6101, 1.985509E+01
REM  CIRCUMFERENTIAL CONDUCTORS REGION 4, LAYER NUMBER  2
DIV   544,       8026,    8027,    A6101, 1.246719E+00,A6101, 3.720487E+00
DIV   546,       8027,    8028,    A6101, 3.720487E+00,A6101, 6.135579E+00
DIV   548,       8028,    8029,    A6101, 6.135579E+00,A6101, 8.453907E+00
DIV   550,       8029,    8030,    A6101, 8.453907E+00,A6101, 1.063891E+01
DIV   552,       8030,    8031,    A6101, 1.063891E+01,A6101, 1.265613E+01
DIV   554,       8031,    8032,    A6101, 1.265613E+01,A6101, 1.447375E+01
DIV   556,       8032,    8033,    A6101, 1.447375E+01,A6101, 1.606313E+01
DIV   558,       8033,    8034,    A6101, 1.606313E+01,A6101, 1.739915E+01
DIV   560,       8034,    8035,    A6101, 1.739915E+01,A6101, 1.846080E+01
DIV   562,       8035,    8036,    A6101, 1.846080E+01,A6101, 1.923132E+01
DIV   564,       8036,    8037,    A6101, 1.923132E+01,A6101, 1.969855E+01
DIV   566,       8037,    8038,    A6101, 1.969855E+01,A6101, 1.985510E+01
REM  CIRCUMFERENTIAL CONDUCTORS REGION 4, LAYER NUMBER  3
DIV   568,       8051,    8052,    A6101, 1.246719E+00,A6101, 3.720488E+00
DIV   570,       8052,    8053,    A6101, 3.720488E+00,A6101, 6.135580E+00
DIV   572,       8053,    8054,    A6101, 6.135580E+00,A6101, 8.453905E+00
DIV   574,       8054,    8055,    A6101, 8.453905E+00,A6101, 1.063891E+01
DIV   576,       8055,    8056,    A6101, 1.063891E+01,A6101, 1.265613E+01
DIV   578,       8056,    8057,    A6101, 1.265613E+01,A6101, 1.447375E+01
DIV   580,       8057,    8058,    A6101, 1.447375E+01,A6101, 1.606313E+01
DIV   582,       8058,    8059,    A6101, 1.606313E+01,A6101, 1.739915E+01
DIV   584,       8059,    8060,    A6101, 1.739915E+01,A6101, 1.846080E+01
DIV   586,       8060,    8061,    A6101, 1.846080E+01,A6101, 1.923132E+01
DIV   588,       8061,    8062,    A6101, 1.923132E+01,A6101, 1.969855E+01
DIV   590,       8062,    8063,    A6101, 1.969855E+01,A6101, 1.985510E+01
REM  CIRCUMFERENTIAL CONDUCTORS REGION 4, LAYER NUMBER  4
DIV   592,       8076,    8077,    A6101, 1.246717E+00,A6101, 3.720484E+00
DIV   594,       8077,    8078,    A6101, 3.720484E+00,A6101, 6.135574E+00
DIV   596,       8078,    8079,    A6101, 6.135574E+00,A6101, 8.453902E+00
DIV   598,       8079,    8080,    A6101, 8.453902E+00,A6101, 1.063890E+01
DIV   600,       8080,    8081,    A6101, 1.063890E+01,A6101, 1.265612E+01
DIV   602,       8081,    8082,    A6101, 1.265612E+01,A6101, 1.447374E+01
DIV   604,       8082,    8083,    A6101, 1.447374E+01,A6101, 1.606311E+01
DIV   606,       8083,    8084,    A6101, 1.606311E+01,A6101, 1.739914E+01
DIV   608,       8084,    8085,    A6101, 1.739914E+01,A6101, 1.846078E+01
DIV   610,       8085,    8086,    A6101, 1.846078E+01,A6101, 1.923131E+01
DIV   612,       8086,    8087,    A6101, 1.923131E+01,A6101, 1.969853E+01
DIV   614,       8087,    8088,    A6101, 1.969853E+01,A6101, 1.985509E+01
REM  RADIAL CONDUCTORS,  CONDUCTION
REM  RADIAL CONDUCTORS REGION 5, LAYER  1 TO BOUNDARY   5- 4
SIM   616,  1,1,  9001,24,10001,24, A6101, 3.426590E+00
SIM   617,  1,1,  9025,24,10025,24, A6301, 3.426590E+00
SIM   618,  1,1,  9002,22,10002,22, A6101, 1.022570E+01
SIM   619,  1,1,  9024,22,10024,22, A6301, 1.022570E+01
SIM   620,  1,1,  9003,20,10003,20, A6101, 1.686354E+01
SIM   621,  1,1,  9023,20,10023,20, A6301, 1.686354E+01
SIM   622,  1,1,  9004,18,10004,18, A6101, 2.323544E+01
SIM   623,  1,1,  9022,18,10022,18, A6301, 2.323544E+01
SIM   624,  1,1,  9005,16,10005,16, A6101, 2.924088E+01
SIM   625,  1,1,  9021,16,10021,16, A6301, 2.924088E+01
SIM   626,  1,1,  9006,14,10006,14, A6101, 3.478519E+01
SIM   627,  1,1,  9020,14,10020,14, A6301, 3.478519E+01
SIM   628,  1,1,  9007,12,10007,12, A6101, 3.978088E+01
SIM   629,  1,1,  9019,12,10019,12, A6301, 3.978088E+01
SIM   630,  1,1,  9008,10,10008,10, A6101, 4.414926E+01
SIM   631,  1,1,  9018,10,10018,10, A6301, 4.414926E+01
SIM   632,  1,1,  9009, 8,10009, 8, A6101, 4.782135E+01
SIM   633,  1,1,  9017, 8,10017, 8, A6301, 4.782135E+01
SIM   634,  1,1,  9010, 6,10010, 6, A6101, 5.073926E+01
SIM   635,  1,1,  9016, 6,10016, 6, A6101, 5.073926E+01
SIM   636,  1,1,  9011, 4,10011, 4, A6101, 5.285699E+01
SIM   637,  1,1,  9015, 4,10015, 4, A6101, 5.285699E+01
SIM   638,  1,1,  9012, 2,10012, 2, A6101, 5.414114E+01
SIM   639,  1,1,  9014, 2,10014, 2, A6101, 5.414114E+01
SIM   640,  1,1,  9013, 0,10013, 0, A6101, 5.457147E+01
REM  RADIAL CONDUCTORS REGION 5, LAYER  1 TO LAYER  2
```

```
DIM   641,  1,1,10001,24,10026,24,A6101, 3.198217E+00,A6101, 2.977718E+00
DIM   642,  1,1,10025,24,10050,24,A6301, 3.198217E+00,A6301, 2.977718E+00
DIM   643,  1,1,10002,22,10027,22,A6101, 9.544186E+00,A6101, 8.886168E+00
DIM   644,  1,1,10024,22,10049,22,A6301, 9.544186E+00,A6301, 8.886168E+00
DIM   645,  1,1,10003,20,10028,20,A6101, 1.573963E+01,A6101, 1.465447E+01
DIM   646,  1,1,10023,20,10048,20,A6301, 1.573963E+01,A6301, 1.465447E+01
DIM   647,  1,1,10004,18,10029,18,A6101, 2.168686E+01,A6101, 2.019167E+01
DIM   648,  1,1,10022,18,10047,18,A6301, 2.168686E+01,A6301, 2.019167E+01
DIM   649,  1,1,10005,16,10030,16,A6101, 2.729204E+01,A6101, 2.541042E+01
DIM   650,  1,1,10021,16,10046,16,A6301, 2.729204E+01,A6301, 2.541042E+01
DIM   651,  1,1,10006,14,10031,14,A6101, 3.246680E+01,A6101, 3.022842E+01
DIM   652,  1,1,10020,14,10045,14,A6301, 3.246680E+01,A6301, 3.022842E+01
DIM   653,  1,1,10007,12,10032,12,A6101, 3.712958E+01,A6101, 3.456970E+01
DIM   654,  1,1,10019,12,10044,12,A6301, 3.712958E+01,A6301, 3.456970E+01
DIM   655,  1,1,10008,10,10033,10,A6101, 4.120682E+01,A6101, 3.836584E+01
DIM   656,  1,1,10018,10,10043,10,A6301, 4.120682E+01,A6301, 3.836584E+01
DIM   657,  1,1,10009, 8,10034, 8,A6101, 4.463416E+01,A6101, 4.155688E+01
DIM   658,  1,1,10017, 8,10042, 8,A6301, 4.463416E+01,A6301, 4.155688E+01
DIM   659,  1,1,10010, 6,10035, 6,A6101, 4.735760E+01,A6101, 4.409256E+01
DIM   660,  1,1,10016, 6,10041, 6,A6101, 4.735760E+01,A6101, 4.409256E+01
DIM   661,  1,1,10011, 4,10036, 4,A6101, 4.933423E+01,A6101, 4.593289E+01
DIM   662,  1,1,10015, 4,10040, 4,A6101, 4.933423E+01,A6101, 4.593289E+01
DIM   663,  1,1,10012, 2,10037, 2,A6101, 5.053278E+01,A6101, 4.704883E+01
DIM   664,  1,1,10014, 2,10039, 2,A6101, 5.053278E+01,A6101, 4.704883E+01
DIM   665,  1,1,10013, 0,10038, 0,A6101, 5.093439E+01,A6101, 4.742279E+01
REM  RADIAL CONDUCTORS REGION 5, LAYER  2 TO LAYER  3
DIM   666,  1,1,10026,24,10051,24,A6101, 2.765093E+00,A6101, 2.560345E+00
DIM   667,  1,1,10050,24,10075,24,A6301, 2.765093E+00,A6301, 2.560345E+00
DIM   668,  1,1,10027,22,10052,22,A6101, 8.251652E+00,A6101, 7.640636E+00
DIM   669,  1,1,10049,22,10074,22,A6301, 8.251652E+00,A6301, 7.640636E+00
DIM   670,  1,1,10028,20,10053,20,A6101, 1.360807E+01,A6101, 1.260043E+01
DIM   671,  1,1,10048,20,10073,20,A6301, 1.360807E+01,A6301, 1.260043E+01
DIM   672,  1,1,10029,18,10054,18,A6101, 1.874988E+01,A6101, 1.736150E+01
DIM   673,  1,1,10047,18,10072,18,A6301, 1.874988E+01,A6301, 1.736150E+01
DIM   674,  1,1,10030,16,10055,16,A6101, 2.359598E+01,A6101, 2.184875E+01
DIM   675,  1,1,10046,16,10071,16,A6301, 2.359598E+01,A6301, 2.184875E+01
DIM   676,  1,1,10031,14,10056,14,A6101, 2.806998E+01,A6101, 2.599146E+01
DIM   677,  1,1,10045,14,10070,14,A6301, 2.806998E+01,A6301, 2.599146E+01
DIM   678,  1,1,10032,12,10057,12,A6101, 3.210129E+01,A6101, 2.972426E+01
DIM   679,  1,1,10044,12,10069,12,A6301, 3.210129E+01,A6301, 2.972426E+01
DIM   680,  1,1,10033,10,10058,10,A6101, 3.562631E+01,A6101, 3.298828E+01
DIM   681,  1,1,10043,10,10068,10,A6301, 3.562631E+01,A6301, 3.298828E+01
DIM   682,  1,1,10034, 8,10059, 8,A6101, 3.858951E+01,A6101, 3.573203E+01
DIM   683,  1,1,10042, 8,10067, 8,A6301, 3.858951E+01,A6301, 3.573203E+01
DIM   684,  1,1,10035, 6,10060, 6,A6101, 4.094415E+01,A6101, 3.791232E+01
DIM   685,  1,1,10041, 6,10066, 6,A6101, 4.094415E+01,A6101, 3.791232E+01
DIM   686,  1,1,10036, 4,10061, 4,A6101, 4.265305E+01,A6101, 3.949469E+01
DIM   687,  1,1,10040, 4,10065, 4,A6101, 4.265305E+01,A6101, 3.949469E+01
DIM   688,  1,1,10037, 2,10062, 2,A6101, 4.368933E+01,A6101, 4.045422E+01
DIM   689,  1,1,10039, 2,10064, 2,A6101, 4.368933E+01,A6101, 4.045422E+01
DIM   690,  1,1,10038, 0,10063, 0,A6101, 4.403656E+01,A6101, 4.077573E+01
REM  RADIAL CONDUCTORS REGION 5, LAYER  3 TO LAYER  4
DIM   691,  1,1,10051,24,10076,24,A6101, 2.363470E+00,A6101, 2.174473E+00
DIM   692,  1,1,10075,24,10100,24,A6301, 2.363470E+00,A6301, 2.174473E+00
DIM   693,  1,1,10052,22,10077,22,A6101, 7.053120E+00,A6101, 6.489105E+00
DIM   694,  1,1,10074,22,10099,22,A6301, 7.053120E+00,A6301, 6.489105E+00
DIM   695,  1,1,10053,20,10078,20,A6101, 1.163154E+01,A6101, 1.070140E+01
DIM   696,  1,1,10073,20,10098,20,A6301, 1.163154E+01,A6301, 1.070140E+01
DIM   697,  1,1,10054,18,10079,18,A6101, 1.602650E+01,A6101, 1.474493E+01
DIM   698,  1,1,10072,18,10097,18,A6301, 1.602650E+01,A6301, 1.474493E+01
DIM   699,  1,1,10055,16,10080,16,A6101, 2.016873E+01,A6101, 1.855589E+01
DIM   700,  1,1,10071,16,10096,16,A6301, 2.016873E+01,A6301, 1.855589E+01
DIM   701,  1,1,10056,14,10081,14,A6101, 2.399287E+01,A6101, 2.207425E+01
DIM   702,  1,1,10070,14,10095,14,A6301, 2.399287E+01,A6301, 2.207425E+01
DIM   703,  1,1,10057,12,10082,12,A6101, 2.743864E+01,A6101, 2.524448E+01
DIM   704,  1,1,10069,12,10094,12,A6301, 2.743864E+01,A6301, 2.524448E+01
DIM   705,  1,1,10058,10,10083,10,A6101, 3.045172E+01,A6101, 2.801659E+01
DIM   706,  1,1,10068,10,10093,10,A6301, 3.045172E+01,A6301, 2.801659E+01
DIM   707,  1,1,10059, 8,10084, 8,A6101, 3.298450E+01,A6101, 3.034685E+01
DIM   708,  1,1,10067, 8,10092, 8,A6101, 3.298450E+01,A6101, 3.034685E+01
```

```
DIM   709,  1,1,10060, 6,10085, 6,A6101, 3.499710E+01,A6101, 3.219852E+01
DIM   710,  1,1,10066, 6,10091, 6,A6101, 3.499710E+01,A6101, 3.219852E+01
DIM   711,  1,1,10061, 4,10086, 4,A6101, 3.645779E+01,A6101, 3.354242E+01
DIM   712,  1,1,10065, 4,10090, 4,A6101, 3.645779E+01,A6101, 3.354242E+01
DIM   713,  1,1,10062, 2,10087, 2,A6101, 3.734354E+01,A6101, 3.435733E+01
DIM   714,  1,1,10064, 2,10089, 2,A6101, 3.734354E+01,A6101, 3.435733E+01
DIM   715,  1,1,10063, 0,10088, 0,A6101, 3.764035E+01,A6101, 3.463037E+01
REM  RADIAL CONDUCTORS REGION 5, LAYER  4 TO LAYER  5
DIM   716,  1,1,10076,24,10101,24,A6101, 1.993349E+00,A6101, 1.820100E+00
DIM   717,  1,1,10100,24,10125,24,A6301, 1.993349E+00,A6301, 1.820100E+00
DIM   718,  1,1,10077,22,10102,22,A6101, 5.948589E+00,A6101, 5.431578E+00
DIM   719,  1,1,10099,22,10124,22,A6301, 5.948589E+00,A6301, 5.431578E+00
DIM   720,  1,1,10078,20,10103,20,A6101, 9.810020E+00,A6101, 8.957396E+00
DIM   721,  1,1,10098,20,10123,20,A6301, 9.810020E+00,A6301, 8.957396E+00
DIM   722,  1,1,10079,18,10104,18,A6101, 1.351674E+01,A6101, 1.234195E+01
DIM   723,  1,1,10097,18,10122,18,A6301, 1.351674E+01,A6301, 1.234195E+01
DIM   724,  1,1,10080,16,10105,16,A6101, 1.701027E+01,A6101, 1.553186E+01
DIM   725,  1,1,10096,16,10121,16,A6301, 1.701027E+01,A6301, 1.553186E+01
DIM   726,  1,1,10081,14,10106,14,A6101, 2.023557E+01,A6101, 1.847681E+01
DIM   727,  1,1,10095,14,10120,14,A6301, 2.023557E+01,A6301, 1.847681E+01
DIM   728,  1,1,10082,12,10107,12,A6101, 2.314172E+01,A6101, 2.113039E+01
DIM   729,  1,1,10094,12,10119,12,A6301, 2.314172E+01,A6301, 2.113039E+01
DIM   730,  1,1,10083,10,10108,10,A6101, 2.568294E+01,A6101, 2.345074E+01
DIM   731,  1,1,10093,10,10118,10,A6301, 2.568294E+01,A6101, 2.345074E+01
DIM   732,  1,1,10084, 8,10109, 8,A6101, 2.781908E+01,A6101, 2.540123E+01
DIM   733,  1,1,10092, 8,10117, 8,A6101, 2.781908E+01,A6101, 2.540123E+01
DIM   734,  1,1,10085, 6,10110, 6,A6101, 2.951653E+01,A6101, 2.695114E+01
DIM   735,  1,1,10091, 6,10116, 6,A6101, 2.951653E+01,A6101, 2.695114E+01
DIM   736,  1,1,10086, 4,10111, 4,A6101, 3.074847E+01,A6101, 2.807602E+01
DIM   737,  1,1,10090, 4,10115, 4,A6101, 3.074847E+01,A6101, 2.807602E+01
DIM   738,  1,1,10087, 2,10112, 2,A6101, 3.149551E+01,A6101, 2.875812E+01
DIM   739,  1,1,10089, 2,10114, 2,A6101, 3.149551E+01,A6101, 2.875812E+01
DIM   740,  1,1,10088, 0,10113, 0,A6101, 3.174583E+01,A6101, 2.898669E+01
REM  RADIAL CONDUCTORS REGION 5, LAYER  5 TO LAYER  6
DIM   741,  1,1,10101,24,10126,24,A6101, 1.654726E+00,A6101, 1.497227E+00
DIM   742,  1,1,10125,24,10150,24,A6301, 1.654726E+00,A6301, 1.497227E+00
DIM   743,  1,1,10102,22,10127,22,A6101, 4.938065E+00,A6101, 4.468052E+00
DIM   744,  1,1,10124,22,10149,22,A6301, 4.938065E+00,A6301, 4.468052E+00
DIM   745,  1,1,10103,20,10128,20,A6101, 8.143528E+00,A6101, 7.368414E+00
DIM   746,  1,1,10123,20,10148,20,A6301, 8.143528E+00,A6301, 7.368414E+00
DIM   747,  1,1,10104,18,10129,18,A6101, 1.122056E+01,A6101, 1.015257E+01
DIM   748,  1,1,10122,18,10147,18,A6301, 1.122056E+01,A6301, 1.015257E+01
DIM   749,  1,1,10105,16,10130,16,A6101, 1.412063E+01,A6101, 1.277661E+01
DIM   750,  1,1,10121,16,10146,16,A6301, 1.412063E+01,A6301, 1.277661E+01
DIM   751,  1,1,10106,14,10131,14,A6101, 1.679800E+01,A6101, 1.519916E+01
DIM   752,  1,1,10120,14,10145,14,A6301, 1.679800E+01,A6301, 1.519916E+01
DIM   753,  1,1,10107,12,10132,12,A6101, 1.921048E+01,A6101, 1.738200E+01
DIM   754,  1,1,10119,12,10144,12,A6301, 1.921048E+01,A6301, 1.738200E+01
DIM   755,  1,1,10108,10,10133,10,A6101, 2.132001E+01,A6101, 1.929074E+01
DIM   756,  1,1,10118,10,10143,10,A6101, 2.132001E+01,A6101, 1.929074E+01
DIM   757,  1,1,10109, 8,10134, 8,A6101, 2.309328E+01,A6101, 2.089522E+01
DIM   758,  1,1,10117, 8,10142, 8,A6101, 2.309328E+01,A6101, 2.089522E+01
DIM   759,  1,1,10110, 6,10135, 6,A6101, 2.450237E+01,A6101, 2.217020E+01
DIM   760,  1,1,10116, 6,10141, 6,A6101, 2.450237E+01,A6101, 2.217020E+01
DIM   761,  1,1,10111, 4,10136, 4,A6101, 2.552504E+01,A6101, 2.309552E+01
DIM   762,  1,1,10115, 4,10140, 4,A6101, 2.552504E+01,A6101, 2.309552E+01
DIM   763,  1,1,10112, 2,10137, 2,A6101, 2.614516E+01,A6101, 2.365663E+01
DIM   764,  1,1,10114, 2,10139, 2,A6101, 2.614516E+01,A6101, 2.365663E+01
DIM   765,  1,1,10113, 0,10138, 0,A6101, 2.635297E+01,A6101, 2.384465E+01
REM  RADIAL CONDUCTORS REGION 5, LAYER  6 TO LAYER  7
DIM   766,  1,1,10126,24,10151,24,A6101, 1.347602E+00,A6101, 1.205853E+00
DIM   767,  1,1,10150,24,10175,24,A6301, 1.347602E+00,A6301, 1.205853E+00
DIM   768,  1,1,10127,22,10152,22,A6101, 4.021540E+00,A6101, 3.598530E+00
DIM   769,  1,1,10149,22,10174,22,A6301, 4.021540E+00,A6301, 3.598530E+00
DIM   770,  1,1,10128,20,10153,20,A6101, 6.632057E+00,A6101, 5.934456E+00
DIM   771,  1,1,10148,20,10173,20,A6301, 6.632057E+00,A6301, 5.934456E+00
DIM   772,  1,1,10129,18,10154,18,A6101, 9.137983E+00,A6101, 8.176792E+00
DIM   773,  1,1,10147,18,10172,18,A6301, 9.137983E+00,A6301, 8.176792E+00
DIM   774,  1,1,10130,16,10155,16,A6101, 1.149979E+01,A6101, 1.029017E+01
DIM   775,  1,1,10146,16,10171,16,A6301, 1.149979E+01,A6301, 1.029017E+01
```

```
DIM   776,  1,1,10131,14,10156,14,A6101, 1.368024E+01,A6101, 1.224127E+01
DIM   777,  1,1,10145,14,10170,14,A6301, 1.368024E+01,A6301, 1.224127E+01
DIM   778,  1,1,10132,12,10157,12,A6101, 1.564495E+01,A6101, 1.399932E+01
DIM   779,  1,1,10144,12,10169,12,A6301, 1.564495E+01,A6101, 1.399932E+01
DIM   780,  1,1,10133,10,10158,10,A6101, 1.736293E+01,A6101, 1.553659E+01
DIM   781,  1,1,10143,10,10168,10,A6101, 1.736293E+01,A6101, 1.553659E+01
DIM   782,  1,1,10134, 8,10159, 8,A6101, 1.880707E+01,A6101, 1.682883E+01
DIM   783,  1,1,10142, 8,10167, 8,A6101, 1.880707E+01,A6101, 1.682883E+01
DIM   784,  1,1,10135, 6,10160, 6,A6101, 1.995462E+01,A6101, 1.785567E+01
DIM   785,  1,1,10141, 6,10166, 6,A6101, 1.995462E+01,A6101, 1.785567E+01
DIM   786,  1,1,10136, 4,10161, 4,A6101, 2.078749E+01,A6101, 1.860092E+01
DIM   787,  1,1,10140, 4,10165, 4,A6101, 2.078749E+01,A6101, 1.860092E+01
DIM   788,  1,1,10137, 2,10162, 2,A6101, 2.129253E+01,A6101, 1.905284E+01
DIM   789,  1,1,10139, 2,10164, 2,A6101, 2.129253E+01,A6101, 1.905284E+01
DIM   790,  1,1,10138, 0,10163, 0,A6101, 2.146175E+01,A6101, 1.920427E+01
REM  RADIAL CONDUCTORS REGION 5, LAYER  7 TO LAYER  8
DIM   791,  1,1,10151,24,10176,24,A6101, 1.071979E+00,A6101, 9.459796E-01
DIM   792,  1,1,10175,24,10200,24,A6301, 1.071979E+00,A6301, 9.459796E-01
DIM   793,  1,1,10152,22,10177,22,A6101, 3.199020E+00,A6101, 2.823009E+00
DIM   794,  1,1,10174,22,10199,22,A6301, 3.199020E+00,A6301, 2.823009E+00
DIM   795,  1,1,10153,20,10178,20,A6101, 5.275610E+00,A6101, 4.655519E+00
DIM   796,  1,1,10173,20,10198,20,A6301, 5.275610E+00,A6301, 4.655519E+00
DIM   797,  1,1,10154,18,10179,18,A6101, 7.269003E+00,A6101, 6.414610E+00
DIM   798,  1,1,10172,18,10197,18,A6301, 7.269003E+00,A6301, 6.414610E+00
DIM   799,  1,1,10155,16,10180,16,A6101, 9.147751E+00,A6101, 8.072533E+00
DIM   800,  1,1,10171,16,10196,16,A6301, 9.147751E+00,A6101, 8.072533E+00
DIM   801,  1,1,10156,14,10181,14,A6101, 1.088224E+01,A6101, 9.603149E+00
DIM   802,  1,1,10170,14,10195,14,A6301, 1.088224E+01,A6101, 9.603149E+00
DIM   803,  1,1,10157,12,10182,12,A6101, 1.244511E+01,A6101, 1.098232E+01
DIM   804,  1,1,10169,12,10194,12,A6101, 1.244511E+01,A6101, 1.098232E+01
DIM   805,  1,1,10158,10,10183,10,A6101, 1.381171E+01,A6101, 1.218830E+01
DIM   806,  1,1,10168,10,10193,10,A6101, 1.381171E+01,A6101, 1.218830E+01
DIM   807,  1,1,10159, 8,10184, 8,A6101, 1.496049E+01,A6101, 1.320205E+01
DIM   808,  1,1,10167, 8,10192, 8,A6101, 1.496049E+01,A6101, 1.320205E+01
DIM   809,  1,1,10160, 6,10185, 6,A6101, 1.587334E+01,A6101, 1.400760E+01
DIM   810,  1,1,10166, 6,10191, 6,A6101, 1.587334E+01,A6101, 1.400760E+01
DIM   811,  1,1,10161, 4,10186, 4,A6101, 1.653584E+01,A6101, 1.459224E+01
DIM   812,  1,1,10165, 4,10190, 4,A6101, 1.653584E+01,A6101, 1.459224E+01
DIM   813,  1,1,10162, 2,10187, 2,A6101, 1.693758E+01,A6101, 1.494676E+01
DIM   814,  1,1,10164, 2,10189, 2,A6101, 1.693758E+01,A6101, 1.494676E+01
DIM   815,  1,1,10163, 0,10188, 0,A6101, 1.707220E+01,A6101, 1.506556E+01
REM  RADIAL CONDUCTORS REGION 5, LAYER  8 TO LAYER  9
DIM   816,  1,1,10176,24,10201,24,A6101, 8.278551E-01,A6101, 7.176057E-01
DIM   817,  1,1,10200,24,10225,24,A6301, 8.278551E-01,A6301, 7.176057E-01
DIM   818,  1,1,10177,22,10202,22,A6101, 2.470499E+00,A6101, 2.141491E+00
DIM   819,  1,1,10199,22,10224,22,A6301, 2.470499E+00,A6101, 2.141491E+00
DIM   820,  1,1,10178,20,10203,20,A6101, 4.074184E+00,A6101, 3.531607E+00
DIM   821,  1,1,10198,20,10223,20,A6301, 4.074184E+00,A6101, 3.531607E+00
DIM   822,  1,1,10179,18,10204,18,A6101, 5.613619E+00,A6101, 4.866026E+00
DIM   823,  1,1,10197,18,10222,18,A6301, 5.613619E+00,A6101, 4.866026E+00
DIM   824,  1,1,10180,16,10205,16,A6101, 7.064514E+00,A6101, 6.123699E+00
DIM   825,  1,1,10196,16,10221,16,A6101, 7.064514E+00,A6101, 6.123699E+00
DIM   826,  1,1,10181,14,10206,14,A6101, 8.404005E+00,A6101, 7.284801E+00
DIM   827,  1,1,10195,14,10220,14,A6101, 8.404005E+00,A6101, 7.284801E+00
DIM   828,  1,1,10182,12,10207,12,A6101, 9.610958E+00,A6101, 8.331018E+00
DIM   829,  1,1,10194,12,10219,12,A6101, 9.610958E+00,A6101, 8.331018E+00
DIM   830,  1,1,10183,10,10208,10,A6101, 1.066635E+01,A6101, 9.245857E+00
DIM   831,  1,1,10193,10,10218,10,A6101, 1.066635E+01,A6101, 9.245857E+00
DIM   832,  1,1,10184, 8,10209, 8,A6101, 1.155351E+01,A6101, 1.001487E+01
DIM   833,  1,1,10192, 8,10217, 8,A6101, 1.155351E+01,A6101, 1.001487E+01
DIM   834,  1,1,10185, 6,10210, 6,A6101, 1.225847E+01,A6101, 1.062595E+01
DIM   835,  1,1,10191, 6,10216, 6,A6101, 1.225847E+01,A6101, 1.062595E+01
DIM   836,  1,1,10186, 4,10211, 4,A6101, 1.277011E+01,A6101, 1.106945E+01
DIM   837,  1,1,10190, 4,10215, 4,A6101, 1.277011E+01,A6101, 1.106945E+01
DIM   838,  1,1,10187, 2,10212, 2,A6101, 1.308036E+01,A6101, 1.133838E+01
DIM   839,  1,1,10189, 2,10214, 2,A6101, 1.308036E+01,A6101, 1.133838E+01
DIM   840,  1,1,10188, 0,10213, 0,A6101, 1.318432E+01,A6101, 1.142850E+01
REM  RADIAL CONDUCTORS REGION 5, LAYER  9 TO LAYER 10
DIM   841,  1,1,10201,24,10226,24,A6101, 6.152312E-01,A6101, 5.207317E-01
DIM   842,  1,1,10225,24,10250,24,A6301, 6.152312E-01,A6101, 5.207317E-01
```

```
DIM   843,  1,1,10202,22,10227,22,A6101, 1.835985E+00,A6101, 1.553978E+00
DIM   844,  1,1,10224,22,10249,22,A6101, 1.835985E+00,A6101, 1.553978E+00
DIM   845,  1,1,10203,20,10228,20,A6101, 3.027784E+00,A6101, 2.562716E+00
DIM   846,  1,1,10223,20,10248,20,A6101, 3.027784E+00,A6101, 2.562716E+00
DIM   847,  1,1,10204,18,10229,18,A6101, 4.171833E+00,A6101, 3.531038E+00
DIM   848,  1,1,10222,18,10247,18,A6101, 4.171833E+00,A6101, 3.531038E+00
DIM   849,  1,1,10205,16,10230,16,A6101, 5.250086E+00,A6101, 4.443672E+00
DIM   850,  1,1,10221,16,10246,16,A6101, 5.250086E+00,A6101, 4.443672E+00
DIM   851,  1,1,10206,14,10231,14,A6101, 6.245544E+00,A6101, 5.286228E+00
DIM   852,  1,1,10220,14,10245,14,A6101, 6.245544E+00,A6101, 5.286228E+00
DIM   853,  1,1,10207,12,10232,12,A6101, 7.142506E+00,A6101, 6.045418E+00
DIM   854,  1,1,10219,12,10244,12,A6101, 7.142506E+00,A6101, 6.045418E+00
DIM   855,  1,1,10208,10,10233,10,A6101, 7.926832E+00,A6101, 6.709270E+00
DIM   856,  1,1,10218,10,10243,10,A6101, 7.926832E+00,A6101, 6.709270E+00
DIM   857,  1,1,10209, 8,10234, 8,A6101, 8.586138E+00,A6101, 7.267307E+00
DIM   858,  1,1,10217, 8,10242, 8,A6101, 8.586138E+00,A6101, 7.267307E+00
DIM   859,  1,1,10210, 6,10235, 6,A6101, 9.110041E+00,A6101, 7.710737E+00
DIM   860,  1,1,10216, 6,10241, 6,A6101, 9.110041E+00,A6101, 7.710737E+00
DIM   861,  1,1,10211, 4,10236, 4,A6101, 9.490273E+00,A6101, 8.032566E+00
DIM   862,  1,1,10215, 4,10240, 4,A6101, 9.490273E+00,A6101, 8.032566E+00
DIM   863,  1,1,10212, 2,10237, 2,A6101, 9.720839E+00,A6101, 8.227716E+00
DIM   864,  1,1,10214, 2,10239, 2,A6101, 9.720839E+00,A6101, 8.227716E+00
DIM   865,  1,1,10213, 0,10238, 0,A6101, 9.798100E+00,A6101, 8.293112E+00
REM  RADIAL CONDUCTORS REGION 5, LAYER 10 TO LAYER 11
DIM   866,  1,1,10226,24,10251,24,A6101, 4.341072E-01,A6101, 3.553575E-01
DIM   867,  1,1,10250,24,10275,24,A6101, 4.341072E-01,A6101, 3.553575E-01
DIM   868,  1,1,10227,22,10252,22,A6101, 1.295471E+00,A6101, 1.060465E+00
DIM   869,  1,1,10249,22,10274,22,A6101, 1.295471E+00,A6101, 1.060465E+00
DIM   870,  1,1,10228,20,10253,20,A6101, 2.136402E+00,A6101, 1.748848E+00
DIM   871,  1,1,10248,20,10273,20,A6101, 2.136402E+00,A6101, 1.748848E+00
DIM   872,  1,1,10229,18,10254,18,A6101, 2.943645E+00,A6101, 2.409649E+00
DIM   873,  1,1,10247,18,10272,18,A6101, 2.943645E+00,A6101, 2.409649E+00
DIM   874,  1,1,10230,16,10255,16,A6101, 3.704458E+00,A6101, 3.032448E+00
DIM   875,  1,1,10246,16,10271,16,A6101, 3.704458E+00,A6101, 3.032448E+00
DIM   876,  1,1,10231,14,10256,14,A6101, 4.406855E+00,A6101, 3.607426E+00
DIM   877,  1,1,10245,14,10270,14,A6101, 4.406855E+00,A6101, 3.607426E+00
DIM   878,  1,1,10232,12,10257,12,A6101, 5.039753E+00,A6101, 4.125511E+00
DIM   879,  1,1,10244,12,10269,12,A6101, 5.039753E+00,A6101, 4.125511E+00
DIM   880,  1,1,10233,10,10258,10,A6101, 5.593172E+00,A6101, 4.578539E+00
DIM   881,  1,1,10243,10,10268,10,A6101, 5.593172E+00,A6101, 4.578539E+00
DIM   882,  1,1,10234, 8,10259, 8,A6101, 6.058378E+00,A6101, 4.959352E+00
DIM   883,  1,1,10242, 8,10267, 8,A6101, 6.058378E+00,A6101, 4.959352E+00
DIM   884,  1,1,10235, 6,10260, 6,A6101, 6.428043E+00,A6101, 5.261959E+00
DIM   885,  1,1,10241, 6,10266, 6,A6101, 6.428043E+00,A6101, 5.261959E+00
DIM   886,  1,1,10236, 4,10261, 4,A6101, 6.696335E+00,A6101, 5.481581E+00
DIM   887,  1,1,10240, 4,10265, 4,A6101, 6.696335E+00,A6101, 5.481581E+00
DIM   888,  1,1,10237, 2,10262, 2,A6101, 6.859022E+00,A6101, 5.614756E+00
DIM   889,  1,1,10239, 2,10264, 2,A6101, 6.859022E+00,A6101, 5.614756E+00
DIM   890,  1,1,10238, 0,10263, 0,A6101, 6.913536E+00,A6101, 5.659382E+00
REM  RADIAL CONDUCTORS REGION 5, LAYER 11 TO LAYER 12
DIM   891,  1,1,10251,24,10276,24,A6101, 2.844828E-01,A6101, 2.214831E-01
DIM   892,  1,1,10275,24,10300,24,A6101, 2.844828E-01,A6101, 2.214831E-01
DIM   893,  1,1,10252,22,10277,22,A6101, 8.489596E-01,A6101, 6.609547E-01
DIM   894,  1,1,10274,22,10299,22,A6101, 8.489596E-01,A6101, 6.609547E-01
DIM   895,  1,1,10253,20,10278,20,A6101, 1.400047E+00,A6101, 1.090002E+00
DIM   896,  1,1,10273,20,10298,20,A6101, 1.400047E+00,A6101, 1.090002E+00
DIM   897,  1,1,10254,18,10279,18,A6101, 1.929055E+00,A6101, 1.501860E+00
DIM   898,  1,1,10272,18,10297,18,A6101, 1.929055E+00,A6101, 1.501860E+00
DIM   899,  1,1,10255,16,10280,16,A6101, 2.427639E+00,A6101, 1.890031E+00
DIM   900,  1,1,10271,16,10296,16,A6101, 2.427639E+00,A6101, 1.890031E+00
DIM   901,  1,1,10256,14,10281,14,A6101, 2.887938E+00,A6101, 2.248394E+00
DIM   902,  1,1,10270,14,10295,14,A6101, 2.887938E+00,A6101, 2.248394E+00
DIM   903,  1,1,10257,12,10282,12,A6101, 3.302694E+00,A6101, 2.571302E+00
DIM   904,  1,1,10269,12,10294,12,A6101, 3.302694E+00,A6101, 2.571302E+00
DIM   905,  1,1,10258,10,10283,10,A6101, 3.665365E+00,A6101, 2.853657E+00
DIM   906,  1,1,10268,10,10293,10,A6101, 3.665365E+00,A6101, 2.853657E+00
DIM   907,  1,1,10259, 8,10284, 8,A6101, 3.970228E+00,A6101, 3.091009E+00
DIM   908,  1,1,10267, 8,10292, 8,A6101, 3.970228E+00,A6101, 3.091009E+00
DIM   909,  1,1,10260, 6,10285, 6,A6101, 4.212481E+00,A6101, 3.279613E+00
DIM   910,  1,1,10266, 6,10291, 6,A6101, 4.212481E+00,A6101, 3.279613E+00
```

```
DIM   911,  1,1,10261, 4,10286, 4,A6101, 4.388302E+00,A6101, 3.416496E+00
DIM   912,  1,1,10265, 4,10290, 4,A6101, 4.388302E+00,A6101, 3.416496E+00
DIM   913,  1,1,10262, 2,10287, 2,A6101, 4.494913E+00,A6101, 3.499500E+00
DIM   914,  1,1,10264, 2,10289, 2,A6101, 4.494913E+00,A6101, 3.499500E+00
DIM   915,  1,1,10263, 0,10288, 0,A6101, 4.530640E+00,A6101, 3.527315E+00
REM  RADIAL CONDUCTORS REGION 5, LAYER 12 TO LAYER 13
DIM   916,  1,1,10276,24,10301,24,A6101, 1.663585E-01,A6101, 1.191087E-01
DIM   917,  1,1,10300,24,10325,24,A6101, 1.663585E-01,A6101, 1.191087E-01
DIM   918,  1,1,10277,22,10302,22,A6101, 4.964504E-01,A6101, 3.554466E-01
DIM   919,  1,1,10299,22,10324,22,A6101, 4.964504E-01,A6101, 3.554466E-01
DIM   920,  1,1,10278,20,10303,20,A6101, 8.187128E-01,A6101, 5.861790E-01
DIM   921,  1,1,10298,20,10323,20,A6101, 8.187128E-01,A6101, 5.861790E-01
DIM   922,  1,1,10279,18,10304,18,A6101, 1.128063E+00,A6101, 8.076669E-01
DIM   923,  1,1,10297,18,10322,18,A6101, 1.128063E+00,A6101, 8.076669E-01
DIM   924,  1,1,10280,16,10305,16,A6101, 1.419623E+00,A6101, 1.016417E+00
DIM   925,  1,1,10296,16,10321,16,A6101, 1.419623E+00,A6101, 1.016417E+00
DIM   926,  1,1,10281,14,10306,14,A6101, 1.688795E+00,A6101, 1.209137E+00
DIM   927,  1,1,10295,14,10320,14,A6101, 1.688795E+00,A6101, 1.209137E+00
DIM   928,  1,1,10282,12,10307,12,A6101, 1.931334E+00,A6101, 1.382790E+00
DIM   929,  1,1,10294,12,10319,12,A6101, 1.931334E+00,A6101, 1.382790E+00
DIM   930,  1,1,10283,10,10308,10,A6101, 2.143415E+00,A6101, 1.534635E+00
DIM   931,  1,1,10293,10,10318,10,A6101, 2.143415E+00,A6101, 1.534635E+00
DIM   932,  1,1,10284, 8,10309, 8,A6101, 2.321690E+00,A6101, 1.662276E+00
DIM   933,  1,1,10292, 8,10317, 8,A6101, 2.321690E+00,A6101, 1.662276E+00
DIM   934,  1,1,10285, 6,10310, 6,A6101, 2.463354E+00,A6101, 1.763703E+00
DIM   935,  1,1,10291, 6,10316, 6,A6101, 2.463354E+00,A6101, 1.763703E+00
DIM   936,  1,1,10286, 4,10311, 4,A6101, 2.566168E+00,A6101, 1.837317E+00
DIM   937,  1,1,10290, 4,10315, 4,A6101, 2.566168E+00,A6101, 1.837317E+00
DIM   938,  1,1,10287, 2,10312, 2,A6101, 2.628513E+00,A6101, 1.881954E+00
DIM   939,  1,1,10289, 2,10314, 2,A6101, 2.628513E+00,A6101, 1.881954E+00
DIM   940,  1,1,10288, 0,10313, 0,A6101, 2.649405E+00,A6101, 1.896912E+00
REM  RADIAL CONDUCTORS REGION 5, LAYER 13 TO LAYER 14
DIM   941,  1,1,10301,24,10326,24,A6101, 7.973397E-02,A6101, 4.823413E-02
DIM   942,  1,1,10325,24,10350,24,A6101, 7.973397E-02,A6101, 4.823413E-02
DIM   943,  1,1,10302,22,10327,22,A6101, 2.379436E-01,A6101, 1.439412E-01
DIM   944,  1,1,10324,22,10349,22,A6101, 2.379436E-01,A6101, 1.439412E-01
DIM   945,  1,1,10303,20,10328,20,A6101, 3.924009E-01,A6101, 2.373781E-01
DIM   946,  1,1,10323,20,10348,20,A6101, 3.924009E-01,A6101, 2.373781E-01
DIM   947,  1,1,10304,18,10329,18,A6101, 5.406696E-01,A6101, 3.270717E-01
DIM   948,  1,1,10322,18,10347,18,A6101, 5.406696E-01,A6101, 3.270717E-01
DIM   949,  1,1,10305,16,10330,16,A6101, 6.804112E-01,A6101, 4.116068E-01
DIM   950,  1,1,10321,16,10346,16,A6101, 6.804112E-01,A6101, 4.116068E-01
DIM   951,  1,1,10306,14,10331,14,A6101, 8.094226E-01,A6101, 4.896506E-01
DIM   952,  1,1,10320,14,10345,14,A6101, 8.094226E-01,A6101, 4.896506E-01
DIM   953,  1,1,10307,12,10332,12,A6101, 9.256690E-01,A6101, 5.599725E-01
DIM   954,  1,1,10319,12,10344,12,A6101, 9.256690E-01,A6101, 5.599725E-01
DIM   955,  1,1,10308,10,10333,10,A6101, 1.027317E+00,A6101, 6.214637E-01
DIM   956,  1,1,10318,10,10343,10,A6101, 1.027317E+00,A6101, 6.214637E-01
DIM   957,  1,1,10309, 8,10334, 8,A6101, 1.112763E+00,A6101, 6.731532E-01
DIM   958,  1,1,10317, 8,10342, 8,A6101, 1.112763E+00,A6101, 6.731532E-01
DIM   959,  1,1,10310, 6,10335, 6,A6101, 1.180661E+00,A6101, 7.142272E-01
DIM   960,  1,1,10316, 6,10341, 6,A6101, 1.180661E+00,A6101, 7.142272E-01
DIM   961,  1,1,10311, 4,10336, 4,A6101, 1.229939E+00,A6101, 7.440374E-01
DIM   962,  1,1,10315, 4,10340, 4,A6101, 1.229939E+00,A6101, 7.440374E-01
DIM   963,  1,1,10312, 2,10337, 2,A6101, 1.259820E+00,A6101, 7.621137E-01
DIM   964,  1,1,10314, 2,10339, 2,A6101, 1.259820E+00,A6101, 7.621137E-01
DIM   965,  1,1,10313, 0,10338, 0,A6101, 1.269834E+00,A6101, 7.681710E-01
REM  RADIAL CONDUCTORS REGION 5, LAYER 14 TO LAYER 15
DIM   966,  1,1,10326,24,10351,24,A6101, 2.460925E-02,A6101, 8.859329E-03
DIM   967,  1,1,10350,24,10375,24,A6101, 2.460925E-02,A6101, 8.859329E-03
DIM   968,  1,1,10327,22,10352,22,A6101, 7.343936E-02,A6101, 2.643818E-02
DIM   969,  1,1,10349,22,10374,22,A6101, 7.343936E-02,A6101, 2.643818E-02
DIM   970,  1,1,10328,20,10353,20,A6101, 1.211113E-01,A6101, 4.360010E-02
DIM   971,  1,1,10348,20,10373,20,A6101, 1.211113E-01,A6101, 4.360010E-02
DIM   972,  1,1,10329,18,10354,18,A6101, 1.668732E-01,A6101, 6.007440E-02
DIM   973,  1,1,10347,18,10372,18,A6101, 1.668732E-01,A6101, 6.007440E-02
DIM   974,  1,1,10330,16,10355,16,A6101, 2.100034E-01,A6101, 7.560122E-02
DIM   975,  1,1,10346,16,10371,16,A6101, 2.100034E-01,A6101, 7.560122E-02
DIM   976,  1,1,10331,14,10356,14,A6101, 2.498218E-01,A6101, 8.993584E-02
DIM   977,  1,1,10345,14,10370,14,A6101, 2.498218E-01,A6101, 8.993584E-02
```

```
DIM   978,  1,1,10332,12,10357,12,A6101, 2.857002E-01,A6101, 1.028521E-01
DIM   979,  1,1,10344,12,10369,12,A6101, 2.857002E-01,A6101, 1.028521E-01
DIM   980,  1,1,10333,10,10358,10,A6101, 3.170732E-01,A6101, 1.141464E-01
DIM   981,  1,1,10343,10,10368,10,A6101, 3.170732E-01,A6101, 1.141464E-01
DIM   982,  1,1,10334, 8,10359, 8,A6101, 3.434455E-01,A6101, 1.236404E-01
DIM   983,  1,1,10342, 8,10367, 8,A6101, 3.434455E-01,A6101, 1.236404E-01
DIM   984,  1,1,10335, 6,10360, 6,A6101, 3.644016E-01,A6101, 1.311846E-01
DIM   985,  1,1,10341, 6,10366, 6,A6101, 3.644016E-01,A6101, 1.311846E-01
DIM   986,  1,1,10336, 4,10361, 4,A6101, 3.796109E-01,A6101, 1.366599E-01
DIM   987,  1,1,10340, 4,10365, 4,A6101, 3.796109E-01,A6101, 1.366599E-01
DIM   988,  1,1,10337, 2,10362, 2,A6101, 3.888335E-01,A6101, 1.399800E-01
DIM   989,  1,1,10339, 2,10364, 2,A6101, 3.888335E-01,A6101, 1.399800E-01
DIM   990,  1,1,10338, 0,10363, 0,A6101, 3.919239E-01,A6101, 1.410925E-01
REM  CIRCUMFERENTIAL CONDUCTORS; Y- DIRECTION,  CONDUCTION
REM  CIRCUMFERENTIAL CONDUCTORS REGION 5, LAYER NUMBER  1
DIV   991,       10001,    10002,    A6101, 9.973752E-01,A6101, 2.976387E+00
DIV   993,       10002,    10003,    A6101, 2.976387E+00,A6101, 4.908460E+00
DIV   995,       10003,    10004,    A6101, 4.908460E+00,A6101, 6.763123E+00
DIV   997,       10004,    10005,    A6101, 6.763123E+00,A6101, 8.511122E+00
DIV   999,       10005,    10006,    A6101, 8.511122E+00,A6101, 1.012489E+01
DIV  1001,       10006,    10007,    A6101, 1.012489E+01,A6101, 1.157899E+01
DIV  1003,       10007,    10008,    A6101, 1.157899E+01,A6101, 1.285050E+01
DIV  1005,       10008,    10009,    A6101, 1.285050E+01,A6101, 1.391933E+01
DIV  1007,       10009,    10010,    A6101, 1.391933E+01,A6101, 1.476864E+01
DIV  1009,       10010,    10011,    A6101, 1.476864E+01,A6101, 1.538505E+01
DIV  1011,       10011,    10012,    A6101, 1.538505E+01,A6101, 1.575883E+01
DIV  1013,       10012,    10013,    A6101, 1.575883E+01,A6101, 1.588408E+01
REM  CIRCUMFERENTIAL CONDUCTORS REGION 5, LAYER NUMBER  2
DIV  1015,       10026,    10027,    A6101, 9.973752E-01,A6101, 2.976387E+00
DIV  1017,       10027,    10028,    A6101, 2.976387E+00,A6101, 4.908460E+00
DIV  1019,       10028,    10029,    A6101, 4.908460E+00,A6101, 6.763123E+00
DIV  1021,       10029,    10030,    A6101, 6.763123E+00,A6101, 8.511122E+00
DIV  1023,       10030,    10031,    A6101, 8.511122E+00,A6101, 1.012490E+01
DIV  1025,       10031,    10032,    A6101, 1.012490E+01,A6101, 1.157899E+01
DIV  1027,       10032,    10033,    A6101, 1.157899E+01,A6101, 1.285050E+01
DIV  1029,       10033,    10034,    A6101, 1.285050E+01,A6101, 1.391932E+01
DIV  1031,       10034,    10035,    A6101, 1.391932E+01,A6101, 1.476865E+01
DIV  1033,       10035,    10036,    A6101, 1.476865E+01,A6101, 1.538506E+01
DIV  1035,       10036,    10037,    A6101, 1.538506E+01,A6101, 1.575883E+01
DIV  1037,       10037,    10038,    A6101, 1.575883E+01,A6101, 1.588408E+01
REM  CIRCUMFERENTIAL CONDUCTORS REGION 5, LAYER NUMBER  3
DIV  1039,       10051,    10052,    A6101, 9.973754E-01,A6101, 2.976388E+00
DIV  1041,       10052,    10053,    A6101, 2.976388E+00,A6101, 4.908460E+00
DIV  1043,       10053,    10054,    A6101, 4.908460E+00,A6101, 6.763124E+00
DIV  1045,       10054,    10055,    A6101, 6.763124E+00,A6101, 8.511123E+00
DIV  1047,       10055,    10056,    A6101, 8.511123E+00,A6101, 1.012490E+01
DIV  1049,       10056,    10057,    A6101, 1.012490E+01,A6101, 1.157900E+01
DIV  1051,       10057,    10058,    A6101, 1.157900E+01,A6101, 1.285050E+01
DIV  1053,       10058,    10059,    A6101, 1.285050E+01,A6101, 1.391933E+01
DIV  1055,       10059,    10060,    A6101, 1.391933E+01,A6101, 1.476865E+01
DIV  1057,       10060,    10061,    A6101, 1.476865E+01,A6101, 1.538505E+01
DIV  1059,       10061,    10062,    A6101, 1.538505E+01,A6101, 1.575883E+01
DIV  1061,       10062,    10063,    A6101, 1.575883E+01,A6101, 1.588408E+01
REM  CIRCUMFERENTIAL CONDUCTORS REGION 5, LAYER NUMBER  4
DIV  1063,       10076,    10077,    A6101, 9.973755E-01,A6101, 2.976387E+00
DIV  1065,       10077,    10078,    A6101, 2.976387E+00,A6101, 4.908460E+00
DIV  1067,       10078,    10079,    A6101, 4.908460E+00,A6101, 6.763124E+00
DIV  1069,       10079,    10080,    A6101, 6.763124E+00,A6101, 8.511122E+00
DIV  1071,       10080,    10081,    A6101, 8.511122E+00,A6101, 1.012490E+01
DIV  1073,       10081,    10082,    A6101, 1.012490E+01,A6101, 1.157900E+01
DIV  1075,       10082,    10083,    A6101, 1.157900E+01,A6101, 1.285049E+01
DIV  1077,       10083,    10084,    A6101, 1.285049E+01,A6101, 1.391932E+01
DIV  1079,       10084,    10085,    A6101, 1.391932E+01,A6101, 1.476864E+01
DIV  1081,       10085,    10086,    A6101, 1.476864E+01,A6101, 1.538505E+01
DIV  1083,       10086,    10087,    A6101, 1.538505E+01,A6101, 1.575883E+01
DIV  1085,       10087,    10088,    A6101, 1.575883E+01,A6101, 1.588409E+01
REM  CIRCUMFERENTIAL CONDUCTORS REGION 5, LAYER NUMBER  5
DIV  1087,       10101,    10102,    A6101, 9.973756E-01,A6101, 2.976387E+00
DIV  1089,       10102,    10103,    A6101, 2.976387E+00,A6101, 4.908460E+00
DIV  1091,       10103,    10104,    A6101, 4.908460E+00,A6101, 6.763124E+00
```

```
DIV  1093,        10104,   10105,    A6101, 6.763124E+00,A6101, 8.511124E+00
DIV  1095,        10105,   10106,    A6101, 8.511124E+00,A6101, 1.012490E+01
DIV  1097,        10106,   10107,    A6101, 1.012490E+01,A6101, 1.157900E+01
DIV  1099,        10107,   10108,    A6101, 1.157900E+01,A6101, 1.285050E+01
DIV  1101,        10108,   10109,    A6101, 1.285050E+01,A6101, 1.391932E+01
DIV  1103,        10109,   10110,    A6101, 1.391932E+01,A6101, 1.476864E+01
DIV  1105,        10110,   10111,    A6101, 1.476864E+01,A6101, 1.538505E+01
DIV  1107,        10111,   10112,    A6101, 1.538505E+01,A6101, 1.575884E+01
DIV  1109,        10112,   10113,    A6101, 1.575884E+01,A6101, 1.588408E+01
REM  CIRCUMFERENTIAL CONDUCTORS REGION 5, LAYER NUMBER  6
DIV  1111,        10126,   10127,    A6101, 9.973757E-01,A6101, 2.976388E+00
DIV  1113,        10127,   10128,    A6101, 2.976388E+00,A6101, 4.908462E+00
DIV  1115,        10128,   10129,    A6101, 4.908462E+00,A6101, 6.763124E+00
DIV  1117,        10129,   10130,    A6101, 6.763124E+00,A6101, 8.511123E+00
DIV  1119,        10130,   10131,    A6101, 8.511123E+00,A6101, 1.012490E+01
DIV  1121,        10131,   10132,    A6101, 1.012490E+01,A6101, 1.157900E+01
DIV  1123,        10132,   10133,    A6101, 1.157900E+01,A6101, 1.285050E+01
DIV  1125,        10133,   10134,    A6101, 1.285050E+01,A6101, 1.391933E+01
DIV  1127,        10134,   10135,    A6101, 1.391933E+01,A6101, 1.476864E+01
DIV  1129,        10135,   10136,    A6101, 1.476864E+01,A6101, 1.538505E+01
DIV  1131,        10136,   10137,    A6101, 1.538505E+01,A6101, 1.575884E+01
DIV  1133,        10137,   10138,    A6101, 1.575884E+01,A6101, 1.588408E+01
REM  CIRCUMFERENTIAL CONDUCTORS REGION 5, LAYER NUMBER  7
DIV  1135,        10151,   10152,    A6101, 9.973759E-01,A6101, 2.976389E+00
DIV  1137,        10152,   10153,    A6101, 2.976389E+00,A6101, 4.908462E+00
DIV  1139,        10153,   10154,    A6101, 4.908462E+00,A6101, 6.763124E+00
DIV  1141,        10154,   10155,    A6101, 6.763124E+00,A6101, 8.511125E+00
DIV  1143,        10155,   10156,    A6101, 8.511125E+00,A6101, 1.012490E+01
DIV  1145,        10156,   10157,    A6101, 1.012490E+01,A6101, 1.157900E+01
DIV  1147,        10157,   10158,    A6101, 1.157900E+01,A6101, 1.285051E+01
DIV  1149,        10158,   10159,    A6101, 1.285051E+01,A6101, 1.391933E+01
DIV  1151,        10159,   10160,    A6101, 1.391933E+01,A6101, 1.476865E+01
DIV  1153,        10160,   10161,    A6101, 1.476865E+01,A6101, 1.538506E+01
DIV  1155,        10161,   10162,    A6101, 1.538506E+01,A6101, 1.575883E+01
DIV  1157,        10162,   10163,    A6101, 1.575883E+01,A6101, 1.588409E+01
REM  CIRCUMFERENTIAL CONDUCTORS REGION 5, LAYER NUMBER  8
DIV  1159,        10176,   10177,    A6101, 9.973755E-01,A6101, 2.976386E+00
DIV  1161,        10177,   10178,    A6101, 2.976386E+00,A6101, 4.908460E+00
DIV  1163,        10178,   10179,    A6101, 4.908460E+00,A6101, 6.763122E+00
DIV  1165,        10179,   10180,    A6101, 6.763122E+00,A6101, 8.511121E+00
DIV  1167,        10180,   10181,    A6101, 8.511121E+00,A6101, 1.012490E+01
DIV  1169,        10181,   10182,    A6101, 1.012490E+01,A6101, 1.157900E+01
DIV  1171,        10182,   10183,    A6101, 1.157900E+01,A6101, 1.285050E+01
DIV  1173,        10183,   10184,    A6101, 1.285050E+01,A6101, 1.391933E+01
DIV  1175,        10184,   10185,    A6101, 1.391933E+01,A6101, 1.476864E+01
DIV  1177,        10185,   10186,    A6101, 1.476864E+01,A6101, 1.538505E+01
DIV  1179,        10186,   10187,    A6101, 1.538505E+01,A6101, 1.575883E+01
DIV  1181,        10187,   10188,    A6101, 1.575883E+01,A6101, 1.588408E+01
REM  CIRCUMFERENTIAL CONDUCTORS REGION 5, LAYER NUMBER  9
DIV  1183,        10201,   10202,    A6101, 9.973756E-01,A6101, 2.976386E+00
DIV  1185,        10202,   10203,    A6101, 2.976386E+00,A6101, 4.908460E+00
DIV  1187,        10203,   10204,    A6101, 4.908460E+00,A6101, 6.763124E+00
DIV  1189,        10204,   10205,    A6101, 6.763124E+00,A6101, 8.511122E+00
DIV  1191,        10205,   10206,    A6101, 8.511122E+00,A6101, 1.012490E+01
DIV  1193,        10206,   10207,    A6101, 1.012490E+01,A6101, 1.157900E+01
DIV  1195,        10207,   10208,    A6101, 1.157900E+01,A6101, 1.285050E+01
DIV  1197,        10208,   10209,    A6101, 1.285050E+01,A6101, 1.391933E+01
DIV  1199,        10209,   10210,    A6101, 1.391933E+01,A6101, 1.476865E+01
DIV  1201,        10210,   10211,    A6101, 1.476865E+01,A6101, 1.538506E+01
DIV  1203,        10211,   10212,    A6101, 1.538506E+01,A6101, 1.575883E+01
DIV  1205,        10212,   10213,    A6101, 1.575883E+01,A6101, 1.588408E+01
REM  CIRCUMFERENTIAL CONDUCTORS REGION 5, LAYER NUMBER 10
DIV  1207,        10226,   10227,    A6301, 9.973755E-01,A6301, 2.976387E+00
DIV  1208,        10249,   10250,    A6301, 9.973755E-01,A6301, 2.976387E+00
DIV  1209,        10227,   10228,    A6301, 2.976387E+00,A6301, 4.908459E+00
DIV  1210,        10248,   10249,    A6301, 2.976387E+00,A6301, 4.908459E+00
DIV  1211,        10228,   10229,    A6301, 4.908459E+00,A6301, 6.763121E+00
DIV  1212,        10247,   10248,    A6301, 4.908459E+00,A6301, 6.763121E+00
DIV  1213,        10229,   10230,    A6301, 6.763121E+00,A6301, 8.511120E+00
DIV  1214,        10246,   10247,    A6301, 6.763121E+00,A6301, 8.511120E+00
```

```
DIV  1215,       10230,    10231,    A6301, 8.511120E+00,A6301, 1.012490E+01
DIV  1216,       10245,    10246,    A6301, 8.511120E+00,A6301, 1.012490E+01
DIV  1217,       10231,    10232,    A6301, 1.012490E+01,A6301, 1.157900E+01
DIV  1218,       10244,    10245,    A6301, 1.012490E+01,A6301, 1.157900E+01
DIV  1219,       10232,    10233,    A6301, 1.157900E+01,A6301, 1.285050E+01
DIV  1220,       10243,    10244,    A6301, 1.157900E+01,A6301, 1.285050E+01
DIV  1221,       10233,    10234,    A6301, 1.285050E+01,A6301, 1.391932E+01
DIV  1222,       10242,    10243,    A6301, 1.285050E+01,A6301, 1.391932E+01
DIV  1223,       10234,    10235,    A6301, 1.391932E+01,A6301, 1.476864E+01
DIV  1224,       10241,    10242,    A6301, 1.391932E+01,A6301, 1.476864E+01
DIV  1225,       10235,    10236,    A6301, 1.476864E+01,A6301, 1.538505E+01
DIV  1226,       10240,    10241,    A6301, 1.476864E+01,A6301, 1.538505E+01
DIV  1227,       10236,    10237,    A6301, 1.538505E+01,A6301, 1.575883E+01
DIV  1228,       10239,    10240,    A6301, 1.538505E+01,A6301, 1.575883E+01
DIV  1229,       10237,    10238,    A6301, 1.575883E+01,A6301, 1.588408E+01
DIV  1230,       10238,    10239,    A6301, 1.575883E+01,A6301, 1.588408E+01
REM  CIRCUMFERENTIAL CONDUCTORS REGION 5, LAYER NUMBER 11
DIV  1231,       10251,    10252,    A6301, 9.973756E-01,A6301, 2.976388E+00
DIV  1232,       10274,    10275,    A6301, 9.973756E-01,A6301, 2.976388E+00
DIV  1233,       10252,    10253,    A6301, 2.976388E+00,A6301, 4.908458E+00
DIV  1234,       10273,    10274,    A6301, 2.976388E+00,A6301, 4.908458E+00
DIV  1235,       10253,    10254,    A6301, 4.908458E+00,A6301, 6.763123E+00
DIV  1236,       10272,    10273,    A6301, 4.908458E+00,A6301, 6.763123E+00
DIV  1237,       10254,    10255,    A6301, 6.763123E+00,A6301, 8.511122E+00
DIV  1238,       10271,    10272,    A6301, 6.763123E+00,A6301, 8.511122E+00
DIV  1239,       10255,    10256,    A6301, 8.511122E+00,A6301, 1.012490E+01
DIV  1240,       10270,    10271,    A6301, 8.511122E+00,A6301, 1.012490E+01
DIV  1241,       10256,    10257,    A6301, 1.012490E+01,A6301, 1.157900E+01
DIV  1242,       10269,    10270,    A6301, 1.012490E+01,A6301, 1.157900E+01
DIV  1243,       10257,    10258,    A6301, 1.157900E+01,A6301, 1.285050E+01
DIV  1244,       10268,    10269,    A6301, 1.157900E+01,A6301, 1.285050E+01
DIV  1245,       10258,    10259,    A6301, 1.285050E+01,A6301, 1.391933E+01
DIV  1246,       10267,    10268,    A6301, 1.285050E+01,A6301, 1.391933E+01
DIV  1247,       10259,    10260,    A6301, 1.391933E+01,A6301, 1.476865E+01
DIV  1248,       10266,    10267,    A6301, 1.391933E+01,A6301, 1.476865E+01
DIV  1249,       10260,    10261,    A6301, 1.476865E+01,A6301, 1.538506E+01
DIV  1250,       10265,    10266,    A6301, 1.476865E+01,A6301, 1.538506E+01
DIV  1251,       10261,    10262,    A6301, 1.538506E+01,A6301, 1.575883E+01
DIV  1252,       10264,    10265,    A6301, 1.538506E+01,A6301, 1.575883E+01
DIV  1253,       10262,    10263,    A6301, 1.575883E+01,A6301, 1.588409E+01
DIV  1254,       10263,    10264,    A6301, 1.575883E+01,A6301, 1.588409E+01
REM  CIRCUMFERENTIAL CONDUCTORS REGION 5, LAYER NUMBER 12
DIV  1255,       10276,    10277,    A6301, 9.973755E-01,A6301, 2.976386E+00
DIV  1256,       10299,    10300,    A6301, 9.973755E-01,A6301, 2.976386E+00
DIV  1257,       10277,    10278,    A6301, 2.976386E+00,A6301, 4.908456E+00
DIV  1258,       10298,    10299,    A6301, 2.976386E+00,A6301, 4.908456E+00
DIV  1259,       10278,    10279,    A6301, 4.908456E+00,A6301, 6.763120E+00
DIV  1260,       10297,    10298,    A6301, 4.908456E+00,A6301, 6.763120E+00
DIV  1261,       10279,    10280,    A6301, 6.763120E+00,A6301, 8.511119E+00
DIV  1262,       10296,    10297,    A6301, 6.763120E+00,A6301, 8.511119E+00
DIV  1263,       10280,    10281,    A6301, 8.511119E+00,A6301, 1.012490E+01
DIV  1264,       10295,    10296,    A6301, 8.511119E+00,A6301, 1.012490E+01
DIV  1265,       10281,    10282,    A6301, 1.012490E+01,A6301, 1.157900E+01
DIV  1266,       10294,    10295,    A6301, 1.012490E+01,A6301, 1.157900E+01
DIV  1267,       10282,    10283,    A6301, 1.157900E+01,A6301, 1.285050E+01
DIV  1268,       10293,    10294,    A6301, 1.157900E+01,A6301, 1.285050E+01
DIV  1269,       10283,    10284,    A6301, 1.285050E+01,A6301, 1.391932E+01
DIV  1270,       10292,    10293,    A6301, 1.285050E+01,A6301, 1.391932E+01
DIV  1271,       10284,    10285,    A6301, 1.391932E+01,A6301, 1.476864E+01
DIV  1272,       10291,    10292,    A6301, 1.391932E+01,A6301, 1.476864E+01
DIV  1273,       10285,    10286,    A6301, 1.476864E+01,A6301, 1.538505E+01
DIV  1274,       10290,    10291,    A6301, 1.476864E+01,A6301, 1.538505E+01
DIV  1275,       10286,    10287,    A6301, 1.538505E+01,A6301, 1.575883E+01
DIV  1276,       10289,    10290,    A6301, 1.538505E+01,A6301, 1.575883E+01
DIV  1277,       10287,    10288,    A6301, 1.575883E+01,A6301, 1.588408E+01
DIV  1278,       10288,    10289,    A6301, 1.575883E+01,A6301, 1.588408E+01
REM  CIRCUMFERENTIAL CONDUCTORS REGION 5, LAYER NUMBER 13
DIV  1279,       10301,    10302,    A6301, 9.973757E-01,A6301, 2.976388E+00
DIV  1280,       10324,    10325,    A6301, 9.973757E-01,A6301, 2.976388E+00
DIV  1281,       10302,    10303,    A6301, 2.976388E+00,A6301, 4.908461E+00
```

```
DIV  1282,      10323,   10324,    A6301, 2.976388E+00,A6301, 4.908461E+00
DIV  1283,      10303,   10304,    A6301, 4.908461E+00,A6301, 6.763122E+00
DIV  1284,      10322,   10323,    A6301, 4.908461E+00,A6301, 6.763122E+00
DIV  1285,      10304,   10305,    A6301, 6.763122E+00,A6301, 8.511123E+00
DIV  1286,      10321,   10322,    A6301, 6.763122E+00,A6301, 8.511123E+00
DIV  1287,      10305,   10306,    A6301, 8.511123E+00,A6301, 1.012490E+01
DIV  1288,      10320,   10321,    A6301, 8.511123E+00,A6301, 1.012490E+01
DIV  1289,      10306,   10307,    A6301, 1.012490E+01,A6301, 1.157900E+01
DIV  1290,      10319,   10320,    A6301, 1.012490E+01,A6301, 1.157900E+01
DIV  1291,      10307,   10308,    A6301, 1.157900E+01,A6301, 1.285050E+01
DIV  1292,      10318,   10319,    A6301, 1.157900E+01,A6301, 1.285050E+01
DIV  1293,      10308,   10309,    A6301, 1.285050E+01,A6301, 1.391933E+01
DIV  1294,      10317,   10318,    A6301, 1.285050E+01,A6301, 1.391933E+01
DIV  1295,      10309,   10310,    A6301, 1.391933E+01,A6301, 1.476865E+01
DIV  1296,      10316,   10317,    A6301, 1.391933E+01,A6301, 1.476865E+01
DIV  1297,      10310,   10311,    A6301, 1.476865E+01,A6301, 1.538506E+01
DIV  1298,      10315,   10316,    A6301, 1.476865E+01,A6301, 1.538506E+01
DIV  1299,      10311,   10312,    A6301, 1.538506E+01,A6301, 1.575884E+01
DIV  1300,      10314,   10315,    A6301, 1.538506E+01,A6301, 1.575884E+01
DIV  1301,      10312,   10313,    A6301, 1.575884E+01,A6301, 1.588409E+01
DIV  1302,      10313,   10314,    A6301, 1.575884E+01,A6301, 1.588409E+01
REM  CIRCUMFERENTIAL CONDUCTORS REGION 5, LAYER NUMBER 14
DIV  1303,      10326,   10327,    A6301, 9.973754E-01,A6301, 2.976388E+00
DIV  1304,      10349,   10350,    A6301, 9.973754E-01,A6301, 2.976388E+00
DIV  1305,      10327,   10328,    A6301, 2.976388E+00,A6301, 4.908461E+00
DIV  1306,      10348,   10349,    A6301, 2.976388E+00,A6301, 4.908461E+00
DIV  1307,      10328,   10329,    A6301, 4.908461E+00,A6301, 6.763123E+00
DIV  1308,      10347,   10348,    A6301, 4.908461E+00,A6301, 6.763123E+00
DIV  1309,      10329,   10330,    A6301, 6.763123E+00,A6301, 8.511121E+00
DIV  1310,      10346,   10347,    A6301, 6.763123E+00,A6301, 8.511121E+00
DIV  1311,      10330,   10331,    A6301, 8.511121E+00,A6301, 1.012490E+01
DIV  1312,      10345,   10346,    A6301, 8.511121E+00,A6301, 1.012490E+01
DIV  1313,      10331,   10332,    A6301, 1.012490E+01,A6301, 1.157899E+01
DIV  1314,      10344,   10345,    A6301, 1.012490E+01,A6301, 1.157899E+01
DIV  1315,      10332,   10333,    A6301, 1.157899E+01,A6301, 1.285050E+01
DIV  1316,      10343,   10344,    A6301, 1.157899E+01,A6301, 1.285050E+01
DIV  1317,      10333,   10334,    A6301, 1.285050E+01,A6301, 1.391932E+01
DIV  1318,      10342,   10343,    A6301, 1.285050E+01,A6301, 1.391932E+01
DIV  1319,      10334,   10335,    A6301, 1.391932E+01,A6301, 1.476864E+01
DIV  1320,      10341,   10342,    A6301, 1.391932E+01,A6301, 1.476864E+01
DIV  1321,      10335,   10336,    A6301, 1.476864E+01,A6301, 1.538505E+01
DIV  1322,      10340,   10341,    A6301, 1.476864E+01,A6301, 1.538505E+01
DIV  1323,      10336,   10337,    A6301, 1.538505E+01,A6301, 1.575883E+01
DIV  1324,      10339,   10340,    A6301, 1.538505E+01,A6301, 1.575883E+01
DIV  1325,      10337,   10338,    A6301, 1.575883E+01,A6301, 1.588408E+01
DIV  1326,      10338,   10339,    A6301, 1.575883E+01,A6301, 1.588408E+01
REM  CIRCUMFERENTIAL CONDUCTORS REGION 5, LAYER NUMBER 15
DIV  1327,      10351,   10352,    A6301, 9.973760E-01,A6301, 2.976389E+00
DIV  1328,      10374,   10375,    A6301, 9.973760E-01,A6301, 2.976389E+00
DIV  1329,      10352,   10353,    A6301, 2.976389E+00,A6301, 4.908461E+00
DIV  1330,      10373,   10374,    A6301, 2.976389E+00,A6301, 4.908461E+00
DIV  1331,      10353,   10354,    A6301, 4.908461E+00,A6301, 6.763125E+00
DIV  1332,      10372,   10373,    A6301, 4.908461E+00,A6301, 6.763125E+00
DIV  1333,      10354,   10355,    A6301, 6.763125E+00,A6301, 8.511126E+00
DIV  1334,      10371,   10372,    A6301, 6.763125E+00,A6301, 8.511126E+00
DIV  1335,      10355,   10356,    A6301, 8.511126E+00,A6301, 1.012490E+01
DIV  1336,      10370,   10371,    A6301, 8.511126E+00,A6301, 1.012490E+01
DIV  1337,      10356,   10357,    A6301, 1.012490E+01,A6301, 1.157901E+01
DIV  1338,      10369,   10370,    A6301, 1.012490E+01,A6301, 1.157901E+01
DIV  1339,      10357,   10358,    A6301, 1.157901E+01,A6301, 1.285051E+01
DIV  1340,      10368,   10369,    A6301, 1.157901E+01,A6301, 1.285051E+01
DIV  1341,      10358,   10359,    A6301, 1.285051E+01,A6301, 1.391933E+01
DIV  1342,      10367,   10368,    A6301, 1.285051E+01,A6301, 1.391933E+01
DIV  1343,      10359,   10360,    A6301, 1.391933E+01,A6301, 1.476865E+01
DIV  1344,      10366,   10367,    A6301, 1.391933E+01,A6301, 1.476865E+01
DIV  1345,      10360,   10361,    A6301, 1.476865E+01,A6301, 1.538506E+01
DIV  1346,      10365,   10366,    A6301, 1.476865E+01,A6301, 1.538506E+01
DIV  1347,      10361,   10362,    A6301, 1.538506E+01,A6301, 1.575884E+01
DIV  1348,      10364,   10365,    A6301, 1.538506E+01,A6301, 1.575884E+01
DIV  1349,      10362,   10363,    A6301, 1.575884E+01,A6301, 1.588409E+01
```

```
DIV  1350,       10363,    10364,     A6301, 1.575884E+01,A6301, 1.588409E+01
REM  CONVECTION CONDUCTORS; ATMOSPHERE TO OUTER SURFACE
GEN  1352,  2,1,20301, 0, 7001,24,0.00001E-79,0.00000E+00, 4.80, 0.00
GEN  1354,  2,1,20301, 0, 7002,22,0.00001E-79,0.00000E+00,14.33, 0.00
GEN  1356,  2,1,20301, 0, 7003,20,0.00001E-79,0.00000E+00,23.62, 0.00
GEN  1358,  2,1,20301, 0, 7004,18,0.00001E-79,0.00000E+00,32.55, 0.00
GEN  1360,  2,1,20301, 0, 7005,16,0.00001E-79,0.00000E+00,40.96, 0.00
GEN  1362,  2,1,20301, 0, 7006,14,0.00001E-79,0.00000E+00,48.73, 0.00
GEN  1364,  2,1,20301, 0, 7007,12,0.00001E-79,0.00000E+00,55.73, 0.00
GEN  1366,  2,1,20301, 0, 7008,10,0.00001E-79,0.00000E+00,61.85, 0.00
GEN  1368,  2,1,20301, 0, 7009, 8,0.00001E-79,0.00000E+00,67.00, 0.00
GEN  1370,  2,1,20301, 0, 7010, 6,0.00001E-79,0.00000E+00,71.08, 0.00
GEN  1372,  2,1,20301, 0, 7011, 4,0.00001E-79,0.00000E+00,74.05, 0.00
GEN  1374,  2,1,20301, 0, 7012, 2,0.00001E-79,0.00000E+00,75.85, 0.00
GEN  1376,  1,1,20301, 0, 7013, 0,0.00001E-79,0.00000E+00,76.45, 0.00
REM  RADIATION  CONDUCTORS; ATMOSPHERE TO OUTER SURFACE
GEN  1377,  2,1,20302, 0, 7001,24,0.00001E-79,0.00000E+00, 0.00, 0.00
GEN  1379,  2,1,20302, 0, 7002,22,0.00001E-79,0.00000E+00, 0.00, 0.00
GEN  1381,  2,1,20302, 0, 7003,20,0.00001E-79,0.00000E+00, 0.00, 0.00
GEN  1383,  2,1,20302, 0, 7004,18,0.00001E-79,0.00000E+00, 0.00, 0.00
GEN  1385,  2,1,20302, 0, 7005,16,0.00001E-79,0.00000E+00, 0.00, 0.00
GEN  1387,  2,1,20302, 0, 7006,14,0.00001E-79,0.00000E+00, 0.00, 0.00
GEN  1389,  2,1,20302, 0, 7007,12,0.00001E-79,0.00000E+00, 0.00, 0.00
GEN  1391,  2,1,20302, 0, 7008,10,0.00001E-79,0.00000E+00, 0.00, 0.00
GEN  1393,  2,1,20302, 0, 7009, 8,0.00001E-79,0.00000E+00, 0.00, 0.00
GEN  1395,  2,1,20302, 0, 7010, 6,0.00001E-79,0.00000E+00, 0.00, 0.00
GEN  1397,  2,1,20302, 0, 7011, 4,0.00001E-79,0.00000E+00, 0.00, 0.00
GEN  1399,  2,1,20302, 0, 7012, 2,0.00001E-79,0.00000E+00, 0.00, 0.00
GEN  1401,  1,1,20302, 0, 7013, 0,0.00001E-79,0.00000E+00, 0.00, 0.00
END
BCD 3CONSTANTS DATA
REM NTHETA NBETAS      BETA        RIN        TVOL
     1=  25, 2=   1, 3=  1.000, 4=  20.000, 5=   19.393
REM K10=SINDA TEMP UNITS; K10=1(DEG F); K10=2(DEG R)
     10= 1
REM   TIMEO(MIN)       TIMEND(MIN)       DTIMEI(MIN)       OUTPUT(MIN)
REM 0.00000E+00        120.00            0.10000E-02       0.25000
    101=0.00000E+00, 102= 2.0000    , 103=0.16667E-04, 104=0.41667E-02
    NLOOP=    500, DRLXCA= 0.001000, ARLXCA= 0.001000
END
BCD 3ARRAY DATA
REM CONDUCTIVITY  BTU/(INCH.HR.F)  FOR ALUMINUM 2219
     6204
      -442., 0.46480E+00, -424., 0.89712E+00, -406., 0.12994E+01
      -388., 0.17243E+01, -370., 0.21491E+01, -352., 0.28238E+01
      -334., 0.28988E+01, -316., 0.32486E+01, -298., 0.33986E+01
      -280., 0.34985E+01, -190., 0.43482E+01, -100., 0.50479E+01
       -10., 0.56476E+01,   80., 0.61474E+01,  170., 0.65472E+01
       260., 0.68471E+01,  350., 0.70470E+01,  440., 0.72969E+01
       530., 0.75968E+01,  620., 0.77967E+01,  710., 0.79466E+01
       800., 0.78467E+01,  890., 0.76967E+01,END
REM SPECIFIC HEAT BTU/(LB.F)        FOR ALUMINUM 2219
     2204
      -442., 0.35300E-03, -424., 0.19800E-02, -406., 0.74100E-02
      -388., 0.18100E-01, -370., 0.33000E-01, -352., 0.51300E-01
      -334., 0.69200E-01, -316., 0.83700E-01, -298., 0.99400E-01
      -280., 0.11200E+00, -190., 0.16000E+00, -100., 0.18300E+00
       -10., 0.20000E+00,   80., 0.20800E+00,  170., 0.21000E+00
       260., 0.21700E+00,  350., 0.22000E+00,  440., 0.22800E+00
       530., 0.23400E+00,  620., 0.23800E+00,  710., 0.24000E+00
       800., 0.24800E+00,  890., 0.25400E+00,END
REM DENSITY         LB/(CUBIC INCH)  FOR ALUMINUM 2219
     3204
      -442., 0.10365E+00, -424., 0.10362E+00, -406., 0.10322E+00
      -388., 0.10318E+00, -370., 0.10312E+00, -352., 0.10308E+00
      -334., 0.10305E+00, -316., 0.10301E+00, -298., 0.10298E+00
      -280., 0.10296E+00, -190., 0.10278E+00, -100., 0.10260E+00
       -10., 0.10224E+00,   80., 0.10188E+00,  170., 0.10152E+00
       260., 0.10116E+00,  350., 0.10079E+00,  440., 0.10043E+00
       530., 0.10007E+00,  620., 0.99711E-01,  710., 0.99169E-01
```

```
     800., 0.98627E-01,  890., 0.98085E-01,END
REM CP * RHO FOR ALUMINUM 2219
    1204
     -442., 0.36588E-04, -424., 0.20516E-03, -406., 0.76488E-03
     -388., 0.18675E-02, -370., 0.34031E-02, -352., 0.52881E-02
     -334., 0.71310E-02, -316., 0.86215E-02, -298., 0.10236E-01
     -280., 0.11532E-01, -190., 0.16445E-01, -100., 0.18776E-01
      -10., 0.20448E-01,   80., 0.21191E-01,  170., 0.21319E-01
      260., 0.21951E-01,  350., 0.22175E-01,  440., 0.22899E-01
      530., 0.23417E-01,  620., 0.23731E-01,  710., 0.23800E-01
      800., 0.24459E-01,  890., 0.24914E-01,END
REM CONDUCTIVITY  BTU/(INCH.HR.F)  FOR STAINLESS 347
    6202
     -442., 0.38983E-01, -424., 0.10995E+00, -406., 0.15993E+00
     -388., 0.22490E+00, -370., 0.26989E+00, -352., 0.27613E+00
     -316., 0.41232E+00, -280., 0.45481E+00, -190., 0.55526E+00
     -100., 0.62973E+00,   80., 0.73969E+00,  260., 0.82465E+00
      440., 0.89462E+00,  620., 0.95959E+00,  800., 0.10246E+01
      980., 0.10945E+01, 1160., 0.11595E+01, 1340., 0.12295E+01
     1520., 0.12945E+01, 1700., 0.13644E+01, 1880., 0.14294E+01
     2060., 0.14994E+01, 2240., 0.15643E+01,END
REM SPECIFIC HEAT BTU/(LB.F)       FOR STAINLESS 347
    2202
     -442., 0.29400E-03, -424., 0.10900E-02, -406., 0.31500E-02
     -388., 0.70800E-02, -370., 0.12800E-01, -352., 0.26000E-01
     -316., 0.44600E-01, -280., 0.63000E-01, -190., 0.87000E-01
     -100., 0.97000E-01,   80., 0.10800E+00,  260., 0.11700E+00
      440., 0.12300E+00,  620., 0.13000E+00,  800., 0.13500E+00
      980., 0.14000E+00, 1160., 0.14500E+00, 1340., 0.14900E+00
     1520., 0.15200E+00, 1700., 0.15600E+00, 1880., 0.16000E+00
     2060., 0.16400E+00, 2240., 0.16800E+00,END
REM DENSITY        LB/(CUBIC INCH)  FOR STAINLESS 347
    3202
     -442., 0.28884E+00, -424., 0.28873E+00, -406., 0.28862E+00
     -388., 0.28851E+00, -370., 0.28840E+00, -352., 0.28829E+00
     -316., 0.28819E+00, -280., 0.28782E+00, -190., 0.28725E+00
     -100., 0.28663E+00,   80., 0.28537E+00,  260., 0.28396E+00
      440., 0.28255E+00,  620., 0.28107E+00,  800., 0.27951E+00
      980., 0.27789E+00, 1160., 0.27655E+00, 1340., 0.27478E+00
     1520., 0.27296E+00, 1700., 0.27102E+00, 1880., 0.26900E+00
     2060., 0.26687E+00, 2240., 0.26463E+00,END
REM CP * RHO FOR STAINLESS 347
    1202
     -442., 0.84918E-04, -424., 0.31471E-03, -406., 0.90915E-03
     -388., 0.20427E-02, -370., 0.36915E-02, -352., 0.74956E-02
     -316., 0.12853E-01, -280., 0.18133E-01, -190., 0.24990E-01
     -100., 0.27803E-01,   80., 0.30820E-01,  260., 0.33223E-01
      440., 0.34754E-01,  620., 0.36539E-01,  800., 0.37734E-01
      980., 0.38904E-01, 1160., 0.40100E-01, 1340., 0.40943E-01
     1520., 0.41490E-01, 1700., 0.42280E-01, 1880., 0.43040E-01
     2060., 0.43767E-01, 2240., 0.44458E-01,END
REM SPECIFIC HEAT BTU/(INCH.HR.F)  FOR HYDROGEN        AT P=   49.0 PSIA
    2101
     -430., 0.53700E+03, -428., 0.56580E+03, -428., 0.57660E+03
     -427., 0.59880E+03, -426., 0.62220E+03, -425., 0.64650E+03
     -424., 0.67140E+03, -423., 0.69750E+03, -422., 0.72450E+03
     -421., 0.75270E+03, -420., 0.78240E+03, -419., 0.81420E+03
     -418., 0.84840E+03, -417., 0.88590E+03, -416., 0.92760E+03,END
REM DENSITY        BTU/LB          FOR HYDROGEN        AT P=   49.0 PSIA
    3101
     -430., 0.46700E+01, -428., 0.46220E+01, -428., 0.46050E+01
     -427., 0.45700E+01, -426., 0.45350E+01, -425., 0.44980E+01
     -424., 0.44600E+01, -423., 0.44200E+01, -422., 0.43790E+01
     -421., 0.43350E+01, -420., 0.42900E+01, -419., 0.42430E+01
     -418., 0.41930E+01, -417., 0.41410E+01, -416., 0.40850E+01,END
REM VISCOSITY     LB/(INCH.HR)     FOR HYDROGEN        AT P=   49.0 PSIA
    4101
     -430., 0.37236E-02, -428., 0.34263E-02, -428., 0.33369E-02
     -427., 0.31701E-02, -426., 0.30174E-02, -425., 0.28775E-02
     -424., 0.27481E-02, -423., 0.26282E-02, -422., 0.25165E-02
```

```
      -421., 0.24121E-02, -420., 0.23141E-02, -419., 0.22217E-02
      -418., 0.21344E-02, -417., 0.20515E-02, -416., 0.19725E-02,END
 REM ENTHALPHY      BTU/(LB.F)         FOR HYDROGEN          AT P=   49.0 PSIA
     5101
      -430.,-0.12220E+03, -428.,-0.11950E+03, -428.,-0.11850E+03
      -427.,-0.11660E+03, -426.,-0.11450E+03, -425.,-0.11240E+03
      -424.,-0.11020E+03, -423.,-0.10790E+03, -422.,-0.10560E+03
      -421.,-0.10310E+03, -420.,-0.10050E+03, -419.,-0.97900E+02
      -418.,-0.95100E+02, -417.,-0.92200E+02, -416.,-0.89200E+02,END
 REM CONDUCTIVITY  BTU/(INCH.HR.F)  FOR HYDROGEN          AT P=   49.0 PSIA
     6101
      -430., 0.44145E-02, -428., 0.45405E-02, -428., 0.45741E-02
      -427., 0.46284E-02, -426., 0.46668E-02, -425., 0.46911E-02
      -424., 0.47391E-02, -423., 0.47868E-02, -422., 0.48231E-02
      -421., 0.48483E-02, -420., 0.48636E-02, -419., 0.48696E-02
      -418., 0.48666E-02, -417., 0.48549E-02, -416., 0.48354E-02,END
 REM CP * RHO FOR HYDROGEN           AT P=   49.0 PSIA
     1101
      -430., 0.25078E+04, -428., 0.26151E+04, -428., 0.26552E+04
      -427., 0.27365E+04, -426., 0.28217E+04, -425., 0.29080E+04
      -424., 0.29944E+04, -423., 0.30829E+04, -422., 0.31726E+04
      -421., 0.32630E+04, -420., 0.33565E+04, -419., 0.34546E+04
      -418., 0.35573E+04, -417., 0.36685E+04, -416., 0.37892E+04,END
 REM SPECIFIC HEAT BTU/(INCH.HR.F)  FOR HYDROGEN          AT P=   49.0 PSIA
     2301
      -408., 0.92820E+03, -407., 0.91350E+03, -406., 0.90060E+03
      -405., 0.88950E+03, -404., 0.87960E+03, -403., 0.87060E+03
      -402., 0.86250E+03, -401., 0.85530E+03, -400., 0.84900E+03
      -399., 0.84300E+03, -398., 0.83760E+03, -397., 0.83280E+03
      -396., 0.82830E+03, -395., 0.82410E+03, -394., 0.82020E+03,END
 REM DENSITY        BTU/LB             FOR HYDROGEN          AT P=   49.0 PSIA
     3301
      -408., 0.20500E+00, -407., 0.19900E+00, -406., 0.19400E+00
      -405., 0.18900E+00, -404., 0.18400E+00, -403., 0.18000E+00
      -402., 0.17600E+00, -401., 0.17200E+00, -400., 0.16800E+00
      -399., 0.16500E+00, -398., 0.16200E+00, -397., 0.15800E+00
      -396., 0.15500E+00, -395., 0.15200E+00, -394., 0.15000E+00,END
 REM VISCOSITY     LB/(INCH.HR)       FOR HYDROGEN          AT P=   49.0 PSIA
     4301
      -408., 0.35931E-03, -407., 0.37224E-03, -406., 0.38703E-03
      -405., 0.40467E-03, -404., 0.42684E-03, -403., 0.45705E-03
      -402., 0.50340E-03, -401., 0.59283E-03, -400., 0.72327E-03
      -399., 0.72711E-03, -398., 0.73098E-03, -397., 0.73485E-03
      -396., 0.73875E-03, -395., 0.74268E-03, -394., 0.74658E-03,END
 REM ENTHALPHY      BTU/(LB.F)         FOR HYDROGEN          AT P=   49.0 PSIA
     5301
      -408., 0.11070E+03, -407., 0.11380E+03, -406., 0.11680E+03
      -405., 0.11980E+03, -404., 0.12270E+03, -403., 0.12560E+03
      -402., 0.12850E+03, -401., 0.13140E+03, -400., 0.13420E+03
      -399., 0.13700E+03, -398., 0.13980E+03, -397., 0.14260E+03
      -396., 0.14540E+03, -395., 0.14810E+03, -394., 0.15090E+03,END
 REM CONDUCTIVITY  BTU/(INCH.HR.F)  FOR HYDROGEN          AT P=   49.0 PSIA
     6301
      -408., 0.13473E-02, -407., 0.14059E-02, -406., 0.14714E-02
      -405., 0.15430E-02, -404., 0.16279E-02, -403., 0.17342E-02
      -402., 0.18823E-02, -401., 0.21532E-02, -400., 0.25921E-02
      -399., 0.26181E-02, -398., 0.26439E-02, -397., 0.26696E-02
      -396., 0.26951E-02, -395., 0.27205E-02, -394., 0.27457E-02,END
 REM CP * RHO FOR HYDROGEN           AT P=   49.0 PSIA
     1301
      -408., 0.19028E+03, -407., 0.18179E+03, -406., 0.17472E+03
      -405., 0.16812E+03, -404., 0.16185E+03, -403., 0.15671E+03
      -402., 0.15180E+03, -401., 0.14711E+03, -400., 0.14263E+03
      -399., 0.13910E+03, -398., 0.13569E+03, -397., 0.13158E+03
      -396., 0.12839E+03, -395., 0.12526E+03, -394., 0.12303E+03,END
  END
  BCD 3EXECUTION
F      COMMON/USER1/ NTHETA,NBETAS,NTUNIT,BETA,RIN,TVOL
F      DIMENSION X( 3900)
F       NDIM=  3900
```

```
M       NTHETA= K1
M       NBETAS= K2
M       BETA   =XK3
M       RIN    =XK4
M       TVOL   =XK5
M       NTUNIT= K10
M       TIMEO = XK101
M       TIMEND= XK102
M       OUTPUT= XK104
M       DTIMEI= XK103
            FWDBCK
        END
        BCD 3VARIABLES 1
F      COMMON/USER1/ NTHETA,NBETAS,NTUNIT,BETA,RIN,TVOL
        END
        BCD 3VARIABLES 2
        END
        BCD 3OUTPUT CALLS
            TPRNTF
        END
        BCD 3END OF DATA
EOF
cossinda  model
ja   -sclf  #  GET ACCOUNTING INFO
```

APPENDIX C

"CryoTran Model" Files Part 2

Spherical Models with no Nodes in Regions 4 & 5

Sample sphere models where regions 4 and 5 are not nodalized.

```
# USER=userid            PW=password
# QSUB -r sphere2               # jobname
# QSUB -eo               # Combine error andstandard output
# QSUB -lT       59        # CPU time
# QSUB -lM  1.5Mw    # Memory requested
#      @$               # End NQS statements
set  -x                 # set echo
ja
cat  >  model  << EOF    # SINDA MODEL TO FOLLOW

       BCD 3THERMAL LPCS
C      REM  THIS SINDA MODEL WAS GENERATED BY CRYOTRAN
C      REM  SPHERE   --- 2D WEDGE SHELL - THICK WALL FILL ANALYSIS
C      REM           WEDGE ANGLE-BETA - 1.0 RADIANS
       BCD 9SAMPLE RUN OF NO NODES IN TANK, CALLING
       BCD 9SUBROUTINES
       END
       BCD 3NODE DATA
       REM  NODE TEMPERATURES ARE IN (DEG R)
       REM  DIMENSIONS ARE IN (IN.),  TIME IS IN (SECS)
       REM  SURFACE NODES, INSIDE TANK WALL
       GEN   1001, 25,  1,  540.0,          -1.000000 $ SURFACE NODES
       REM  DIFFUSION NODES, REGION  1, TANKWALL
       REM   REGION  1,  LAYER NO.   1
       SIM   2001,  2, 24,  540.0, A1201,     2.610795 $ STAINLESS 304A
       SIM   2002,  2, 22,  540.0, A1201,     7.791187 $ STAINLESS 304A
       SIM   2003,  2, 20,  540.0, A1201,    12.848701 $ STAINLESS 304A
       SIM   2004,  2, 18,  540.0, A1201,    17.703583 $ STAINLESS 304A
       SIM   2005,  2, 16,  540.0, A1201,    22.279266 $ STAINLESS 304A
       SIM   2006,  2, 14,  540.0, A1201,    26.503586 $ STAINLESS 304A
       SIM   2007,  2, 12,  540.0, A1201,    30.309937 $ STAINLESS 304A
       SIM   2008,  2, 10,  540.0, A1201,    33.638306 $ STAINLESS 304A
       SIM   2009,  2,  8,  540.0, A1201,    36.436127 $ STAINLESS 304A
       SIM   2010,  2,  6,  540.0, A1201,    38.659363 $ STAINLESS 304A
       SIM   2011,  2,  4,  540.0, A1201,    40.272919 $ STAINLESS 304A
       SIM   2012,  2,  2,  540.0, A1201,    41.251343 $ STAINLESS 304A
       SIV   2013,          540.0, A1201,    41.579208 $ STAINLESS 304A
       REM   REGION  1,  LAYER NO.   2
       SIM   2026,  2, 24,  540.0, A1201,     2.510389 $ STAINLESS 304A
       SIM   2027,  2, 22,  540.0, A1201,     7.491554 $ STAINLESS 304A
       SIM   2028,  2, 20,  540.0, A1201,    12.354561 $ STAINLESS 304A
       SIM   2029,  2, 18,  540.0, A1201,    17.022736 $ STAINLESS 304A
       SIM   2030,  2, 16,  540.0, A1201,    21.422440 $ STAINLESS 304A
       SIM   2031,  2, 14,  540.0, A1201,    25.484314 $ STAINLESS 304A
       SIM   2032,  2, 12,  540.0, A1201,    29.144287 $ STAINLESS 304A
       SIM   2033,  2, 10,  540.0, A1201,    32.344635 $ STAINLESS 304A
       SIM   2034,  2,  8,  540.0, A1201,    35.034866 $ STAINLESS 304A
       SIM   2035,  2,  6,  540.0, A1201,    37.172607 $ STAINLESS 304A
       SIM   2036,  2,  4,  540.0, A1201,    38.724106 $ STAINLESS 304A
       SIM   2037,  2,  2,  540.0, A1201,    39.664902 $ STAINLESS 304A
       SIV   2038,          540.0, A1201,    39.980148 $ STAINLESS 304A
       REM   REGION  1,  LAYER NO.   3
       SIM   2051,  2, 24,  540.0, A1201,     2.411952 $ STAINLESS 304A
       SIM   2052,  2, 22,  540.0, A1201,     7.197796 $ STAINLESS 304A
       SIM   2053,  2, 20,  540.0, A1201,    11.870125 $ STAINLESS 304A
       SIM   2054,  2, 18,  540.0, A1201,    16.355255 $ STAINLESS 304A
       SIM   2055,  2, 16,  540.0, A1201,    20.582428 $ STAINLESS 304A
       SIM   2056,  2, 14,  540.0, A1201,    24.485031 $ STAINLESS 304A
       SIM   2057,  2, 12,  540.0, A1201,    28.001480 $ STAINLESS 304A
       SIM   2058,  2, 10,  540.0, A1201,    31.076340 $ STAINLESS 304A
       SIM   2059,  2,  8,  540.0, A1201,    33.661087 $ STAINLESS 304A
       SIM   2060,  2,  6,  540.0, A1201,    35.714996 $ STAINLESS 304A
       SIM   2061,  2,  4,  540.0, A1201,    37.205658 $ STAINLESS 304A
       SIM   2062,  2,  2,  540.0, A1201,    38.109558 $ STAINLESS 304A
       SIV   2063,          540.0, A1201,    38.412460 $ STAINLESS 304A
       REM   REGION  1,  LAYER NO.   4
```

```
SIM   2076,  2, 24,  540.0, A1201,      2.315484 $ STAINLESS 304A
SIM   2077,  2, 22,  540.0, A1201,      6.909912 $ STAINLESS 304A
SIM   2078,  2, 20,  540.0, A1201,     11.395363 $ STAINLESS 304A
SIM   2079,  2, 18,  540.0, A1201,     15.701111 $ STAINLESS 304A
SIM   2080,  2, 16,  540.0, A1201,     19.759216 $ STAINLESS 304A
SIM   2081,  2, 14,  540.0, A1201,     23.505722 $ STAINLESS 304A
SIM   2082,  2, 12,  540.0, A1201,     26.881531 $ STAINLESS 304A
SIM   2083,  2, 10,  540.0, A1201,     29.833420 $ STAINLESS 304A
SIM   2084,  2,  8,  540.0, A1201,     32.314789 $ STAINLESS 304A
SIM   2085,  2,  6,  540.0, A1201,     34.286545 $ STAINLESS 304A
SIM   2086,  2,  4,  540.0, A1201,     35.717575 $ STAINLESS 304A
SIM   2087,  2,  2,  540.0, A1201,     36.585342 $ STAINLESS 304A
SIV   2088,          540.0, A1201,     36.876114 $ STAINLESS 304A
REM  SURFACE NODES, OUTSIDE SURFACE, REGION  1, TANKWALL
GEN   3001, 25,  1,  540.0,             -1.000000 $ SURFACE NODES
REM  CONSTANT VALUE BOUNDARY NODES; REGION 4, INSIDE OF TANK
GEN -18001, 25,  1,    0.0,              1.000000 $ INSIDE TANK     1
END
BCD 3CONDUCTOR DATA
REM  RADIAL CONDUCTORS,  CONDUCTION
REM  RADIAL CONDUCTORS REGION 1, LAYER  1 TO BOUNDARY   1- 4
SIM     1,  2,1, 1001,24, 2001,24, A6201, 1.833339E+01
SIM     3,  2,1, 1002,22, 2002,22, A6201, 5.471088E+01
SIM     5,  2,1, 1003,20, 2003,20, A6201, 9.022552E+01
SIM     7,  2,1, 1004,18, 2004,18, A6201, 1.243173E+02
SIM     9,  2,1, 1005,16, 2005,16, A6201, 1.564483E+02
SIM    11,  2,1, 1006,14, 2006,14, A6201, 1.861122E+02
SIM    13,  2,1, 1007,12, 2007,12, A6201, 2.128409E+02
SIM    15,  2,1, 1008,10, 2008,10, A6201, 2.362133E+02
SIM    17,  2,1, 1009, 8, 2009, 8, A6201, 2.558600E+02
SIM    19,  2,1, 1010, 6, 2010, 6, A6201, 2.714719E+02
SIM    21,  2,1, 1011, 4, 2011, 4, A6201, 2.828025E+02
SIM    23,  2,1, 1012, 2, 2012, 2, A6201, 2.896731E+02
SIM    25,  1,1, 1013, 0, 2013, 0, A6201, 2.919753E+02
REM  RADIAL CONDUCTORS REGION 1, LAYER  1 TO LAYER  2
DIM    26,  2,1, 2001,24, 2026,24,A6201, 1.871533E+01,A6201, 1.910120E+01
DIM    28,  2,1, 2002,22, 2027,22,A6201, 5.585065E+01,A6201, 5.700220E+01
DIM    30,  2,1, 2003,20, 2028,20,A6201, 9.210516E+01,A6201, 9.400415E+01
DIM    32,  2,1, 2004,18, 2029,18,A6201, 1.269071E+02,A6201, 1.295237E+02
DIM    34,  2,1, 2005,16, 2030,16,A6201, 1.597076E+02,A6201, 1.630004E+02
DIM    36,  2,1, 2006,14, 2031,14,A6201, 1.899894E+02,A6201, 1.939067E+02
DIM    38,  2,1, 2007,12, 2032,12,A6201, 2.172751E+02,A6201, 2.217549E+02
DIM    40,  2,1, 2008,10, 2033,10,A6201, 2.411343E+02,A6201, 2.461060E+02
DIM    42,  2,1, 2009, 8, 2034, 8,A6201, 2.611902E+02,A6201, 2.665754E+02
DIM    44,  2,1, 2010, 6, 2035, 6,A6201, 2.771274E+02,A6201, 2.828411E+02
DIM    46,  2,1, 2011, 4, 2036, 4,A6201, 2.886941E+02,A6201, 2.946462E+02
DIM    48,  2,1, 2012, 2, 2037, 2,A6201, 2.957078E+02,A6201, 3.018047E+02
DIM    50,  1,1, 2013, 0, 2038, 0,A6201, 2.980581E+02,A6201, 3.042034E+02
REM  RADIAL CONDUCTORS REGION 1, LAYER  2 TO LAYER  3
DIM    51,  2,1, 2026,24, 2051,24,A6201, 1.949101E+01,A6201, 1.988475E+01
DIM    53,  2,1, 2027,22, 2052,22,A6201, 5.816547E+01,A6201, 5.934052E+01
DIM    55,  2,1, 2028,20, 2053,20,A6201, 9.592261E+01,A6201, 9.786041E+01
DIM    57,  2,1, 2029,18, 2054,18,A6201, 1.321669E+02,A6201, 1.348369E+02
DIM    59,  2,1, 2030,16, 2055,16,A6201, 1.663269E+02,A6201, 1.696870E+02
DIM    61,  2,1, 2031,14, 2056,14,A6201, 1.978638E+02,A6201, 2.018610E+02
DIM    63,  2,1, 2032,12, 2057,12,A6201, 2.262803E+02,A6201, 2.308516E+02
DIM    65,  2,1, 2033,10, 2058,10,A6201, 2.511284E+02,A6201, 2.562014E+02
DIM    67,  2,1, 2034, 8, 2059, 8,A6201, 2.720156E+02,A6201, 2.775107E+02
DIM    69,  2,1, 2035, 6, 2060, 6,A6201, 2.886133E+02,A6201, 2.944436E+02
DIM    71,  2,1, 2036, 4, 2061, 4,A6201, 3.006594E+02,A6201, 3.067332E+02
DIM    73,  2,1, 2037, 2, 2062, 2,A6201, 3.079639E+02,A6201, 3.141851E+02
DIM    75,  1,1, 2038, 0, 2063, 0,A6201, 3.104114E+02,A6201, 3.166824E+02
REM  RADIAL CONDUCTORS REGION 1, LAYER  3 TO LAYER  4
DIM    76,  2,1, 2051,24, 2076,24,A6201, 2.028244E+01,A6201, 2.068407E+01
DIM    78,  2,1, 2052,22, 2077,22,A6201, 6.052728E+01,A6201, 6.172580E+01
DIM    80,  2,1, 2053,20, 2078,20,A6201, 9.981750E+01,A6201, 1.017941E+02
DIM    82,  2,1, 2054,18, 2079,18,A6201, 1.375336E+02,A6201, 1.402570E+02
DIM    84,  2,1, 2055,16, 2080,16,A6201, 1.730806E+02,A6201, 1.765079E+02
DIM    86,  2,1, 2056,14, 2081,14,A6201, 2.058981E+02,A6201, 2.099752E+02
DIM    88,  2,1, 2057,12, 2082,12,A6201, 2.354684E+02,A6201, 2.401311E+02
```

```
DIM    90,  2,1,  2058,10,  2083,10,A6201,  2.613254E+02,A6201,  2.665000E+02
DIM    92,  2,1,  2059, 8,  2084, 8,A6201,  2.830608E+02,A6201,  2.886658E+02
DIM    94,  2,1,  2060, 6,  2085, 6,A6201,  3.003325E+02,A6201,  3.062795E+02
DIM    96,  2,1,  2061, 4,  2086, 4,A6201,  3.128677E+02,A6201,  3.190630E+02
DIM    98,  2,1,  2062, 2,  2087, 2,A6201,  3.204687E+02,A6201,  3.268145E+02
DIM   100,  1,1,  2063, 0,  2088, 0,A6201,  3.230159E+02,A6201,  3.294119E+02
REM  RADIAL CONDUCTORS REGION 1, LAYER  4 TO BOUNDARY   1- 2
SIM   101,  2,1,  2076,24,  3001,24,  A6201,  2.108963E+01
SIM   103,  2,1,  2077,22,  3002,22,  A6201,  6.293610E+01
SIM   105,  2,1,  2078,20,  3003,20,  A6201,  1.037900E+02
SIM   107,  2,1,  2079,18,  3004,18,  A6201,  1.430071E+02
SIM   109,  2,1,  2080,16,  3005,16,  A6201,  1.799687E+02
SIM   111,  2,1,  2081,14,  3006,14,  A6201,  2.140922E+02
SIM   113,  2,1,  2082,12,  3007,12,  A6201,  2.448394E+02
SIM   115,  2,1,  2083,10,  3008,10,  A6201,  2.717253E+02
SIM   117,  2,1,  2084, 8,  3009, 8,  A6201,  2.943259E+02
SIM   119,  2,1,  2085, 6,  3010, 6,  A6201,  3.122847E+02
SIM   121,  2,1,  2086, 4,  3011, 4,  A6201,  3.253188E+02
SIM   123,  2,1,  2087, 2,  3012, 2,  A6201,  3.332224E+02
SIM   125,  1,1,  2088, 0,  3013, 0,  A6201,  3.358708E+02
REM  CIRCUMFERENTIAL CONDUCTORS; Y- DIRECTION,  CONDUCTION
REM  CIRCUMFERENTIAL CONDUCTORS REGION 1, LAYER NUMBER  1
DIM   126,  2,1,  2001,23,  2002,23,A6201,  4.986877E-01,A6201,  1.488194E+00
DIM   128,  2,1,  2002,21,  2003,21,A6201,  1.488194E+00,A6201,  2.454229E+00
DIM   130,  2,1,  2003,19,  2004,19,A6201,  2.454229E+00,A6201,  3.381560E+00
DIM   132,  2,1,  2004,17,  2005,17,A6201,  3.381560E+00,A6201,  4.255559E+00
DIM   134,  2,1,  2005,15,  2006,15,A6201,  4.255559E+00,A6201,  5.062449E+00
DIM   136,  2,1,  2006,13,  2007,13,A6201,  5.062449E+00,A6201,  5.789497E+00
DIM   138,  2,1,  2007,11,  2008,11,A6201,  5.789497E+00,A6201,  6.425247E+00
DIM   140,  2,1,  2008, 9,  2009, 9,A6201,  6.425247E+00,A6201,  6.959660E+00
DIM   142,  2,1,  2009, 7,  2010, 7,A6201,  6.959660E+00,A6201,  7.384319E+00
DIM   144,  2,1,  2010, 5,  2011, 5,A6201,  7.384319E+00,A6201,  7.692525E+00
DIM   146,  2,1,  2011, 3,  2012, 3,A6201,  7.692525E+00,A6201,  7.879416E+00
DIM   148,  2,1,  2012, 1,  2013, 1,A6201,  7.879416E+00,A6201,  7.942040E+00
REM  CIRCUMFERENTIAL CONDUCTORS REGION 1, LAYER NUMBER  2
DIM   150,  2,1,  2026,23,  2027,23,A6201,  4.986876E-01,A6201,  1.488194E+00
DIM   152,  2,1,  2027,21,  2028,21,A6201,  1.488194E+00,A6201,  2.454229E+00
DIM   154,  2,1,  2028,19,  2029,19,A6201,  2.454229E+00,A6201,  3.381560E+00
DIM   156,  2,1,  2029,17,  2030,17,A6201,  3.381560E+00,A6201,  4.255560E+00
DIM   158,  2,1,  2030,15,  2031,15,A6201,  4.255560E+00,A6201,  5.062449E+00
DIM   160,  2,1,  2031,13,  2032,13,A6201,  5.062449E+00,A6201,  5.789499E+00
DIM   162,  2,1,  2032,11,  2033,11,A6201,  5.789499E+00,A6201,  6.425249E+00
DIM   164,  2,1,  2033, 9,  2034, 9,A6201,  6.425249E+00,A6201,  6.959660E+00
DIM   166,  2,1,  2034, 7,  2035, 7,A6201,  6.959660E+00,A6201,  7.384320E+00
DIM   168,  2,1,  2035, 5,  2036, 5,A6201,  7.384320E+00,A6201,  7.692525E+00
DIM   170,  2,1,  2036, 3,  2037, 3,A6201,  7.692525E+00,A6201,  7.879413E+00
DIM   172,  2,1,  2037, 1,  2038, 1,A6201,  7.879413E+00,A6201,  7.942039E+00
REM  CIRCUMFERENTIAL CONDUCTORS REGION 1, LAYER NUMBER  3
DIM   174,  2,1,  2051,23,  2052,23,A6201,  4.986877E-01,A6201,  1.488194E+00
DIM   176,  2,1,  2052,21,  2053,21,A6201,  1.488194E+00,A6201,  2.454230E+00
DIM   178,  2,1,  2053,19,  2054,19,A6201,  2.454230E+00,A6201,  3.381561E+00
DIM   180,  2,1,  2054,17,  2055,17,A6201,  3.381561E+00,A6201,  4.255561E+00
DIM   182,  2,1,  2055,15,  2056,15,A6201,  4.255561E+00,A6201,  5.062448E+00
DIM   184,  2,1,  2056,13,  2057,13,A6201,  5.062448E+00,A6201,  5.789500E+00
DIM   186,  2,1,  2057,11,  2058,11,A6201,  5.789500E+00,A6201,  6.425246E+00
DIM   188,  2,1,  2058, 9,  2059, 9,A6201,  6.425246E+00,A6201,  6.959663E+00
DIM   190,  2,1,  2059, 7,  2060, 7,A6201,  6.959663E+00,A6201,  7.384321E+00
DIM   192,  2,1,  2060, 5,  2061, 5,A6201,  7.384321E+00,A6201,  7.692526E+00
DIM   194,  2,1,  2061, 3,  2062, 3,A6201,  7.692526E+00,A6201,  7.879416E+00
DIM   196,  2,1,  2062, 1,  2063, 1,A6201,  7.879416E+00,A6201,  7.942042E+00
REM  CIRCUMFERENTIAL CONDUCTORS REGION 1, LAYER NUMBER  4
DIM   198,  2,1,  2076,23,  2077,23,A6201,  4.986876E-01,A6201,  1.488194E+00
DIM   200,  2,1,  2077,21,  2078,21,A6201,  1.488194E+00,A6201,  2.454229E+00
DIM   202,  2,1,  2078,19,  2079,19,A6201,  2.454229E+00,A6201,  3.381561E+00
DIM   204,  2,1,  2079,17,  2080,17,A6201,  3.381561E+00,A6201,  4.255559E+00
DIM   206,  2,1,  2080,15,  2081,15,A6201,  4.255559E+00,A6201,  5.062448E+00
DIM   208,  2,1,  2081,13,  2082,13,A6201,  5.062448E+00,A6201,  5.789497E+00
DIM   210,  2,1,  2082,11,  2083,11,A6201,  5.789497E+00,A6201,  6.425248E+00
DIM   212,  2,1,  2083, 9,  2084, 9,A6201,  6.425248E+00,A6201,  6.959662E+00
DIM   214,  2,1,  2084, 7,  2085, 7,A6201,  6.959662E+00,A6201,  7.384322E+00
```

```
DIM   216,  2,1, 2085, 5, 2086, 5,A6201, 7.384322E+00,A6201, 7.692526E+00
DIM   218,  2,1, 2086, 3, 2087, 3,A6201, 7.692526E+00,A6201, 7.879414E+00
DIM   220,  2,1, 2087, 1, 2088, 1,A6201, 7.879414E+00,A6201, 7.942040E+00
REM  CONVECTION CONDUCTORS; INSIDE TANK TO TANK WALL
GEN 18001, 25,1,18001, 1, 1001, 1,0.00000E+00,0.00000E+00, 1.00, 1.00
END
BCD 3CONSTANTS DATA
REM NTHETA NBETAS       BETA        RIN        TVOL
     1=  25, 2=   1, 3=  1.000, 4=  24.000, 5=   33.510
REM  SPECIAL INPUT VALUES
     6=     0.500, 7=   40.000, 8=   60.000, 9=   95.000
REM K10=SINDA TEMP UNITS; K10=1(DEG F); K10=2(DEG R)
     10= 2
REM   TIMEO(MIN)       TIMEND(MIN)       DTIMEI(MIN)       OUTPUT(MIN)
REM 0.00000E+00          360.00            0.12500E-01       0.25000
    101=0.00000E+00, 102= 6.0000    , 103=0.20833E-03, 104=0.41667E-02
    NLOOP=   300, DRLXCA= 0.001000, ARLXCA= 0.001000
END
BCD 3ARRAY DATA
    1 $REGION 1,(TANKWALL                  ),INSIDE  SURFACE AREAS (IN**2)
      4.53598E+00, 1.35363E+01, 2.23232E+01, 3.07581E+01, 3.87078E+01
      4.60471E+01, 5.26603E+01, 5.84429E+01, 6.33039E+01, 6.71665E+01
      6.99699E+01, 7.16698E+01, 7.22394E+01, 7.16698E+01, 6.99699E+01
      6.71665E+01, 6.33039E+01, 5.84429E+01, 5.26603E+01, 4.60471E+01
      3.87078E+01, 3.07581E+01, 2.23232E+01, 1.35363E+01, 4.53598E+00
    END
    2 $REGION 1,(TANKWALL                  ),OUTSIDE SURFACE AREAS (IN**2)
      5.32347E+00, 1.58864E+01, 2.61988E+01, 3.60980E+01, 4.54279E+01
      5.40414E+01, 6.18027E+01, 6.85893E+01, 7.42941E+01, 7.88274E+01
      8.21174E+01, 8.41125E+01, 8.47810E+01, 8.41125E+01, 8.21174E+01
      7.88274E+01, 7.42941E+01, 6.85893E+01, 6.18027E+01, 5.40414E+01
      4.54279E+01, 3.60980E+01, 2.61988E+01, 1.58864E+01, 5.32347E+00
    END
REM CONDUCTIVITY  BTU/(INCH.HR.F)  FOR STAINLESS 304A
    6201
       36., 0.10346E+00,   72., 0.21616E+00,  108., 0.35610E+00
      144., 0.42607E+00,  180., 0.47480E+00,  270., 0.57476E+00
      360., 0.64972E+00,  450., 0.70970E+00,  540., 0.75968E+00
      630., 0.80966E+00,  720., 0.84964E+00,  810., 0.88462E+00
      900., 0.91961E+00,  990., 0.94960E+00, 1080., 0.98958E+00
     1170., 0.10246E+01, 1260., 0.10596E+01, 1350., 0.10895E+01
     1440., 0.11245E+01, 1530., 0.11595E+01, 1620., 0.11945E+01
     1800., 0.12645E+01, 1980., 0.13344E+01, 2160., 0.14044E+01
     2340., 0.14744E+01, 2520., 0.15443E+01, 2700., 0.16143E+01,END
REM SPECIFIC HEAT BTU/(LB.F)        FOR STAINLESS 304A
    2201
       36., 0.10200E-02,   72., 0.69600E-02,  108., 0.25800E-01
      144., 0.44500E-01,  180., 0.58500E-01,  270., 0.81000E-01
      360., 0.93000E-01,  450., 0.10000E+00,  540., 0.10800E+00
      630., 0.11200E+00,  720., 0.11700E+00,  810., 0.12150E+00
      900., 0.12600E+00,  990., 0.12950E+00, 1080., 0.13300E+00
     1170., 0.13500E+00, 1260., 0.13800E+00, 1350., 0.14000E+00
     1440., 0.14200E+00, 1530., 0.14500E+00, 1620., 0.14800E+00
     1800., 0.15000E+00, 1980., 0.15200E+00, 2160., 0.15400E+00
     2340., 0.15700E+00, 2520., 0.16000E+00, 2700., 0.16200E+00,END
REM DENSITY         LB/(CUBIC INCH)  FOR STAINLESS 304A
    3201
       36., 0.28873E+00,   72., 0.28858E+00,  108., 0.28837E+00
      144., 0.28808E+00,  180., 0.28782E+00,  270., 0.28725E+00
      360., 0.28663E+00,  450., 0.28600E+00,  540., 0.28537E+00
      630., 0.28468E+00,  720., 0.28396E+00,  810., 0.28324E+00
      900., 0.28255E+00,  990., 0.28179E+00, 1080., 0.28107E+00
     1170., 0.28031E+00, 1260., 0.27951E+00, 1350., 0.27883E+00
     1440., 0.27789E+00, 1530., 0.27709E+00, 1620., 0.27655E+00
     1800., 0.27478E+00, 1980., 0.27294E+00, 2160., 0.27102E+00
     2340., 0.26900E+00, 2520., 0.26687E+00, 2700., 0.26463E+00,END
REM CP * RHO FOR STAINLESS 304A
    1201
       36., 0.29450E-03,   72., 0.20085E-02,  108., 0.74398E-02
      144., 0.12819E-01,  180., 0.16838E-01,  270., 0.23267E-01
```

```
       360., 0.26657E-01,  450., 0.28600E-01,  540., 0.30820E-01
       630., 0.31884E-01,  720., 0.33223E-01,  810., 0.34413E-01
       900., 0.35601E-01,  990., 0.36492E-01, 1080., 0.37382E-01
      1170., 0.37842E-01, 1260., 0.38573E-01, 1350., 0.39036E-01
      1440., 0.39460E-01, 1530., 0.40179E-01, 1620., 0.40930E-01
      1800., 0.41217E-01, 1980., 0.41487E-01, 2160., 0.41738E-01
      2340., 0.42233E-01, 2520., 0.42699E-01, 2700., 0.42870E-01,END
REM SPECIFIC HEAT BTU/(INCH.HR.F)  FOR HYDROGEN        AT P=    49.0 PSIA
    2101
       30., 0.53700E+03,   32., 0.56580E+03,   32., 0.57660E+03
       33., 0.59880E+03,   34., 0.62220E+03,   35., 0.64650E+03
       36., 0.67140E+03,   37., 0.69750E+03,   38., 0.72450E+03
       39., 0.75270E+03,   40., 0.78240E+03,   41., 0.81420E+03
       42., 0.84840E+03,   43., 0.88590E+03,   44., 0.92760E+03,END
REM DENSITY        BTU/LB              FOR HYDROGEN        AT P=    49.0 PSIA
    3101
       30., 0.46700E+01,   32., 0.46220E+01,   32., 0.46050E+01
       33., 0.45700E+01,   34., 0.45350E+01,   35., 0.44980E+01
       36., 0.44600E+01,   37., 0.44200E+01,   38., 0.43790E+01
       39., 0.43350E+01,   40., 0.42900E+01,   41., 0.42430E+01
       42., 0.41930E+01,   43., 0.41410E+01,   44., 0.40850E+01,END
REM VISCOSITY      LB/(INCH.HR)        FOR HYDROGEN        AT P=    49.0 PSIA
    4101
       30., 0.37236E-02,   32., 0.34263E-02,   32., 0.33369E-02
       33., 0.31701E-02,   34., 0.30174E-02,   35., 0.28775E-02
       36., 0.27481E-02,   37., 0.26282E-02,   38., 0.25165E-02
       39., 0.24121E-02,   40., 0.23141E-02,   41., 0.22217E-02
       42., 0.21344E-02,   43., 0.20515E-02,   44., 0.19725E-02,END
REM ENTHALPHY      BTU/(LB.F)          FOR HYDROGEN        AT P=    49.0 PSIA
    5101
       30.,-0.12220E+03,   32.,-0.11950E+03,   32.,-0.11850E+03
       33.,-0.11660E+03,   34.,-0.11450E+03,   35.,-0.11240E+03
       36.,-0.11020E+03,   37.,-0.10790E+03,   38.,-0.10560E+03
       39.,-0.10310E+03,   40.,-0.10050E+03,   41.,-0.97900E+02
       42.,-0.95100E+02,   43.,-0.92200E+02,   44.,-0.89200E+02,END
REM CONDUCTIVITY  BTU/(INCH.HR.F)  FOR HYDROGEN        AT P=    49.0 PSIA
    6101
       30., 0.44145E-02,   32., 0.45405E-02,   32., 0.45741E-02
       33., 0.46284E-02,   34., 0.46668E-02,   35., 0.46911E-02
       36., 0.47391E-02,   37., 0.47868E-02,   38., 0.48231E-02
       39., 0.48483E-02,   40., 0.48636E-02,   41., 0.48696E-02
       42., 0.48666E-02,   43., 0.48549E-02,   44., 0.48354E-02,END
REM CP * RHO FOR HYDROGEN          AT P=    49.0 PSIA
    1101
       30., 0.25078E+04,   32., 0.26151E+04,   32., 0.26552E+04
       33., 0.27365E+04,   34., 0.28217E+04,   35., 0.29080E+04
       36., 0.29944E+04,   37., 0.30829E+04,   38., 0.31726E+04
       39., 0.32630E+04,   40., 0.33565E+04,   41., 0.34546E+04
       42., 0.35573E+04,   43., 0.36685E+04,   44., 0.37892E+04,END
REM SPECIFIC HEAT BTU/(INCH.HR.F)  FOR HYDROGEN        AT P=    49.0 PSIA
    2301
       52., 0.92820E+03,   53., 0.91350E+03,   54., 0.90060E+03
       55., 0.88950E+03,   56., 0.87960E+03,   57., 0.87060E+03
       58., 0.86250E+03,   59., 0.85530E+03,   60., 0.84900E+03
       61., 0.84300E+03,   62., 0.83760E+03,   63., 0.83280E+03
       64., 0.82830E+03,   65., 0.82410E+03,   66., 0.82020E+03,END
REM DENSITY        BTU/LB              FOR HYDROGEN        AT P=    49.0 PSIA
    3301
       52., 0.20500E+00,   53., 0.19900E+00,   54., 0.19400E+00
       55., 0.18900E+00,   56., 0.18400E+00,   57., 0.18000E+00
       58., 0.17600E+00,   59., 0.17200E+00,   60., 0.16800E+00
       61., 0.16500E+00,   62., 0.16200E+00,   63., 0.15800E+00
       64., 0.15500E+00,   65., 0.15200E+00,   66., 0.15000E+00,END
REM VISCOSITY      LB/(INCH.HR)        FOR HYDROGEN        AT P=    49.0 PSIA
    4301
       52., 0.35931E-03,   53., 0.37224E-03,   54., 0.38703E-03
       55., 0.40467E-03,   56., 0.42684E-03,   57., 0.45705E-03
       58., 0.50340E-03,   59., 0.59283E-03,   60., 0.72327E-03
       61., 0.72711E-03,   62., 0.73098E-03,   63., 0.73485E-03
       64., 0.73875E-03,   65., 0.74268E-03,   66., 0.74658E-03,END
```

```
       REM ENTHALPHY     BTU/(LB.F)       FOR HYDROGEN        AT P=   49.0 PSIA
            5301
               52., 0.11070E+03,   53., 0.11380E+03,   54., 0.11680E+03
               55., 0.11980E+03,   56., 0.12270E+03,   57., 0.12560E+03
               58., 0.12850E+03,   59., 0.13140E+03,   60., 0.13420E+03
               61., 0.13700E+03,   62., 0.13980E+03,   63., 0.14260E+03
               64., 0.14540E+03,   65., 0.14810E+03,   66., 0.15090E+03,END
       REM CONDUCTIVITY  BTU/(INCH.HR.F)  FOR HYDROGEN        AT P=   49.0 PSIA
            6301
               52., 0.13473E-02,   53., 0.14059E-02,   54., 0.14714E-02
               55., 0.15430E-02,   56., 0.16279E-02,   57., 0.17342E-02
               58., 0.18823E-02,   59., 0.21532E-02,   60., 0.25921E-02
               61., 0.26181E-02,   62., 0.26439E-02,   63., 0.26696E-02
               64., 0.26951E-02,   65., 0.27205E-02,   66., 0.27457E-02,END
       REM CP * RHO FOR HYDROGEN        AT P=   49.0 PSIA
            1301
               52., 0.19028E+03,   53., 0.18179E+03,   54., 0.17472E+03
               55., 0.16812E+03,   56., 0.16185E+03,   57., 0.15671E+03
               58., 0.15180E+03,   59., 0.14711E+03,   60., 0.14263E+03
               61., 0.13910E+03,   62., 0.13569E+03,   63., 0.13158E+03
               64., 0.12839E+03,   65., 0.12526E+03,   66., 0.12303E+03,END
       END
       BCD 3EXECUTION
F      COMMON/USER1/ NTHETA,NBETAS,NTUNIT,BETA,RIN,TVOL
F      COMMON/USER2/ PTIME, DELTIM, XC1, XC2, XC3, XC4
F      COMMON/INSA /SARIN (   25)
F      COMMON/OUTSA/SAROUT(   25)
F      COMMON/SURFT/TSURF (   25)
F      COMMON/BNDYT/TBDY  (   25)
F      COMMON/HTRCO/HCOEF (   25)
F      COMMON/SURFQ/QSURF (   25)
F      DIMENSION X(  800)
F       NDIM=   800
M       NTHETA= K1
M       NBETAS= K2
M       BETA  =XK3
M       RIN   =XK4
M       TVOL  =XK5
M       XC1   =XK6
M       XC2   =XK7
M       XC3   =XK8
M       XC4   =XK9
M       NTUNIT= K10
F       DO 120 I=1,NTHETA
M       SARIN(I) =A(1+I)
M       SAROUT(I)=A(2+I)
F 120  CONTINUE
F       CALL THWSE1
M       TIMEO = XK101
M       TIMEND= XK102
M       OUTPUT= XK104
M       DTIMEI= XK103
           FWDBCK
F       CALL THWSE2
        END
        BCD 3VARIABLES 1
F      COMMON/USER1/ NTHETA,NBETAS,NTUNIT,BETA,RIN,TVOL
F      COMMON/USER2/ PTIME, DELTIM, XC1, XC2, XC3, XC4
F      COMMON/INSA /SARIN (   25)
F      COMMON/OUTSA/SAROUT(   25)
F      COMMON/SURFT/TSURF (   25)
F      COMMON/BNDYT/TBDY  (   25)
F      COMMON/HTRCO/HCOEF (   25)
F      COMMON/SURFQ/QSURF (   25)
F       PTIME =TIMEO
F       DELTIM=DTIMEU
F       DO 270 I=1,NTHETA
F       IM1=I-1
M       TSURF(I)=T(1001+IM1)
F 270  CONTINUE
```

```
F       CALL THWSV1
F       DO 271 I=1,NTHETA
F       IM1=I-1
M       T(18001+IM1)=TBDY (I)
M       Q(1001+IM1)=Q(1001+IM1)+QSURF(I)
M       G(18001+IM1)=HCOEF(I)*SARIN(I)
F 271 CONTINUE
        END
        BCD 3VARIABLES 2
F       CALL THWSV2
        END
        BCD 3OUTPUT CALLS
F       CALL THWSOU
F       END
CC* SUBROUTINES CALLED BY SINDA CRYOTRAN PROGRAMS NTYP = 1, NAN = 3.
CC* THESE SUBROUTINES ARE CALLED FROM THE EXECUTION AND VARIABLES BLOCKS
CC*  OF THE THICK WALL FILL ANALYSIS OF A SPHERE. THIS IS TAKEN FROM THE
CC*  PROJECT DONE FOR R. DEWITT OF LERC DURING THE YEAR 1977.
CC*  THE UNITS USED IN THE ORIGINAL PROGRAM WERE;
CC*  DEGR,  IN.,  MIN.,  LBS.,  BTU
CC*  CRYOTRAN USES DEGF OR DEGR,  IN.,  HR.,   LBS.,  BTU
CC*
CC  THE FOLLOWING LISTED COMMON BLOCKS ARE DEFINED BY CRYOTRAN TO
CC  COMMUNICATE BETWEEN CRYOTRAN AND THESE SUBS.
CC    BLOCKS  USER1, USER2, SURFA, SURFT   ARE INPUT TO THIS PGM.
CC    BLOCKS  BNDYT, HTRCF, SURFG, SURFQ   ARE OUTPUT TO SINDA
CC
CC  IF  NTUNIT=1--> SINDA TEMPS = DEGF; IF NTUNIT=2--> SINDA TEMPS=DEGR
F       SUBROUTINE THWSE1
F       COMMON /USER1/ NTHETA,NBETAS,NTUNIT,BETA,RIN,TVOL
F       COMMON /USER2/ TIMEO,DTIMEU,FFLOW,TLIQ,TGAS,PCTFIL
F       COMMON /BNDYT/ TBDY(1)
F       COMMON /TQOA/ A100(26),A101(26)
F       COMMON /PLTSAV/ NOUT,NNCOV(200), VOLCUM(200), TOTVIN(200)
F       COMMON /CONSTS/ PI,FORPI,TWOPIR,TWOR,CON1,TBETA,THTARC,ARCO2,NTV1,
F      1              XK11
F       COMMON/OUTVAR/TOTWT,TOTVOL,ARCOLD,ARCNEW,HOLD,NCOLD,SRFOLD,VTOTIN
F       COMMON /LIQST/NC,BAKING,TKVTST,FULL,DELTMP(100)
F       COMMON /HFCLC/  HFSUM,SUMN,VNEWRE,DENS,RHOLH2,HVAP
F       COMMON /DIAMS/  DIAM(100)
F       COMMON /BGL3S/  BGL3(100)
F       COMMON /ARCCUM/ CUMARC(100)
F       COMMON /LATTD/  PHIARC(100)
F       COMMON /DBUG/ DEBUG
F       COMMON /FINOUT/ TTEST,ARCWET,ARCHLB,ARCHUB
CC
F       EQUIVALENCE(IA100,A100(1)), (IA101,A101(1))
C
F        DIMENSION FBDT(25), QOA(25)
CC
F       LOGICAL  BAKING,FULL
F       LOGICAL  DEBUG
C
F       DEBUG=.FALSE.
CC
CC        TGAS,TLIQ  (DEGR),    FLOW(LB/SEC)*3600=(LB/HR)
F       DATA  FBDT /0.,.94,1.26,1.44,1.80,2.70,3.60,3.96,4.32,4.68,
F      1  5.04,5.399, 5.40, 7.2, 10.8,  14.4, 18.0,
F      2    36.0,72.0,108.,144.,180.,360.,720.,1080. /
CC        Q/A  (BTU/FT2-HR)
F       DATA  QOA /  0.172E0,3.172E2,6.92E2,9.52E2,1.78E3,5.08E3,9.83E3,
F      1  1.28E4, 1.62E4, 2.00E4, 2.35E4, 2.95E4,
F      2  .603E3, .714E3, .92E3, 1.05E3, 1.221E3,
F      3  2.00E3, 3.81E3, 5.74E3,
F      4  7.61E3,9.52E3,1.98E4,4.60E4,8.09E4  /
CC
F       DATA GRAV/32.2/,  PI/3.14159265/
F       IA100=25
F       IA101=25
CC
```

```
C  INITIALIZE PROPERTIES FOR SS AND LH2
F      DENS=0.29
F      RHOLH2=.0024722
F      HVAP=186.5
C
F      X9=60.
F      XK10=2.0
F      XK11=TLIQ+XK10
F      NTH=0
F      NOUT=0
F      VTEST=0.0
F      BAKING=.FALSE.
F      TOTWT=0.
F      TOTVOL=0.
F      VTOTIN=0.
F      SRFOLD=0.
F      ARCOLD=0.
F      HOLD=0.
F      NCOLD=0
F      NTV1=0
F      FFLOW=  FFLOW/ 60.
C   TNKVOL(IN3)=TVOL(FT3)*1728
F      TNKVOL=TVOL*1728.
F      TBETA=1./60.
F      FORPI=4.*PI
F      TWOR =2.*RIN
F      TWOPIR= TWOR*PI
F      CON1= 3./2./PI/RIN**3
CC  PUT  DELTEMP (DEGR) AND Q/A (BTU/FT2-HR) INTO ARRAYS 100,101
F      DO  1 I=1,25
F      A100(I+1)=       FBDT(I)
F      A101(I+1)=QOA(I)/144.
F   1 CONTINUE
CC
F      TKVTST=PCTFIL*TNKVOL
F      FULL=.FALSE.
F      ANG=NTHETA
F      THETA=PI/ANG
F      THTARC=RIN*THETA
F      ARCO2=THTARC/2.
F      PHI=1.
F      NT   =NTHETA
F      NTP1=NTHETA+1
CC
CC     COMPUTE DIAMETERS (FT), THEN COMPUTE BETA*G*(L**3) AT EACH STATION
CC     COMPUTE INSIDE ARC LENGTHS OF SPHERE.
F      TWOR=2.*RIN
F      NNN=(NT+1)/2
F      PRINT 1002,TVOL,FFLOW,XK9
F1002 FORMAT('1',F6.1,' CU. FT. TANK WITH LIQ FLOW=',F10.5,
F     1  ' (LB/MIN),    BETA=1/',F7.2)
F      PRINT 1003, TNKVOL,TKVTST
F1003 FORMAT('   TANK VOL(IN**3),   VOLTEST',1P2G14.7)
F      IF(DEBUG) PRINT 1001
F1001 FORMAT(//10X,'I',9X,'II',7X,'ANGLE1',5X,'ANGLE2',5X,'SIN(ANGLE)',
F     1 3X,'RADIUS',6X,'PHIARC',5X,'DIAM',3X,'SURF AREA')
F      DO 69 I=1,NNN
F      ANGLE=I*THETA
F      II=NTP1-I
F      SINANG=SIN(ANGLE)
F      RADI=RIN*SINANG
F      PHIARC(I)=RADI*PHI
F      PHIARC(II)=PHIARC(I)
F      DIAM(I)=RADI*2
F      DIAM(II)=DIAM(I)
F      ANG2=PI-ANGLE
F      IF(DEBUG) PRINT 1000,I,II,ANGLE,ANG2,SINANG,RADI,PHIARC(I),
F     1  DIAM(I), SAREA(I)
F1000 FORMAT('EXECN1'/(1X,2I12,8G12.5))
F  69 CONTINUE
```

```
F      THPHI=THETA*PHI
F      DO 68 I=1,NT
F      EL3=(DIAM(I)/12.)**3
F      BGL3(I)=GRAV*TBETA*EL3
F      TBDY(I)= TGAS
F      IF(NTUNIT .EQ. 1) TBDY(I)=TBDY(I)-460.
F   68 CONTINUE
F      CUMARC(1)=ARCO2
F      DO 74 I=2,NT
F      CUMARC(I)=CUMARC(I-1)+THTARC
F   74 CONTINUE
F      CUMARC(NT)=CUMARC(NT)-ARCO2
F
C
C   COMPUTE LOWER AND UPPER BOUNDS FOR FINE OUTPUT AT EQUATOR
F      ARCHAF=RIN*PI/2.
F      ARCHLB=ARCHAF-THTARC
F      ARCHUB=ARCHAF+THTARC
F      NTO2=NTHETA/2
F      TTEST=TBDY(NTO2)
F      IF(DEBUG) PRINT 2000,
F    1        (I,NA(I),NB(I),ELA(I),ELB(I),FAREA(I),I=1,NCOND)
F2000 FORMAT('EXECN3',3I8,3G13.5)
F      RETURN
F      END
F      SUBROUTINE THWSE2
F      COMMON /USER1/ NTHETA,NBETAS,NTUNIT,BETA,RIN,TNKVOL
F      COMMON /PLTSAV/ NOUT,NNCOV(200), VOLCUM(200), TOTVIN(200)
C
F      WRITE(23,2001) NOUT, (NNCOV(I),I=1,NOUT)
F      WRITE(23,2002) NOUT, (VOLCUM(I),I=1,NOUT)
F      DO 101 I=1,NOUT
F 101  VOLCUM(I)=VOLCUM(I)/TNKVOL
F      WRITE(23,2002) NOUT, (VOLCUM(I),I=1,NOUT)
F      WRITE(23,2002) NOUT, (TOTVIN(I),I=1,NOUT)
F2001 FORMAT(I6/(20I6))
F2002 FORMAT(I6/(1P10E12.5))
F      RETURN
F      END
F      SUBROUTINE THWSV1
C  COMMON BLOCKS TO COMMUNICATE WITH SINDA
F      COMMON /USER1/ NTHETA,NBETAS,NTUNIT,BETA,RIN,TNKVOL
F      COMMON /USER2/ TIMEO,DTIMEU,FFLOW,TLIQ,TGAS
F      COMMON /SURFA/ SAREA(1)
F      COMMON /SURFT/ TSURF(1)
F      COMMON /BNDYT/ TBDY(1)
F      COMMON /HTRCF/ HCOF(1)
F      COMMON /SURFG/ GSURF(1)
F      COMMON /SURFQ/ QSURF(1)
C
F      COMMON /CGDATA/ NDN,NAN,NBD,NIIG,NISG,NSBG,NINTGS
F      COMMON /CONSTS/ PI,FORPI,TWOPIR,TWOR,CON1,TBETA,THTARC,ARCO2,NTV1,
F     1                XK11
F      COMMON /FINOUT/ TTEST,ARCWET,ARCHLB,ARCHUB
F      COMMON/OUTVAR/TOTWT,TOTVOL,ARCOLD,ARCNEW,HOLD,NCOLD,SRFOLD,VTOTIN
F      COMMON/NEWOLD/ NCOLNW,TOTVNW,SRFONW,ARCONW,DELVOL
F      COMMON /HFCLC/  HFSUM,SUMN,VNEWRE,DENS,RHOLH2,HVAP
F      COMMON /RQOA/   QOA(100)
F      COMMON /TQOA/ A100(26),A101(26)
F      COMMON /DIAMS/  DIAM(1)
F      COMMON /BGL3S/  BGL3(1)
F      COMMON /ARCCUM/ CUMARC(1)
F      COMMON /LATTD/  PHIARC(1)
F      COMMON /LIQST/NC,BAKING,TKVTST,FULL,DELTMP(100)
F      COMMON /DBUG/ DEBUG
CC
F      LOGICAL       BAKING,FULL
F      LOGICAL  DEBUG
CC
CC
```

```
CC    DIMENSION TTBL(27), SH(27), AKT(27)
F     DIMENSION TTBL(27)
F     DIMENSION GPCP(27), GPRHO(27), GPMU(27), GPK(27)
CC
CC TGAS,TLIQ (DEGR),   FLOW(LB/MIN)
CC DENSITY , RHO STAINLESS   LB/IN**3,   RHOLH2 (LB/IN3),   HVAP(BTU/LB)
C  DATA  DENS, RHOLH2, HVAP/ 0.29, .0024722, 186.5/ THESE VARIABLES
C              ARE INITIALIZED IN SUB DWEXC1
CC TEMPS FOR PROPERTIES DEGR
F     DATA  TTBL /  20.,40.,60.,80.,100.,120.,140.,160.,180.,200.,
F    1 220.,240.,260.,280.,300.,320.,340.,360.,380.,400.,420.,440.,
F    2 460.,480.,500.,520.,540. /
CC         CP  STAINLESS  BTU/LB
CC    DATA SH /.001,.002,.005,.012,.021,.032,.041,.049,.057,.064,
CC   1 .071,.077,.082,.086,.090,.093,.097,.099,.102,.103,.106,
CC   2 .1075,.109,.110,.112,.113,.114 /
CC    THERMAL COND STAINLESS    BTU/HR-FT-DEGR
CC    DATA AKT / 0.80,1.70,2.45,3.15,3.78,4.35,4.85,5.26,5.62,
CC   1  5.98,6.31,6.63,6.92,7.20,7.44,7.71,7.93,8.16,8.37,8.58,
CC   2  8.78,8.97,9.16,9.33,9.52,9.69,9.87 /
CC
CC     PROPERTY TABLES FOR G-H2, USE TEMP TABLE IN VBL1, TTBL(I) 20-540/20
CC
CC  GAS  H2  CP(BTU/LB)
F     DATA  GPCP    / 2.46,2.46,2.46,2.48,2.515,2.60,2.74,2.92,3.17,
F    1 3.44,3.62,3.76,3.86,3.88,3.88,3.87,3.85,3.83,3.80,3.76,3.72,
F    2 3.67,3.64,3.61,3.58,3.56,3.54 /
CC  GAS  H2  RHO(LB/FT3)
F     DATA  GPRHO    / .0762,.0762,.0482,.0356,.0283,.0236,.0202,
F    1 .0176,.0157,.0141,.0128,.0117,.0108,.0101,.0094,.0088,.0083,
F    2 .0078,.0074,.0070,.0067,.0064,.0061,.0059,.0056,.0054,.0052 /
CC  GAS  H2  MU  (LB/FT-SEC)
F     DATA GPMU    / 0.70E-6,0.70E-6,1.10E-6,1.45E-6,1.70E-6,2.00E-6,
F    1  2.20E-6,2.54E-6,2.75E-6,3.00E-6,3.22E-6,3.44E-6,3.62E-6,
F    2  3.83E-6,4.02E-6,4.22E-6,4.39E-6,4.56E-6,4.74E-6,4.90E-6,
F    3  5.00E-6,5.24E-6,5.39E-6,5.53E-6,5.70E-6,5.87E-6,6.02E-6 /
CC  GAS  H2  K(BTU/FT-HR-DEGR)
F     DATA GPK    / .0100,.0100,.0140,.0190,.0230,.0270,.0310,.0355,
F    1  .0395,.0435,.0475,.0515,.0555,.0595,.0630,.0670,.0705,.0750,
F    2  .0780,.0810,.0850,.0885,.0915,.0950,.0985,.1020,.1050 /
CC
CC
CC
CC     COMPUTE GS AND QS FOR BOUNDARY CONDITIONS
CC
F     DELTIM=DTIMEU*60.
F     TIMEO=TIME0*60.
F     NTV1=NTV1+1
F     VNEWRE=0.
F     IF(FULL)  GO TO 87
F     WTIN=FFLOW*DELTIM
F     DELVOL= WTIN/RHOLH2
F     VOLNEW= TOTVOL+DELVOL
F     COSGAM= 1.-CON1*VOLNEW
F     IF(ABS(COSGAM) .GE. 1.0) COSGAM=SIGN(1.,COSGAM)
F     GAMCU=  ACOS(COSGAM)
F     HT=RIN+TWOR*COS((GAMCU+FORPI)/3.)
F     SRFNEW=TWOPIR*HT
F     CARG=(RIN-HT)/RIN
F      IF(DEBUG) PRINT 9999,
F    1                 NTV1,  GAMCU,    RIN,      HT, TWOPIR, SRFNEW,
F    2                 CARG,   WTIN, DELVOL, VOLNEW, COSGAM
F9999 FORMAT( 'VARBL11',I6/(6E12.4))
F     IF(ABS(CARG) .GE. 1.0) CARG=SIGN(1.,CARG)
F     ARCLEN=ACOS(CARG)
F     ARCNEW=RIN*ARCLEN
F
F     ARCWET=ARCNEW
F     DELARC=ARCNEW-ARCOLD
F     DELSRF=SRFNEW-SRFOLD
```

```
F      BTUAVA= WTIN*HVAP
CC   NC IS NUMBER OF NODES COMPLETELY COVERED BY LIQUID
F      HNC=ARCNEW/ARCO2
F      WETNEW=(HNC+1.)/2.
F      NC=WETNEW
F      NNWN=WETNEW+1.
F      NCNEW=NC-NCOLD
F      SUMN=0.
F      SUM=0.
CC    GET AVERAGE SURFACE TEMP OF NEWELY WETTED NODES
F      NCOP1=NCOLD+1
F      NC2=NNWN
F      IF(NCOP1 .GT. NC2) NCOP1=NC2
F      DO 81 I=NCOP1,NC2
F      SUMN=SUMN+1.
F      TSURFR=TSURF(I)
F      IF(NTUNIT .EQ. 1) TSURFR=TSURFR+460.
F  81  SUM=SUM+TSURFR
F      TAVG= SUM/SUMN
F      XK104=TAVG-TLIQ
CC    FILM BOILING COEF. IN XK105 (BTU/IN2-MIN)
F      CALL  D1D1DA(XK104,A100,A101,XK105)
F      DTIME=BTUAVA/XK105/DELSRF
CC    VOL OF NEW LIQ REMAINING AT END OF TIME STEP
F      BTUTR=BTUAVA
F      IF(DTIME .LT. DELTIM) GO TO 85
F      BTUTRA=XK105*DELSRF*DELTIM
F      BTUREM=BTUAVA-BTUTRA
F      IF(BTUREM) 85,85,86
F  86  CONTINUE
F        WREM=BTUREM/HVAP
F      VNEWRE=WREM/RHOLH2
F  85  CONTINUE
F      IF(DEBUG) PRINT 9998,
F     1              NC,  NCNEW,  NCOLD,  NCOP1,    NC2,   NWNN, FULL,
F     2          FFLOW,   WTIN, DELVOL, TOTVOL, VOLNEW, COSGAM,
F     3             HT, SRFNEW,   CARG, ARCLEN, ARCNEW, DELARC,
F     4          ARCO2, DELSRF, BTUAVA,    HNC, WETNEW,    SUM,
F     5           SUMN,   TAVG,  XK104,  XK105,  DTIME, DELTIM,
F     6         BTUTRA, BTUREM,   WREM, VNEWRE,  TIMEO, TIMEND,
F     7          TIMEM,  TIMEN, DTIMEU, TNKVOL, TKVTST, TOTVOL,
F     8          TOTWT,TVOL
F9998 FORMAT('VARBL12',6I8,L6/(6E14.5))
CC   COMPUTE Q FOR WETTED NODES  Q=QOA*SURFA
CC
CC   COMPUTE Q(FILM BOILING, BTU/IN*Q-MIN) FOR LIQ COVERED NODES
F  87  SUMN=NCOLD
F      HFSUM=0.
F      IF(NC .EQ. 0) GO TO 92
F      IF(BAKING) GO TO 94
F      DO 95 I=1,NC
F      IM1=I-1
F      TSURFR=TSURF(I)
F      IF(NTUNIT .EQ. 1) TSURFR=TSURFR+460.
F      DELTMP(I)=TSURFR-TLIQ
F  95  CONTINUE
F  94  CONTINUE
F      DO 91 I=1,NC
F      QOA(I)=0.
F      IM1=I-1
F      IF(TSURFR .LT. XK11) GO TO 90
F      XK104=DELTMP(I)
F      CALL  D1D1DA(XK104,A100,A101,XK105)
F      QOA(I)=-XK105
F      IF(I .LE. NCOLD) HFSUM=HFSUM+XK105
F      QSURF(I)=-XK105* SAREA(I)*60.
F      GSURF(I)      =0.
F      IF(TIMEO .GT. 75. .AND. DEBUG) PRINT 9997,
F     1          I,XK105,SAREA(I),QSURF(I)
F9997 FORMAT('VARBL13',I8,3E14.5)
```

```
F       GO TO 91
F   90 CONTINUE
F       QOA(I)=0.0
F       QSURF(I)=0.0
F       GSURF(I)=1.E15
F       TBDY(I)=TLIQ+.001
F       IF(NTUNIT .EQ. 1) TBDY(I)=TBDY(I)-460.
F   91 CONTINUE
F       QMULT=1.
F       GMULT=0.
F       IF(DTIME       .GE. DELTIM) GO TO 75
F       QMULT=DTIME/DELTIM
F       GMULT=1.-QMULT
F       IF(NCOLD       .EQ. NC) GO TO 75
F       NP1=NCOLD+1
F       ASSIGN 5001 TO NGRTRN
F       DO 74 I=NP1,NC
F       IM1=I-1
F       QSURF(I)=QSURF(I)*QMULT*60.
CCC
CC      CALL GETH(I,HFILM)
F        NGH1=I
F        GO TO 5000
F5001 CONTINUE
CCC
F       GSURF(I)=HFILM*SAREA(I)*GMULT*60.
F   74 CONTINUE
F   75 CONTINUE
CC    Q AND G=HA FOR PARTIALLY COVERED NODE   NC=NO NODES COMPLETELY COVERED
CC
F   92 NPC=NC+1
F       TSURFR=TSURF(NPC)
F       IF(NTUNIT .EQ. 1) TSURFR=TSURFR+460.
F       XK104=TSURFR
CC   GET QOA FOR PARTIALLY COVERED NODE
F       CALL  D1D1DA(XK104,A100,A101,XK105)
CC       HFSUM=HFSUM+XK105
CC       SUMN=SUMN+1
F       WSAREA=(ARCNEW-CUMARC(NC))*PHIARC(NPC)
F       GSAREA=(CUMARC(NPC)-ARCNEW)*PHIARC(NPC)
F       QSURF(I)=-XK105*WSAREA*60.
CCC
C       CALL GETH(NPC,HFILM)
F       ASSIGN 5002 TO NGRTRN
F        NGHI=NPC
F        GO TO 5000
F5002 CONTINUE
CCC
F       GSURF(NC+1)=HFILM*GSAREA*60.
CC         NOW IF DTIME .LT. DELTIM CORRECT Q AND G
F       IF(DTIME       .GE. DELTIM) GO TO 97
F       QSURF(NC+1)=QSURF(NC+1)*QMULT*60.
F       GSURF(NC+1)=GSURF(NC+1)+HFILM*WSAREA*GMULT*60.
F   97 NG1=NPC+1
CC
CC   REMAINDER OF NODES ALL GAS COVERED
F       ASSIGN 5003 TO NGRTRN
F       DO 93 I=NG1,NBD
F       IM1=I-1
CCC
CC      CALL GETH(I,HFILM)
F        NGHI=I
F        GO TO 5000
F5003 CONTINUE
CCC
F       GSURF(I)= HFILM*SAREA(I)*60.
F   93 CONTINUE
F       IF(DEBUG) PRINT 9996,       NCOLD,NC,NG1,NPC,
F    1              TIMEO, TOTVOL,   WTIN, DELVOL, VNEWRE,  HFILM,
F    2              XK104,  XK105,  HFSUM,    SUMN,  GMULT,  QMULT,
```

```
F    3      CUMARC(NC),CUMARC(NPC),PHIARC(NPC),WSAREA,GSAREA,VOLOST,
F    4      (QSURF(NN),NN=1,6),    (GSURF(NN),NN=1,6)
F9996 FORMAT('VARBL14',4I8/(6E14.5))
F       IF(DEBUG) PRINT 3001
F3001  FORMAT('  END OF VARBS1'/)
F       IF(.NOT. DEBUG) GO TO 98
F      IF(NTV1 .LE. 10)PRINT 9995,NCOLNW,TOTWT,TOTVNW,HOLD,SRFONW,ARCONW
F9995 FORMAT('VARBL15',I8,5E14.5)
F       IF(NTV1 .GT. 2) GO TO 98
F      DO 50 I=1,NTHETA
F      PRINT  2000,I,QSURF(I),GSURF(I)
F  50 CONTINUE
F2000 FORMAT(1X,I6,2F12.5)
F      GO TO 98
CC
CC  INTERNAL SUBROUTINE TO CALCULATE H-FILM HEAT TRANS COEF.
CC                                          (BTU/MIN-IN2-DEGR)
CC
CCCCCCCCCC  SUBROUTINE  GETH(NGHI,HFILM)
F5000 CONTINUE
CC
F      TSURFR=TSURF(NGHI)
F      IF(NTUNIT .EQ. 1) TSURFR=TSURFR+460.
F      TWALL=TSURFR
F      DELT=ABS(TWALL-TGAS)
F      TFLMAV=(TWALL+TGAS)/2.
F      TFLNT=TFLMAV/20.
F      NT=TFLNT
F      NTP1= NT+1
F      FRACT= (TFLMAV-TTBL(NT))/20.
F      CP= GPCP(NT)+FRACT*(GPCP(NTP1)-GPCP(NT))
F      RHO=GPRHO(NT)+FRACT*(GPRHO(NTP1)-GPRHO(NT))
F      AMU=GPMU(NT)+FRACT*(GPMU(NTP1)-GPMU(NT))
F      AKHR=GPK(NT)+FRACT*(GPK(NTP1)-GPK(NT))
F      AKSEC=AKHR/3600.
F      GRPR= BGL3(NGHI)*DELT*RHO*RHO*CP/AMU/AKSEC
F      IF(NGHI .LE.18 .AND. DEBUG) PRINT 1000,
F     1   NGRTRN,NGHI,NT,TWALL,TGAS,DELT,TFLMAV,
F     2  FRACT,CP,RHO,AMU,AKHR,AKSEC,GRPR
F      IF(GRPR .GE. 1.E9) GO TO 221
F      ANU=0.555* (GRPR**.25)
F      GO TO 220
F 221 ANU=0.0210* (GRPR**.4)
F 220 HFILM= ANU*AKHR/DIAM(NGHI) /60./12.
F      QOA(NGHI)=HFILM
F      IF(NGHI .LE. 18 .AND. DEBUG) PRINT 1000,
F     1   NGRTRN,NGHI,NGHI,ANU,DIAM(NGHI),HFILM
F1000  FORMAT('GETH1',3I8/(6E14.5))
F      GO TO NGRTRN
F  98 IF(VTEST .GT. 0.0) GO TO 99
F      IF(.NOT. FULL) GO TO 99
F      CALL OUTCAL
F      VTEST=10.0
F  99 CONTINUE
F       RETURN
F       END
F       SUBROUTINE THWSV2
F      COMMON /USER1/ NTHETA,NBETAS,NTUNIT,BETA,RIN,TNKVOL
F      COMMON /USER2/ TCMEO,DTIMEU,FFLOW,TLIQ,TGAS
F      COMMON /SURFT/ TSURF(1)
F      COMMON /SURFG/ GSURF(1)
F      COMMON /SURFQ/ QSURF(1)
F      COMMON /FIXCON/XKON(50)
F      COMMON /CONSTS/ PI,FORPI,TWOPIR,TWOR,CON1,THETA,THTARC,ARCO2,NTV1,
F     1                 XK11
F      COMMON/NEWOLD/ NCOLNW,TOTVNW,SRFONW,ARCONW,DELVOL
F      COMMON/OUTVAR/TOTWT,TOTVOL,ARCOLD,ARCNEW,HOLD,NCOLD,SRFOLD,VTOTIN
F      COMMON /HFCLC/  HFSUM,SUMN,VNEWRE,DENS,RHOLH2,HVAP
F      COMMON/LOST/ HFAVG,BOLOST,WOLOST,VOLOST
F      COMMON /LIQST/NC,BAKING,TKVTST,FULL,DELTMP(100)
```

```
F      COMMON /FINOUT/ TTEST,ARCWET,ARCHLB,ARCHUB
F      COMMON /DBUG/ DEBUG
F      LOGICAL  DEBUG
F      LOGICAL  BAKING,FULL
F      DATA  NTV2/0/
F      DATA  NBUP/0/
CC
F      DELTIM=DTIMEU*60.
F      NTV2=NTV2+1
F      BAKING=.FALSE.
F      DO 10 I=1,NC
F      TSURFR=TSURF(I)
F      IF(NTUNIT .EQ. 1) TSURFR=TSURFR+460.
F      IF (TSURFR .GE. TLIQ) GO TO 10
F      DELTMP(I)=DELTMP(I)/2.
F      BAKING=.TRUE.
F      BACKUP=0.1
F      XKON(12)=BACKUP
F      NNN=1000+I
F   10 CONTINUE
F      IF(BACKUP .GT. 0.) GO TO 100
F      VOLOST=0.
F      IF(TOTVOL .LE. 0.) GO TO 98
F      HFAVG=HFSUM/SUMN
F      BOLOST=HFAVG*SRFOLD*DELTIM
F      WOLOST=BOLOST/HVAP
F      VOLOST=WOLOST/RHOLH2
F       VTOTIN=VTOTIN+DELVOL
F      IF(DEBUG) PRINT 9999,HFAVG,BOLOST,WOLOST,VOLOST,HFSUM,SUMN,VTOTIN
F9999 FORMAT('VARBL21',6E14.5)
F      IF(VOLOST .GT. TOTVOL) VOLOST=TOTVOL
F   98 TOTVOL=TOTVOL-VOLOST+VNEWRE
F      TOTWT=TOTVOL*RHOLH2
F      COSGAM=1.-CON1*TOTVOL
F      IF(ABS(COSGAM) .GE. 1.0) THEN
F         GAMCU=0.0
F       ELSE
F         GAMCU=ACOS(COSGAM)
F      ENDIF
F      HOLD=RIN+TWOR*COS((GAMCU+FORPI)/3.)
F      SRFOLD=TWOPIR*HOLD
F      ARG=1.-HOLD/RIN
F      IF(ABS(ARG) .GE. 1.0) THEN
F         ARCLEN=0.0
F       ELSE
F         ARCLEN=ACOS(ARG)
F      ENDIF
F      ARCOLD=RIN*ARCLEN
F      ARCARC=ARCOLD/ARCO2
F      NCOLD=ARCARC
F      NCOLD=(NCOLD+1)/2
F      IF(TOTVOL .LE. TKVTST) GO TO 90
F      IF(FULL) GO TO 90
F      PRINT 1000, TOTVOL,NC,HOLD,TOTWT
F      FULL=.TRUE.
CC     CALL  OUTCAL
F   90 CONTINUE
C  TEST FOR FINE OUTPUT AT EQUATOR
F      IF(ARCWET .LT. ARCHLB .OR. ARCWET .GT. ARCHUB) GO TO 100
C      IF(TTEST-T50049 .LT. 20.) GO TO 100
C      TTEST=T50049
F      NTEST=NTHETA/2
F      IF(TTEST-TBDY(NTEST) .LT. 20.) GO TO 100
F      TTEST=TBDY(NTEST)
F      CALL OUTCAL
F  100 CONTINUE
F      IF(BAKING) NBUP=NBUP+1
F  999 FORMAT('BACKING UP, NTV2, I, NODE, TEMP, DT, Q=',3I7,F9.2,2F12.5)
F1000 FORMAT('   TANK FULL TO WITHIN .05 OF TANK VOLUME,'/
F     1 '   TOTVOL,  NO. NODES COV.,  HEIGHT OF LIQ.,  WT. OF LIQ.'/
```

```
F     2  G14.6,I14,2G14.6)
F      RETURN
F      END
F      SUBROUTINE THWSOU
F      COMMON /USER1/ NTHETA,NBETAS,NTUNIT,BETA,RIN,TNKVOL
F      COMMON /USER2/ TIME0,DTIMEU,FFLOW,TLIQ,TGAS
F      COMMON /SURFA/ SAREA(1)
F      COMMON /SURFT/ TSURF(1)
F      COMMON /BNDYT/ TBDY(1)
F      COMMON /HTRCF/ HCOF(1)
F      COMMON /SURFG/ GSURF(1)
F      COMMON /SURFQ/ QSURF(1)
F      COMMON/OUTVAR/TOTWT,TOTVOL,ARCOLD,ARCNEW,HOLD,NCOLD,SRFOLD,VTOTIN
F      COMMON /HFCLC/  HFSUM,SUMN,VNEWRE,DENS,RHOLH2,HVAP
F      COMMON/RQOA/   QOA(1)
F      COMMON/LOST/   HFAVG,BOLOST,WOLOST,VOLOST
F      COMMON /LIQST/NC,BAKING,TKVTST,FULL,DELTMP(100)
F      COMMON /DBUG/ DEBUG
F      COMMON /PLTSAV/ NOUT,NNCOV(200), VOLCUM(200), TOTVIN(200)
F      COMMON /FIXCON/ XKON(50)
F      LOGICAL  DEBUG
F      TIMEN=XKON(1)
F      BACKUP=XKON(12)
F      IF(BACKUP      .GT. 0.) GO TO 49
F      CALL  WRTMP(T1,0.)
F      NOUT=NOUT+1
F       NNCOV(NOUT)=NCOLD
F       VOLCUM(NOUT)=TOTVOL
F       TOTVIN(NOUT)=VTOTIN
C  GET DATE AND TIME; THE FOLLOWING ARE CALLS FROM THE CRAY SYSTEM
C  TO GET DATE AND TIME. ON ANOTHER SYSTEM THESE 2 LINES NEED
C  TO BE CHANGED TO THE PROPER CALLS.
F      NL=K1-1
F      NLM1=NL-1
F  49 CONTINUE
F      CALL TOPLIN
F      CALL STNDRD
F      TINHRS=(TIMEN+.05)/60.
F      NHRS=TINHRS
F      XHRS=NHRS
F      XMINS=TIMEN-XHRS*60.
F      MINUT=XMINS+0.05
F      XMINUT=MINUT
F      XSECS=XMINS-XMINUT
F      NSECS=XSECS*60.
F      PRINT 2013, NHRS,MINUT,NSECS
F      PRINT 2007,TOTWT,TOTVOL,ARCOLD,ARCNEW,HOLD,SRFOLD,NCOLD,NC
F      IF(BACKUP .GT. 0.) GO TO 50
F  50 CONTINUE
F      IF(BACKUP .GT. 0.) PRINT 2002,N1,(TSURF(J),J=1,13)
F      PRINT 2008,HFSUM,SUMN,HFAVG,BOLOST,WOLOST,VOLOST,VNEWRE
F      PRINT 2009,(QSURF(I),I=1,NTHETA)
F      NTHP1=NTHETA+1
F      PRINT 2012,(DELTMP(I),I=1,NTHETA)
F      PRINT 2010,(QOA(I),I=1,NTHETA)
F      IF(BACKUP .GT. 0.) GO TO 51
F      IF(TIMEN+2. .GE. 920.)  OUTPUT=10.
F      XKON(18)=OUTPUT
F       IF(DEBUG)  CALL  TPRINT
F  51 CONTINUE
F2001 FORMAT(10F8.3)
F2002 FORMAT(I4,12F10.3)
F2007 FORMAT(/'   LIQUID IN TANK AT THIS TIME'/
F     1 5X,'WEIGHT',6X,'VOLUME',6X,'ARC ALONG WALL (IN.)',3X,'DEPTH OF',
F     2 3X,'SURFACE',5X,'NO. NODES',5X,'NO. NODES'/
F     3 5X,'(LBS)',7X,'(IN**3)',5X,'LIQUID',6X,'WETTED',
F     4 5X,'LIQ  (IN)',3X,'AREA COV',4X,'COVERED',6X,'WETTED'/
F     5 6G12.5,2I10/)
F2008 FORMAT(4X,'HFSUM',8X,'SUMN',7X,'HFAVG',6X,'BOLOST',6X,'WOLOST',
F     1  6X,'VOLOST',6X,'VNEWRE'
```

ORIGINAL PAGE IS
OF POOR QUALITY

```
F    2  /1X,7G12.5)
F2009 FORMAT('  SOURCE VALUES,  Q'/(10G13.5))
F2010 FORMAT('  QOA AND  HFILM'/(10G13.5))
F2012 FORMAT('    DELTMP'/(10F13.5))
F2013 FORMAT(' TIME=',I4,' HRS,',I3,' MINS,',I3,' SECS')
F2014 FORMAT('133 FT LH2 TANK, TIME=',
F    1  I4,' HRS',I3,' MINS',I3,' SECS, TIMEDATE=',2A6)
F      RETURN
F      END
F      SUBROUTINE WRTMP(TT,TINC)
C
C   SUBROUTINE TO SAVE THE TIME AND TEMPERATURES AT THAT TIME
C   FOR LATER PLOTTING OR POSTPROCESSING.
C   FORMAT OF THE FILE IS AS FOLLOWS,
C   LINE 1.    TITLE      UP TO 120 CHARACTERS.
C   LINE 2.    NO. NODES,  -99,  -99.0,   -99.0,   DATE/TIME OF RUN
C            WITH FORMAT(2I8,2F8.2,A8,1X,A8)
C   LINES 3.   NODE NUMBERS  WITH FORMAT  (20I6)
C   LINES 4.  ETC.  TIME, TEMPS OF ALL NODES  USING FORMAT (10E12.6).
C   THE FINAL TIME AND TEMPS ARE REPEATED WITH THE TIME AS A NEGATIVE NO.
C
F      COMMON /DIMENS/ NNA,NND,NNT,NGL,NNG,NCH,NARY,LSEQ
F      COMMON /FIXCON/KON(1)
F      COMMON /TITLE/H
F      COMMON /TEMP/T
F      COMMON /XSPACE/ NDIM,NTH,X
F      COMMON /POINTN/ LNODE,LCOND,LCONS,LARRY,ICOMP
F      DIMENSION HEADER(20), H(1), T(1), CON(50)
F      DIMENSION X(1), NX(1)
F      EQUIVALENCE (KON(1),CON(1))
F      EQUIVALENCE (X,NX)
F      DATA KK/0/
F      IF (LNODE .EQ. 0) CALL NNREAD(1)
F      DT = CON(2)
F      NSL = NNT
F      IF (KK .GT. 0) GO TO 10
F      DO 5 MM=1,20
F    5 HEADER(MM) = H(MM)
F      LL=-99
F      ELL=LL
F      CALL DATE(CDATE)
F      CALL CLOCK(CTIME)
F      WRITE (23,2001) HEADER,NSL,LL,ELL,ELL,CDATE,CTIME
F      WRITE(23,2002) (NX(I+LNODE),I=1,NSL)
F      TIME2 = 0.
F      TIME1 = CON(13) + CON(2)
F      TIME1 = CON(13) + TINC
C      WRITE(23,2003)TINC,TIME1,TIME2,DT,CON(1),CON(2),CON(3),CON(13)
F      WRITE (23,2003) TIME1, (T(I),I=1,NSL)
F      KK=1
F      GO TO 50
F   10 TIME2 = TIME2 + DT
F      IF (CON(1)*1.000001 .LT. CON(3)) GO TO 12
F      GO TO 15
F   12 IF (TIME2 .LT. TINC) GO TO 50
C      IF (CON(1) .LT. TIME1) GO TO 50
F      IF (CON(13) .LT. TIME1) GO TO 50
F   15 CONTINUE
F1115 TIME1 = CON(1)
F      TIME1 = CON(13)+TINC
F      TIME2 = 0.
C      WRITE (23,2003) CON(1), (T(I),I=1,NSL)
F      WRITE (23,2003) CON(13), (T(I),I=1,NSL)
F      IF (CON(1)*1.000001 .LT. CON(3)) GO TO 50
C   20 TIME1 =-CON(1)
F   20 TIME1 =-CON(13)
F      WRITE (23,2003) TIME1, (T(I),I=1,NSL)
F      KK=0
F   50 CONTINUE
F      RETURN
```

```
F2001 FORMAT(20A6/2I8,2F8.2,A8,1X,A8)
F2002 FORMAT(20I6)
F2003 FORMAT(1P10E12.5)
CC     END
        END
        BCD 3END OF DATA
EOF
cossinda  model
ja   -sclf  #  GET ACCOUNTING INFO
```

```
# USER=userid              PW=password
# QSUB -r sphere3                # jobname
# QSUB -eo                 # Combine error andstandard output
# QSUB -lT       59          # CPU time
# QSUB -lM  1.5Mw    # Memory requested
#      @$                  # End NQS statements
set  -x                    # set echo
ja
cat  >  model  << EOF     # SINDA MODEL TO FOLLOW

       BCD 3THERMAL LPCS
C      REM  THIS SINDA MODEL WAS GENERATED BY CRYOTRAN
C      REM  SPHERE   --- 2D WEDGE SHELL - NO NODES INSIDE OF TANK
C      REM              WEDGE ANGLE=BETA = 1.0 RADIANS
       BCD 9SAMPLE OF SPHERE NOT NODALIZED IN TANK
       BCD 9
       END
       BCD 3NODE DATA
       REM  NODE TEMPERATURES ARE IN (DEG R)
       REM  DIMENSIONS ARE IN (IN.),  TIME IS IN (SECS)
       REM  SURFACE NODES, INSIDE TANK WALL
       GEN   1001, 40,  1,  540.0,          -1.000000 $ SURFACE NODES
       REM  DIFFUSION NODES, REGION  1, TANKWALL
       REM   REGION  1,  LAYER NO.   1
       SIM   2001,  2, 39,  540.0, A1204,     0.587964 $ ALUMINUM 2219
       SIM   2002,  2, 37,  540.0, A1204,     1.760254 $ ALUMINUM 2219
       SIM   2003,  2, 35,  540.0, A1204,     2.921695 $ ALUMINUM 2219
       SIM   2004,  2, 33,  540.0, A1204,     4.065123 $ ALUMINUM 2219
       SIM   2005,  2, 31,  540.0, A1204,     5.183486 $ ALUMINUM 2219
       SIM   2006,  2, 29,  540.0, A1204,     6.269894 $ ALUMINUM 2219
       SIM   2007,  2, 27,  540.0, A1204,     7.317644 $ ALUMINUM 2219
       SIM   2008,  2, 25,  540.0, A1204,     8.320272 $ ALUMINUM 2219
       SIM   2009,  2, 23,  540.0, A1204,     9.271607 $ ALUMINUM 2219
       SIM   2010,  2, 21,  540.0, A1204,    10.165776 $ ALUMINUM 2219
       SIM   2011,  2, 19,  540.0, A1204,    10.997278 $ ALUMINUM 2219
       SIM   2012,  2, 17,  540.0, A1204,    11.760979 $ ALUMINUM 2219
       SIM   2013,  2, 15,  540.0, A1204,    12.452162 $ ALUMINUM 2219
       SIM   2014,  2, 13,  540.0, A1204,    13.066572 $ ALUMINUM 2219
       SIM   2015,  2, 11,  540.0, A1204,    13.600422 $ ALUMINUM 2219
       SIM   2016,  2,  9,  540.0, A1204,    14.050434 $ ALUMINUM 2219
       SIM   2017,  2,  7,  540.0, A1204,    14.413813 $ ALUMINUM 2219
       SIM   2018,  2,  5,  540.0, A1204,    14.688324 $ ALUMINUM 2219
       SIM   2019,  2,  3,  540.0, A1204,    14.872272 $ ALUMINUM 2219
       SIM   2020,  2,  1,  540.0, A1204,    14.964533 $ ALUMINUM 2219
       REM   REGION  1,  LAYER NO.   2
       SIM   2041,  2, 39,  540.0, A1204,     0.585274 $ ALUMINUM 2219
       SIM   2042,  2, 37,  540.0, A1204,     1.752204 $ ALUMINUM 2219
       SIM   2043,  2, 35,  540.0, A1204,     2.908333 $ ALUMINUM 2219
       SIM   2044,  2, 33,  540.0, A1204,     4.046532 $ ALUMINUM 2219
       SIM   2045,  2, 31,  540.0, A1204,     5.159781 $ ALUMINUM 2219
       SIM   2046,  2, 29,  540.0, A1204,     6.241218 $ ALUMINUM 2219
       SIM   2047,  2, 27,  540.0, A1204,     7.284177 $ ALUMINUM 2219
       SIM   2048,  2, 25,  540.0, A1204,     8.282219 $ ALUMINUM 2219
       SIM   2049,  2, 23,  540.0, A1204,     9.229204 $ ALUMINUM 2219
```

```
SIM   2050,  2, 21,  540.0, A1204,     10.119285 $ ALUMINUM 2219
SIM   2051,  2, 19,  540.0, A1204,     10.946982 $ ALUMINUM 2219
SIM   2052,  2, 17,  540.0, A1204,     11.707189 $ ALUMINUM 2219
SIM   2053,  2, 15,  540.0, A1204,     12.395211 $ ALUMINUM 2219
SIM   2054,  2, 13,  540.0, A1204,     13.006806 $ ALUMINUM 2219
SIM   2055,  2, 11,  540.0, A1204,     13.538227 $ ALUMINUM 2219
SIM   2056,  2,  9,  540.0, A1204,     13.986176 $ ALUMINUM 2219
SIM   2057,  2,  7,  540.0, A1204,     14.347882 $ ALUMINUM 2219
SIM   2058,  2,  5,  540.0, A1204,     14.621149 $ ALUMINUM 2219
SIM   2059,  2,  3,  540.0, A1204,     14.804255 $ ALUMINUM 2219
SIM   2060,  2,  1,  540.0, A1204,     14.896100 $ ALUMINUM 2219
REM  SURFACE NODES, OUTSIDE SURFACE, REGION  1, TANKWALL
GEN   3001, 40,  1,  540.0,            -1.000000 $ SURFACE NODES
REM  CONSTANT VALUE BOUNDARY NODES; REGION 4, INSIDE OF TANK
GEN -18001, 26,  1,   36.0,             1.000000 $ IN TANK, LIQUID
GEN -18027, 14,  1,   45.0,             1.000000 $ IN TANK, VAPOR
END
BCD 3CONDUCTOR DATA
REM  RADIAL CONDUCTORS,  CONDUCTION
REM  RADIAL CONDUCTORS REGION 1, LAYER  1 TO BOUNDARY   1- 4
SIM      1,  2,1, 1001,39, 2001,39, A6204, 1.169207E+02
SIM      3,  2,1, 1002,37, 2002,37, A6204, 3.500393E+02
SIM      5,  2,1, 1003,35, 2003,35, A6204, 5.810002E+02
SIM      7,  2,1, 1004,33, 2004,33, A6204, 8.083787E+02
SIM      9,  2,1, 1005,31, 2005,31, A6204, 1.030774E+03
SIM     11,  2,1, 1006,29, 2006,29, A6204, 1.246813E+03
SIM     13,  2,1, 1007,27, 2007,27, A6204, 1.455166E+03
SIM     15,  2,1, 1008,25, 2008,25, A6204, 1.654546E+03
SIM     17,  2,1, 1009,23, 2009,23, A6204, 1.843726E+03
SIM     19,  2,1, 1010,21, 2010,21, A6204, 2.021538E+03
SIM     21,  2,1, 1011,19, 2011,19, A6204, 2.186887E+03
SIM     23,  2,1, 1012,17, 2012,17, A6204, 2.338755E+03
SIM     25,  2,1, 1013,15, 2013,15, A6204, 2.476202E+03
SIM     27,  2,1, 1014,13, 2014,13, A6204, 2.598382E+03
SIM     29,  2,1, 1015,11, 2015,11, A6204, 2.704542E+03
SIM     31,  2,1, 1016, 9, 2016, 9, A6204, 2.794029E+03
SIM     33,  2,1, 1017, 7, 2017, 7, A6204, 2.866290E+03
SIM     35,  2,1, 1018, 5, 2018, 5, A6204, 2.920877E+03
SIM     37,  2,1, 1019, 3, 2019, 3, A6204, 2.957459E+03
SIM     39,  2,1, 1020, 1, 2020, 1, A6204, 2.975807E+03
REM  RADIAL CONDUCTORS REGION 1, LAYER  1 TO LAYER  2
DIM     41,  2,1, 2001,39, 2041,39,A6204, 1.171893E+02,A6204, 1.174582E+02
DIM     43,  2,1, 2002,37, 2042,37,A6204, 3.508435E+02,A6204, 3.516482E+02
DIM     45,  2,1, 2003,35, 2043,35,A6204, 5.823347E+02,A6204, 5.836707E+02
DIM     47,  2,1, 2004,33, 2044,33,A6204, 8.102358E+02,A6204, 8.120942E+02
DIM     49,  2,1, 2005,31, 2045,31,A6204, 1.033141E+03,A6204, 1.035511E+03
DIM     51,  2,1, 2006,29, 2046,29,A6204, 1.249677E+03,A6204, 1.252544E+03
DIM     53,  2,1, 2007,27, 2047,27,A6204, 1.458509E+03,A6204, 1.461854E+03
DIM     55,  2,1, 2008,25, 2048,25,A6204, 1.658346E+03,A6204, 1.662150E+03
DIM     57,  2,1, 2009,23, 2049,23,A6204, 1.847961E+03,A6204, 1.852200E+03
DIM     59,  2,1, 2010,21, 2050,21,A6204, 2.026182E+03,A6204, 2.030829E+03
DIM     61,  2,1, 2011,19, 2051,19,A6204, 2.191911E+03,A6204, 2.196939E+03
DIM     63,  2,1, 2012,17, 2052,17,A6204, 2.344128E+03,A6204, 2.349504E+03
DIM     65,  2,1, 2013,15, 2053,15,A6204, 2.481890E+03,A6204, 2.487583E+03
DIM     67,  2,1, 2014,13, 2054,13,A6204, 2.604349E+03,A6204, 2.610323E+03
DIM     69,  2,1, 2015,11, 2055,11,A6204, 2.710755E+03,A6204, 2.716973E+03
DIM     71,  2,1, 2016, 9, 2056, 9,A6204, 2.800448E+03,A6204, 2.806871E+03
DIM     73,  2,1, 2017, 7, 2057, 7,A6204, 2.872875E+03,A6204, 2.879464E+03
DIM     75,  2,1, 2018, 5, 2058, 5,A6204, 2.927586E+03,A6204, 2.934303E+03
DIM     77,  2,1, 2019, 3, 2059, 3,A6204, 2.964251E+03,A6204, 2.971053E+03
DIM     79,  2,1, 2020, 1, 2060, 1,A6204, 2.982643E+03,A6204, 2.989483E+03
REM  RADIAL CONDUCTORS REGION 1, LAYER  2 TO BOUNDARY   1- 2
SIM     81,  2,1, 2041,39, 3001,39, A6204, 1.177274E+02
SIM     83,  2,1, 2042,37, 3002,37, A6204, 3.524543E+02
SIM     85,  2,1, 2043,35, 3003,35, A6204, 5.850083E+02
SIM     87,  2,1, 2044,33, 3004,33, A6204, 8.139556E+02
SIM     89,  2,1, 2045,31, 3005,31, A6204, 1.037885E+03
SIM     91,  2,1, 2046,29, 3006,29, A6204, 1.255415E+03
SIM     93,  2,1, 2047,27, 3007,27, A6204, 1.465205E+03
SIM     95,  2,1, 2048,25, 3008,25, A6204, 1.665960E+03
```

```
SIM    97,  2,1, 2049,23, 3009,23, A6204, 1.856445E+03
SIM    99,  2,1, 2050,21, 3010,21, A6204, 2.035484E+03
SIM   101,  2,1, 2051,19, 3011,19, A6204, 2.201975E+03
SIM   103,  2,1, 2052,17, 3012,17, A6204, 2.354889E+03
SIM   105,  2,1, 2053,15, 3013,15, A6204, 2.493284E+03
SIM   107,  2,1, 2054,13, 3014,13, A6204, 2.616307E+03
SIM   109,  2,1, 2055,11, 3015,11, A6204, 2.723199E+03
SIM   111,  2,1, 2056, 9, 3016, 9, A6204, 2.813304E+03
SIM   113,  2,1, 2057, 7, 3017, 7, A6204, 2.886063E+03
SIM   115,  2,1, 2058, 5, 3018, 5, A6204, 2.941029E+03
SIM   117,  2,1, 2059, 3, 3019, 3, A6204, 2.977862E+03
SIM   119,  2,1, 2060, 1, 3020, 1, A6204, 2.996336E+03
REM  CIRCUMFERENTIAL CONDUCTORS; Y- DIRECTION,  CONDUCTION
REM  CIRCUMFERENTIAL CONDUCTORS REGION 1, LAYER NUMBER  1
DIM   121,  2,1, 2001,38, 2002,38,A6204, 9.989804E-02,A6204, 2.990765E-01
DIM   123,  2,1, 2002,36, 2003,36,A6204, 2.990765E-01,A6204, 4.964110E-01
DIM   125,  2,1, 2003,34, 2004,34,A6204, 4.964110E-01,A6204, 6.906856E-01
DIM   127,  2,1, 2004,32, 2005,32,A6204, 6.906856E-01,A6204, 8.807010E-01
DIM   129,  2,1, 2005,30, 2006,30,A6204, 8.807010E-01,A6204, 1.065287E+00
DIM   131,  2,1, 2006,28, 2007,28,A6204, 1.065287E+00,A6204, 1.243305E+00
DIM   133,  2,1, 2007,26, 2008,26,A6204, 1.243305E+00,A6204, 1.413657E+00
DIM   135,  2,1, 2008,24, 2009,24,A6204, 1.413657E+00,A6204, 1.575294E+00
DIM   137,  2,1, 2009,22, 2010,22,A6204, 1.575294E+00,A6204, 1.727219E+00
DIM   139,  2,1, 2010,20, 2011,20,A6204, 1.727219E+00,A6204, 1.868494E+00
DIM   141,  2,1, 2011,18, 2012,18,A6204, 1.868494E+00,A6204, 1.998251E+00
DIM   143,  2,1, 2012,16, 2013,16,A6204, 1.998251E+00,A6204, 2.115686E+00
DIM   145,  2,1, 2013,14, 2014,14,A6204, 2.115686E+00,A6204, 2.220078E+00
DIM   147,  2,1, 2014,12, 2015,12,A6204, 2.220078E+00,A6204, 2.310783E+00
DIM   149,  2,1, 2015,10, 2016,10,A6204, 2.310783E+00,A6204, 2.387242E+00
DIM   151,  2,1, 2016, 8, 2017, 8,A6204, 2.387242E+00,A6204, 2.448982E+00
DIM   153,  2,1, 2017, 6, 2018, 6,A6204, 2.448982E+00,A6204, 2.495623E+00
DIM   155,  2,1, 2018, 4, 2019, 4,A6204, 2.495623E+00,A6204, 2.526877E+00
DIM   157,  2,1, 2019, 2, 2020, 2,A6204, 2.526877E+00,A6204, 2.542554E+00
DIV   159,       2020,    2021,    A6204, 2.542554E+00,A6204, 2.542554E+00
REM  CIRCUMFERENTIAL CONDUCTORS REGION 1, LAYER NUMBER  2
DIM   160,  2,1, 2041,38, 2042,38,A6204, 9.989798E-02,A6204, 2.990764E-01
DIM   162,  2,1, 2042,36, 2043,36,A6204, 2.990764E-01,A6204, 4.964109E-01
DIM   164,  2,1, 2043,34, 2044,34,A6204, 4.964109E-01,A6204, 6.906855E-01
DIM   166,  2,1, 2044,32, 2045,32,A6204, 6.906855E-01,A6204, 8.807011E-01
DIM   168,  2,1, 2045,30, 2046,30,A6204, 8.807011E-01,A6204, 1.065287E+00
DIM   170,  2,1, 2046,28, 2047,28,A6204, 1.065287E+00,A6204, 1.243305E+00
DIM   172,  2,1, 2047,26, 2048,26,A6204, 1.243305E+00,A6204, 1.413656E+00
DIM   174,  2,1, 2048,24, 2049,24,A6204, 1.413656E+00,A6204, 1.575294E+00
DIM   176,  2,1, 2049,22, 2050,22,A6204, 1.575294E+00,A6204, 1.727218E+00
DIM   178,  2,1, 2050,20, 2051,20,A6204, 1.727218E+00,A6204, 1.868494E+00
DIM   180,  2,1, 2051,18, 2052,18,A6204, 1.868494E+00,A6204, 1.998250E+00
DIM   182,  2,1, 2052,16, 2053,16,A6204, 1.998250E+00,A6204, 2.115685E+00
DIM   184,  2,1, 2053,14, 2054,14,A6204, 2.115685E+00,A6204, 2.220078E+00
DIM   186,  2,1, 2054,12, 2055,12,A6204, 2.220078E+00,A6204, 2.310783E+00
DIM   188,  2,1, 2055,10, 2056,10,A6204, 2.310783E+00,A6204, 2.387241E+00
DIM   190,  2,1, 2056, 8, 2057, 8,A6204, 2.387241E+00,A6204, 2.448981E+00
DIM   192,  2,1, 2057, 6, 2058, 6,A6204, 2.448981E+00,A6204, 2.495622E+00
DIM   194,  2,1, 2058, 4, 2059, 4,A6204, 2.495622E+00,A6204, 2.526876E+00
DIM   196,  2,1, 2059, 2, 2060, 2,A6204, 2.526876E+00,A6204, 2.542553E+00
DIV   198,       2060,    2061,    A6204, 2.542553E+00,A6204, 2.542553E+00
REM  CONVECTION CONDUCTORS; INSIDE TANK TO TANK WALL
GEN 18001, 40,1,18001, 1, 1001, 1,0.00000E+00,0.00000E+00, 1.00, 1.00
END
BCD 3CONSTANTS DATA
REM NTHETA NBETAS       BETA        RIN        TVOL
     1-  40, 2-   1, 3-  1.000, 4-  43.534, 5-  200.000
REM K10-SINDA TEMP UNITS; K10-1(DEG F); K10-2(DEG R)
     10- 2
REM   TIMEO(MIN)       TIMEND(MIN)       DTIMEI(MIN)       OUTPUT(MIN)
REM 0.00000E+00         360.00            0.12500E-01        0.25000
    101-0.00000E+00, 102- 6.0000     , 103-0.20833E-03, 104-0.41667E-02
    NLOOP-  2000, DRLXCA- 0.001000, ARLXCA- 0.001000
END
BCD 3ARRAY DATA
     1 $REGION 1,(TANKWALL              ),INSIDE  SURFACE AREAS (IN**2)
```

```
      5.83933E+00, 1.74819E+01, 2.90167E+01, 4.03726E+01, 5.14795E+01
      6.22691E+01, 7.26748E+01, 8.26324E+01, 9.20805E+01, 1.00961E+02
      1.09219E+02, 1.16804E+02, 1.23668E+02, 1.29770E+02, 1.35072E+02
      1.39541E+02, 1.43150E+02, 1.45876E+02, 1.47703E+02, 1.48620E+02
      1.48620E+02, 1.47703E+02, 1.45876E+02, 1.43150E+02, 1.39541E+02
      1.35072E+02, 1.29770E+02, 1.23668E+02, 1.16804E+02, 1.09219E+02
      1.00961E+02, 9.20805E+01, 8.26324E+01, 7.26748E+01, 6.22691E+01
      5.14795E+01, 4.03726E+01, 2.90167E+01, 1.74819E+01, 5.83933E+00
     END
     2 $REGION 1,(TANKWALL                ),OUTSIDE SURFACE AREAS (IN**2)
      5.89311E+00, 1.76429E+01, 2.92839E+01, 4.07444E+01, 5.19536E+01
      6.28426E+01, 7.33441E+01, 8.33933E+01, 9.29285E+01, 1.01891E+02
      1.10225E+02, 1.17879E+02, 1.24807E+02, 1.30965E+02, 1.36316E+02
      1.40826E+02, 1.44468E+02, 1.47220E+02, 1.49063E+02, 1.49988E+02
      1.49988E+02, 1.49063E+02, 1.47220E+02, 1.44468E+02, 1.40826E+02
      1.36316E+02, 1.30965E+02, 1.24807E+02, 1.17879E+02, 1.10225E+02
      1.01891E+02, 9.29285E+01, 8.33933E+01, 7.33441E+01, 6.28426E+01
      5.19536E+01, 4.07444E+01, 2.92839E+01, 1.76429E+01, 5.89311E+00
     END
 REM CONDUCTIVITY  BTU/(INCH.HR.F)  FOR ALUMINUM 2219
     6204
        18., 0.46480E+00,   36., 0.89712E+00,   54., 0.12994E+01
        72., 0.17243E+01,   90., 0.21491E+01,  108., 0.28238E+01
       126., 0.28988E+01,  144., 0.32486E+01,  162., 0.33986E+01
       180., 0.34985E+01,  270., 0.43482E+01,  360., 0.50479E+01
       450., 0.56476E+01,  540., 0.61474E+01,  630., 0.65472E+01
       720., 0.68471E+01,  810., 0.70470E+01,  900., 0.72969E+01
       990., 0.75968E+01, 1080., 0.77967E+01, 1170., 0.79466E+01
      1260., 0.78467E+01, 1350., 0.76967E+01,END
 REM SPECIFIC HEAT BTU/(LB.F)        FOR ALUMINUM 2219
     2204
        18., 0.35300E-03,   36., 0.19800E-02,   54., 0.74100E-02
        72., 0.18100E-01,   90., 0.33000E-01,  108., 0.51300E-01
       126., 0.69200E-01,  144., 0.83700E-01,  162., 0.99400E-01
       180., 0.11200E+00,  270., 0.16000E+00,  360., 0.18300E+00
       450., 0.20000E+00,  540., 0.20800E+00,  630., 0.21000E+00
       720., 0.21700E+00,  810., 0.22000E+00,  900., 0.22800E+00
       990., 0.23400E+00, 1080., 0.23800E+00, 1170., 0.24000E+00
      1260., 0.24800E+00, 1350., 0.25400E+00,END
 REM DENSITY        LB/(CUBIC INCH)  FOR ALUMINUM 2219
     3204
        18., 0.10365E+00,   36., 0.10362E+00,   54., 0.10322E+00
        72., 0.10318E+00,   90., 0.10312E+00,  108., 0.10308E+00
       126., 0.10305E+00,  144., 0.10301E+00,  162., 0.10298E+00
       180., 0.10296E+00,  270., 0.10278E+00,  360., 0.10260E+00
       450., 0.10224E+00,  540., 0.10188E+00,  630., 0.10152E+00
       720., 0.10116E+00,  810., 0.10079E+00,  900., 0.10043E+00
       990., 0.10007E+00, 1080., 0.99711E-01, 1170., 0.99169E-01
      1260., 0.98627E-01, 1350., 0.98085E-01,END
 REM CP * RHO FOR ALUMINUM 2219
     1204
        18., 0.36588E-04,   36., 0.20516E-03,   54., 0.76488E-03
        72., 0.18675E-02,   90., 0.34031E-02,  108., 0.52881E-02
       126., 0.71310E-02,  144., 0.86215E-02,  162., 0.10236E-01
       180., 0.11532E-01,  270., 0.16445E-01,  360., 0.18776E-01
       450., 0.20448E-01,  540., 0.21191E-01,  630., 0.21319E-01
       720., 0.21951E-01,  810., 0.22175E-01,  900., 0.22899E-01
       990., 0.23417E-01, 1080., 0.23731E-01, 1170., 0.23800E-01
      1260., 0.24459E-01, 1350., 0.24914E-01,END
 END
 BCD 3EXECUTION
F      COMMON/USER1/ NTHETA,NBETAS,NTUNIT,BETA,RIN,TVOL
F      COMMON/USER2/ PTIME, DELTIM, XC1, XC2, XC3, XC4
F      COMMON/INSA /SARIN (   40)
F      COMMON/OUTSA/SAROUT(   40)
F      COMMON/SURFT/TSURF (   40)
F      COMMON/BNDYT/TBDY  (   40)
F      COMMON/HTRCO/HCOEF (   40)
F      COMMON/SURFQ/QSURF (   40)
F      DIMENSION X(  900)
```

```
F       NDIM=   900
M       NTHETA= K1
M       NBETAS= K2
M       BETA  =XK3
M       RIN   =XK4
M       TVOL  =XK5
M       NTUNIT= K10
F       DO 120 I=1,NTHETA
M       SARIN(I) =A(1+I)
M       SAROUT(I)=A(2+I)
F 120 CONTINUE
F       HL=    2400.00    /144.
F       HV=    200.000    /144.
F       DO 272 I=1, 26
F       IM1=I-1
M       G(18001+IM1)= HL*SARIN(I)
F 272 CONTINUE
F       DO 273 I= 27, 40
F       IM1=I-1
M       G(18001+IM1)= HV*SARIN(I)
F 273 CONTINUE
             STDSTL
        END
        BCD 3VARIABLES 1
F      COMMON/USER1/ NTHETA,NBETAS,NTUNIT,BETA,RIN,TVOL
        END
        BCD 3VARIABLES 2
        END
        BCD 3OUTPUT CALLS
             TPRNTF
        END
        BCD 3END OF DATA
 EOF
 cossinda  model
 ja   -sclf  #  GET ACCOUNTING INFO
```

APPENDIX C

"CryoTran Model" Files Part 3

Sample Case of SOLA-ECLIPSE

- Input Data Requirements
- Input Screens for Sample Case
- Model to submit to CRAY
- Run Output
- Plots

file management system

5 - Input file
6 - Printed output file including debug output
7 - History file
8 - Formatted plotfile
9 - Unformatted plotfile (now formatted)
10 - Restart input file
11 - Restart output file
53 - Printed debug file
59 - Debug file (now unit 6)
The CRAY will automatically dispose units 6, 7, and 9.

The input data to run the code is to be provided either in an input file or may be keyed in within CryoTran. The prepared input file may be resident on the VM computer or on the CRAY. The user will be interrogated for the name of the file in CryoTran. The only additional means of providing input is through the restart file if the user is restarting an analysis. All input values except the problen title, (NAME), is input by use of NAMELIST data. All reading of the input file is performed by Subroutine READER. If a restart of an analysis is being performed, only the title and the first namelist, CNTRL, is required. Many variables have default values given in the program. If a value for a variable is provided in the input file, it replaces the default value. The names of the namelists are: CNTRL, HYDRO, MESHES, ASETIN, THERMS, TURB, and FEATS. The input variable names are listed below grouped by namelist. Each subgroup has a brief description of its contents followed by a listing of the input variables contained in it. An explanation of each variable and the default value, if any, is provided. The default values are enclosed in brackets, [ ].

Variable name   Description

NAME   problem identification, (title), 48 characters maximum.

Namelist CNTRL
These variables are primarily associated with controlling execution of the code.

AUTOT   automatic adjustment of time step   [1.0]   =1.0 for automatic time step adjustment
=0.0 for constant time step
BUGB   print plotfile data to unit 8   logical   [.false.]   CON   c.f.l.condition - cell width fraction moved   [0.50]
in time step   DEBUG   prints selective output to unit 6,   logical   [.false.]
DELT   time step   [none]
DTCRMX   maximum delt using conjugate residual   [0.001]
solution method   IDEFM   defoamer option flag   on = 1 *** off = 0   [0]
IDIV   divergence correction flag 1=on 0=off   [1]
IEQIC   flag used to activate equilibrium free surface   [none]   calculation during setup

ISOR   pressure iteration solution method   [0]
conjugate residual = 0   ****   sor = 1
NDUMP   ndump=0 new case   [0]
ndump>0 restart, read previously dumped file.
NPACK   flag to activate packing; 0=off, 1=on   [0]
PLTDT   time increment between plots and/or prints   [none]
to be output on film   PRTDT   time increment between prints on paper   [none]
TWFIN   problem time to end calculation   [none]
LHYDRO   selects execution of hydrodynamics   logical   [none]
LHEAT   selects execution of heat transfer   logical   [none]
LTHERM   not used   logical   [none]
LTURB   selectsturbulence model in hydro sol.   logical   [none]

Namelist HYDRO
The variables in this namelist fall into several categories;
fluid properties, constants used in the numerical method, gravitational environment, and problem initial state. For dimensional variables the burden of maintaining a consistent set of units falls to the user. One possible consistent set of units is provided in parentheses after the description of each variable where appropriate.

ALPHA   controls amount of donor cell fluxing   [1.0]
=1.0 for full donor cell differencing

	=0.0 for central differencing)		
CANGLE	contact angle between fluid and wall	(deg)	[90.0]
EPSI	pressure iteration convergence criterion		[1.0E-3]
FLHT	fluid height, in y-direction	(cm)	[0.0]
GX	body acceleration in positive x-direction	(cm/s^2)	[0.0]
GY	body acceleration in positive y-direction	(cm/s^2)	[0.0]
ISURF10	surface tension indicator =1 for surface tension =0 for no surface tension		[0]
KB	indicator for boundary condition to be used along the bottom of the mesh, minimum x =1 for rigid free-slip wall =2 for rigid no-slip wall =3 for continuative boundary =4 for periodic boundary =5 for constant pressure boundary		[1]
KL	indicator for boundary condition along left side of mesh, minimum y, (see KB)		[1]
KR	indicator for boundary condition along right side of mesh, maximum x, (see KB)		[1]
KT	indicator for boundary condition along top of mesh, maximum y, (see KB)		[1]
OMG	over-relaxation factor used in pressure iteration		[1.7]
PERFUL	percent full; percentage of tank volume occupied by liquid. If value is zero, FLHT sets liquid height. If value is non-zerosupercedes FLHT.		[0.0]
RHOF	fluid density (for f=1.0 region)	(g/cm^3)	[1.0]
SIGMA	surface tension coefficient	(g/s^2)	[0.0]
UI	initial x-direction velocity	(cm/s)	[0.0]
VI	initial y-direction velocity	(cm/s)	[0.0]
XNU	coefficient of kinematic viscosity	(cm^2/s)	[0.0]

Namelist MESHS

All variables in this group are required for generation of the computational mesh. All lengths must be expressed in units consistent with the fluid properties in the HYDRO namelist. For array variables, the number of entries required is enclosed in { } after the description.

DXMN(N)	minimum cell width (delta-x) in submesh n	{NKX}	[none]
DYMN(N)	minimum cell width (delta-y) in submesh n	{NKY}	[none]
ICYL	mesh geometry indicator =1 for cylindrical coordinates =0 for plane coordinates		[0]
NKX	number of submesh regions in x-direction		[none]
NKY	number of submesh regions in y-direction		[none]
NXL(N)	number of cells between locations xl(n) and xc(n) in submesh n	{NKX}	[none]
NXR(N)	number of cells between locations xc(n) and xl(n+1) in submesh n	{NKX}	[none]
NYL(N)	number of cells between locations yl(n) and yc(n) in submesh n	{NKY}	[none]
NYR(N)	number of cells between locations yc(n) and yl(n+1) in submesh n	{NKY}	[none]
XC(N)	x-coordinate of the convergence point (cm) in submesh n	{NKX}	[none]
XL(N)	location of the left edge of submesh n (cm) (NKX+1) values of xl(n) are necessary because the right edge (xr) of submesh n is determined by the left edge of submesh (n+1).	{NKX+1}	[none]
YC(N)	y-coordinate of the convergence point (cm) in submesh n	{NKY}	[none]
YL(N)	location of the bottom of submesh n (cm) (nky+1) values of yl(n) are necessary because the top edge (yr) of submesh n is determined by the bottom edge of submesh (n+1)	{NKY+1}	[none]

Namelist ASETIN

All variables in this namelist are associated with solid boundary definition within the computational mesh. The boundary modeling procedure is detailed elsewhere in ref.??????? with only brief descriptions of the variables included in this section.

IOH	Select effect of obstacle function =1 to add obstacle "inside" function =0 to subtract obstacle "inside" function	(NOBS)	[none]
NOBS	number of obstacle functions to be defined		[0]
OA1	coefficient of x^1 in obstacle function	(NOBS)	[0.0]
OA2	coefficient of x^2 in obstacle function	(NOBS)	[0.0]
OB1	coefficient of y^1 in obstacle function	(NOBS)	[0.0]
OB2	coefficient of y^2 in obstacle function	(NOBS)	[0.0]
OA1	coefficient of xy in obstacle function	(NOBS)	[0.0]
OA1	constatnt term in obstacle function	(NOBS)	[0.0]

Namelist THERMS
The variables in this namelist provide the thermal properties of the fluid being modeled.

CPL	cp		
FLK	k		
GASVOL	volume of ullage	(cm^3)	[none]
GSURF	surface area of ullage	(cm^2)	[none]
PGAS	initial gas pressure	(Pa)	[none]
PGEND	gas pressure to terminate execution	(pa)	[none]
PSAT	liquid saturation pressure if nonzero code simulates phase change in nf = 5 cells	(pa)	[0.0]
QFLBC	heat flux at boundary		[none]
TFLD	initial liquid temperature	(K)	[none]
TGAS	initial gas temperature	(K)	[none]

Namelist TURB
The variables in this list will provide constants required by the turbulence model. To date, the turbulence models being used do not require input data. This namelist has not been used but its "place" is being held by a dummy variable.

DUMMY

Namelist FEATS
Certain aspects of the code execution and model building require modification and/or addition of FORTRAN coding. Although these areas are clearly identiofied within the program, new coding obviously requires a higher level of effort than simply changing input variables. FEATS has been established to simplify the inclusion and exclusion of features which commonly occur, such as tank inlets and outlets. Each feature typically requires a logical variable which selects activation of the feature and associated dimensional variables which define the attributes of the feature.

LDRAIN	selects activation of tank outlet at bottom			[.false.]
	DRAINID	inside diameter	(cm)	[none]
	DRANOD	outside diameter	(cm)	[none]
	DRANQV	volume flow rate supercedes VDRAIN	(cm^3/s)	[none]
	VDRAIN	fluid velocity	(cm/s)	[none]
LJET	selects activation of an axial jet and suction			[.false.]
	BOTJET	y-value for jet suction	(cm)	[0.0]
	EPSJET	jet turbulence energy dissipation rate	(cm^2/s^3)	[0.0]
	RADJET	jet radius	(cm)	[0.0]
	TKEJET	jet turbulence kinetic energy	(cm^2/s^2)	[0.0]
	TMPJET	jet fluid temperature	(K)	[0.0]
	TOPJET	y-value of jet issue	(cm)	[0.0]
	VELJET	jet fluid velocity	(cm/s)	[0.0]
	VOLJET	volume flow rate, supercedes VELJET	(cm^3/s)	[0.0]
LQBOT	selects heat flux at bottom of tank			[.false.]
	QBOT	heat flux for bottom half of tank		[none]
LQTOP	selects heat flux at top of tank			[.false.]
	QTOP	heat flux for top half of tank		[none]
LQUNI	selects uniform heat flux at tank walls if .true. uniform heat flux if .false. non-uniform heat flux or adiabatic			[.false.]
	QUNI	uniform heat flux at tank walls		[none]

Sample Case of SOLA-ECLIPSE; Input Screens

```
   WELCOME TO CRYOTRAN
   YOU WILL BE PROMPTED FOR ALL NECESSARY INPUT.
   READ THE INSTRUCTIONS CAREFULLY.
   TYPE IN THE INPUT DATA CAREFULLY TO AVOID TROUBLE,
   YOU MAY QUIT THE PROGRAM AT ANY INPUT PROMPT BY TYPING A  "Q"  (QUIT)


  ENTER THE NUMBER FOR THE DESIRED PROBLEM TYPE
   THE PROBLEM TYPES ARE AS FOLLOWS:

  1 -  THERMO/THERMAL SINDA ANALYSIS ON A SPHERE.
  2 -  THERMO/THERMAL SINDA ANALYSIS ON A CYLINDER.
  3 -  RUN A PRESTORED ANALYSIS PROGRAM
 3


     CHOOSE THE ANALYSIS PROGRAM YOU WISH TO USE.
     TYPE IN THE NUMBER OF THE DESIRED ANALYSIS.
     1     NOVENT FILL
     2     CHILL TO TEMP
     3     TARGET FOR NVFILL
     4     SOLA-ECLIPSE
     5     CSAM
 4


    THIS TASK IS BEING SET UP FOR THE CRAY,
    NOW INPUT NECESSARY CRAY INFO.


   WHICH CRAY SYSTEM  COS  OR  UNICOS
     TYPE IN   C   OR   U
u

    TYPE IN YOUR  CRAY  USERID.
userid


    TYPE IN YOUR  CRAY  PASSWORD.
password

    TYPE IN NO. OF CRAY CPU SECONDS TO BE USED.
   IF NUMBER OF SECONDS REQUESTED IS < 10,   60 WILL BE USED.
59

    NOW GIVE YOUR JOB A NAME, TYPE IN THE NAME,
     1 - 7 ALPHABETIC CHARACTERS.
ecltest


   THE CRAY JCL THAT WAS INPUT IS AS FOLLOWS:
   USERID           = userid
   PASSWORD         = password
   CPU TIME REQUEST =       59 SECS.
   MEMORY REQUEST   =   1500000  words
   JOB  NAME        = ecltest

   ARE THESE ALL CORRECT?  TYPE   Y   OR   N   OR   Q    TO QUIT
y
   NOW WE NEED THE INPUT DATA FOR THE ANALYSIS
   THIS INPUT DATA CAN BE:
```

```
  1  STORED ON CRAY
  2  STORED ON VM
  3  TYPED IN NOW
  4  NO INPUT DATA FOR THIS ANALYSIS
  TYPE IN  1  2  3  OR  4
2
  ANALYSIS INPUT DATA IS STORED ON VM
  NOW WE NEED  FILE NAME;  FILE TYPE;  FILE MODE
  TYPE IN        FN FT FM
solaecl test1a a
JCL COMMAND - IRC-FILEDEF VMDATA DISK SOLAECL TEST1A A                  0
JCL COMMAND - IRC-FILEDEF VMDATA CLEAR          0
  THE INPUT DATA IS NOW ALL IN.
   END OF CRYOTRAN PREPROCESSOR PROGRAM,
   THE OUTPUT FILE IS CALLED "CRYOTRAN MODEL".

  DO YOU WANT TO GO TO BEGINNING OF SYSTEM  OR  QUIT?
     TYPE  Y  TO GO BACK TO BEGINNING OF SYSTEM,
  OR TYPE  N  TO QUIT.
n
    ON TO ANALYSIS PROGRAM
   THE OUTPUT FILE IS CALLED "CRYOTRAN MODEL".
   THIS "CRYOTRAN MODEL" FILE IS A SOLA-ECLIPSE MODEL.


   USER MAY NOW SUBMIT THE FILE  'CRYOTRAN MODEL'
    TO THE CRAY COMPUTER FOR EXECUTION,
    OR MAKE ANY DESIRED MODIFICATIONS WITH AN EDITOR
    PRIOR TO SUBMITTING IT TO THE CRAY.


   TO SUBMIT THE FILE TO CRAY,
    ON THE VM SYSTEM TYPE:  CRSUBMIT CRYOTRAN MODEL


  UPON COMPLETION OF THE CRAY EXECUTION OF SOLA-ECLIPSE
  USER MAY PLOT THESE RESULTS BY TYPING:

               DOECLPLT SOLA PLOTFILE
Ready; T=1.15/2.40 16:03:45
crsubmit cryotran model     .    *  submit the SOLA model to CRAY
Ready; T=0.02/0.07 16:04:03
16:04:04

MSG FROM NCRAYUX : CRIRDR002I Job vvglenn staged to the Cray

Ready; T=0.03/0.10 16:05:38
PRT FILE 0153 FROM NCRAYUX  COPY 001   NOHOLD
PRT FILE 0154 FROM NCRAYUX  COPY 001   NOHOLD
PRT FILE 0155 FROM NCRAYUX  COPY 001   NOHOLD
RL
Ready; T=0.57/1.41 16:20:46
doeclplt sola plotfile          *  produce plots from SOLA output
DMSACP723I F (500) R/O

DMSLIO740I Execution begins...   *  begin execution of the plot          program
  THE FOLLOWING VARIABLES ARE AVAILABLE TO CONTROL GRAPHICAL OUTPUT
                                                           CURRENT VALUE
DEBUG  - T/F ---- WRITE DEBUG OUTPUT TO FILE  <DEBUG OUTPUT>-      F
MODE   - INTEGER- 1  NO PAUSES, NO PROMPTS ------------------      1
                  2  PROMPTSTO CHANGE CONTROL VARIABLES
LVEC   - T/F  --- PRODUCE VELOCITY FIELD VECTOR PLOTS-------       T
LCNTR  - T/F  --- PRODUCE TEMPERATURE FIELD CONTOUR PLOTS---       F
LQUIK  - T/F  --- ABREVIATED/FULL DISPLAY ------------------       F
ISYMPL - T/F  --- SYMMETRIC/HALF-FIELD DISPLAYS ------------       T

   WANT TO CHANGE THE VALUE OF    ANY OF THE CONTROL VARIABLES?  (Y/N)
n
CEGDIN100I Graphics device NOT assigned.
CEGDIN100I ENTER desired device name or HELP HELP.
```

```
CEGDIN100R DEFAULT to CANCEL.
lgaos                          * name of plot device to print plots
CEGDIO300I Device LGAOS attached.
   SOLA-ECL GRAPHICS PROGRAM,  NORMAL TERMINATION
PRT FILE 2480  TO  RSCS     COPY 001    NOHOLD
CEGDIO800I Device DISCONNECTED from VM/GRAPH3D.
Ready; T=*.**/*.** 16:21:40
DMTRGX170I FROM MVSLERC1: 16.24.15 JOB 2480 $HASP546 RSCS2480 (JOB 2480 FROM VMLERC1 ) SYSTEM OUTPUT RECEIVED
AT MVSLERC1
```

Sample Case of SOLA-ECLIPSE; Model File, Output of Preprocessor

```
# USER=vvglenn           PW=dendrob
# QSUB -r ecltest               # jobname
# QSUB -eo              # Combine error andstandard output
# QSUB -lT       59       # CPU time
# QSUB -lM  1.5Mw     # Memory requested
#      @$               # End NQS statements
set  -x                 # set echo
ja
### This SOLECL file,(model), was generated by CRYOTRAN.
cat  >  model  << EOF     # DATA FROM VM, FN FT FM= SOLAECL TESTlA
OTVJ1: LH2, 50%, 4.5 CM/S
 &CNTRL
    NDUMP= 0,
    TWFIN= 0.1,          PRTDT= 1.E10,        PLTDT= 60.,
    DELT = 0.01,          AUTOT=  1,            DTCRMX=  1.0,
    ISOR=  1,             CON=  0.35,           IEQIC= 1,
    IDEFM= 0,             NPACK= 0,             IDIV= 0,
    LHYDRO= .TRUE.,       LHEAT= .TRUE.,
    LTHERM= .FALSE.,      LTURB= .TRUE.,
 &END
 &HYDRO
    RHOF= 0.0701,         XNU= 1.803E-3,
    ISRF10= 1,            SIGMA= 1.813,           CANGLE= 5.0,
    EPSI= 1.E-05,         ALPHA= 1.0,           OMG= 1.7,
    GX= 0.0,              GY= 0.0,
    UI= 0.0,              VI= 0.0,
    KL= 1,                KR= 1,                KT= 1,          KB= 1,
    FLHT=0.,              PERFUL= 50.0,
 &END
 &MESHES
    ICYL= 1,
    NKX= 1,
      XL= 0.0, 210.,
      XC= 20.,
      NXL= 2,
      NXR= 10,
      DXMN= 10.0,
    NKY= 1,
      YL= 0.0, 1020.,
      YC= 30.,
      NYL= 1,
      NYR= 33,
      DYMN= 30.0,
 &END
 &ASETIN
    NOBS= 4,
      IOH(1)= 1,
        OA2(1)= 0.0,       OB2(1)= 0.0,       OC2(1)= 0.0,
        OA1(1)= 0.0,       OB1(1)= 1.0,       OC1(1)=-210.,
      IOH(2)= 0,
        OA2(2)= 1.0,       OB2(2)= 1.0,       OC2(2)= 0.0,
        OA1(2)= 0.0,       OB1(2)=-420.0,     OC1(2)= 0.0,
      IOH(3)= 1,
        OA2(3)= 0.0,       OB2(3)= 0.0,       OC2(3)= 0.0,
        OA1(3)= 0.0,       OB1(3)=-1.0,       OC1(3)= 810.0,
      IOH(4)= 0,
        OA2(4)= 1.0,       OB2(4)= 1.0,       OC2(4)= 0.0,
        OA1(4)= 0.0,       OB1(4)=-1620.0,    OC1(4)= 6.12E+5,
 &END
 &THERMS
    PSAT= 0.0,     PGAS= 20.0,
    TFLD= 21.0,       TGAS= 21.0,
    GSURF= 0.0,       GASVOL= 0.0,
    PGEND = 0.0,
    QFLBC = 0.0,
    CPL= 9.6E+7,      FLK = 1.0E+04,
 &END
 &TURB
```

```
   DUMMY=0.0,
 &END
 &FEATS
   LDRAIN= .FALSE.,
   LQUNI = .FALSE.,   QUNI= 0.0,
   LQTOP = .TRUE.,    QTOP= 1.3,
   LQBOT = .TRUE.,    QBOT= 1.3,
   LJET = .TRUE.,
       RADJET= 10.0,      BOTJET= 60.0,      TOPJET= 120.0,
       VELJET= 4.5,      VOLJET= 0.0,       TMPJET= 18.0,
 &END
 &FLOBC
   NFLBC = 0,
   XEND1(1) = 0.0, YEND1(1) = 0., XVEL(1) = 0.,
   XEND2(1) = .000, YEND2(1) = 0, YVEL(1) = .0,
 &END
EOF
/space/cryolib/solecl  model
ja   -sclf  #  GET ACCOUNTING INFO
```

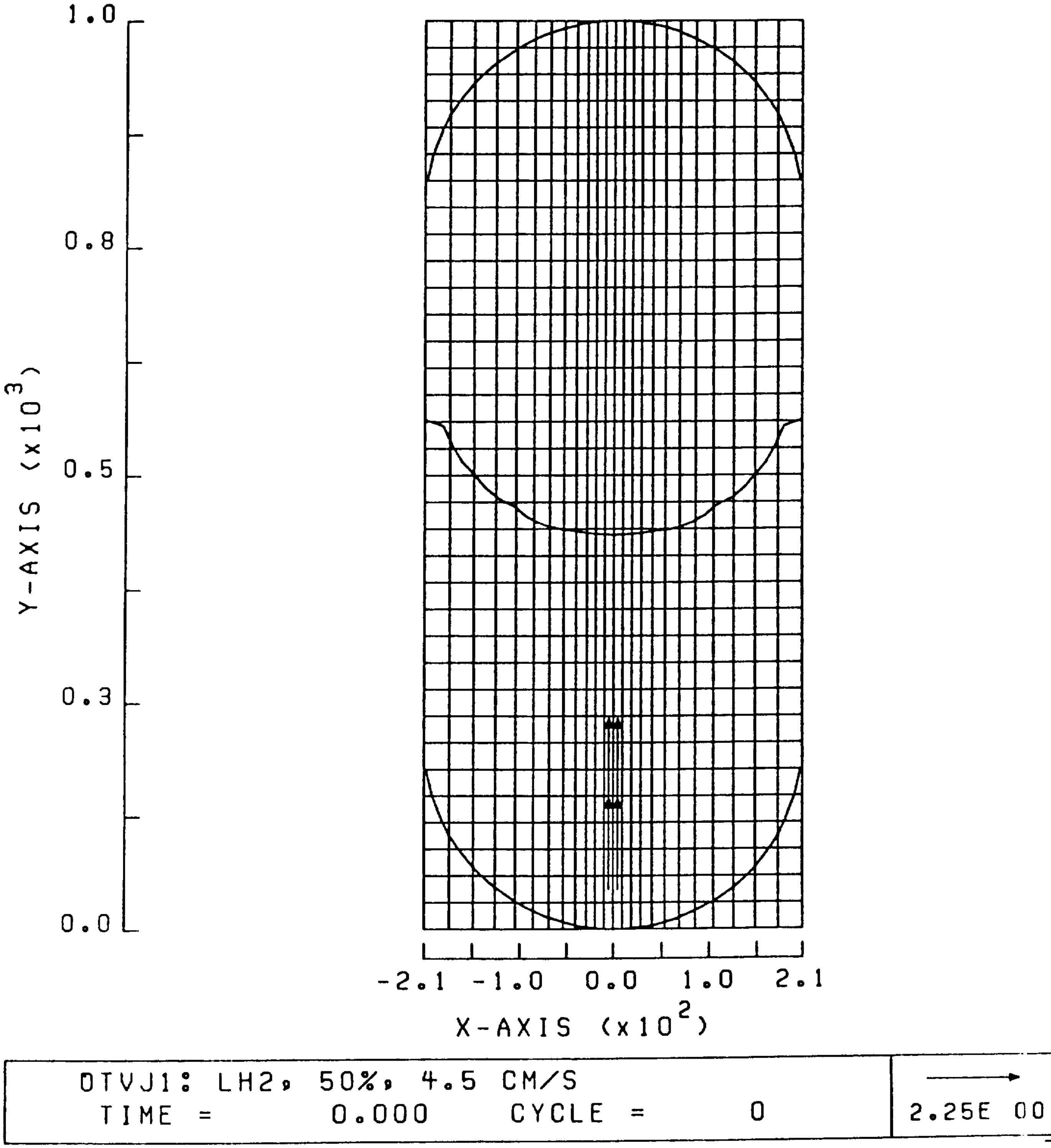
Sample case of SOLA-ECLIPSE; CRAY Output of Run
This output file from the CRAY has been edited and some of the output deleted.

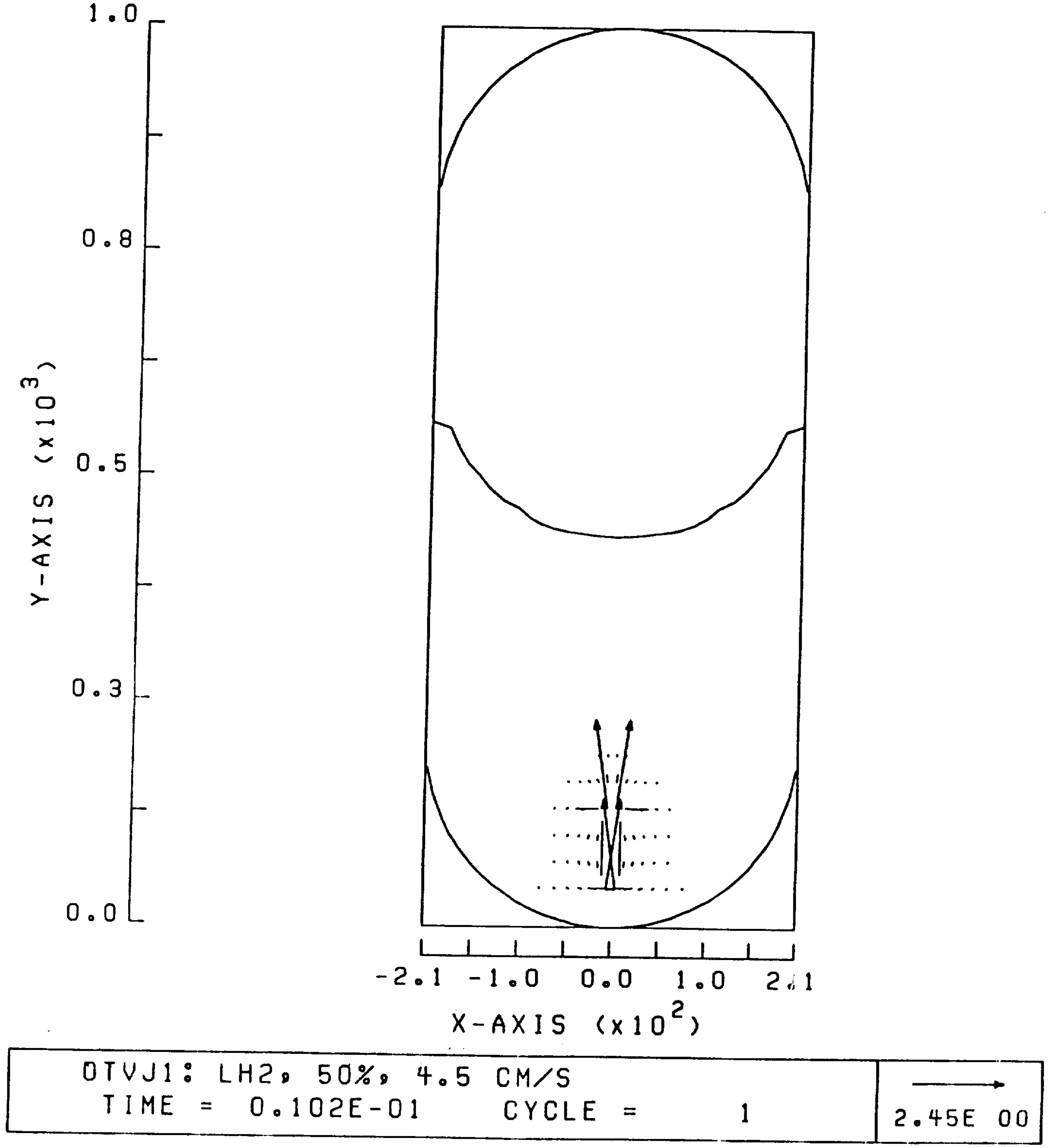
```
 BEGIN EXECUTION OF SOLA ECLIPSE
   NAME =OTVJ1: LH2, 50%, 4.5 CM/S
 &CNTRL  NDUMP = 0,  TWFIN = 0.1,  PRTDT = 10000000000.,  PLTDT = 60.,  DELT = 1.E-2,  AUTOT = 1.,  ISOR = 1,
CON = 0.35,
  IDEFM = 0,  NPACK = 0,  DTCRMX = 1.,  IDIV = 0,  IEQIC = 1,  LHYDRO = .T.,  LHEAT = .T.,  LTHERM = .F.,
LTURB = .T.,
  DEBUG = .F.,  BUG8 = .F.,  &END
 &HYDRO  RHOF = 7.01E-2,  XNU = 1.803E-3,  EPSI = 1.E-5,  GX = 0.,  GY = 0.,  UI = 0.,  VI = 0.,  OMG = 1.7,
ALPHA = 1.,  KL = 1,
  KR = 1,  KT = 1,  KB = 1,  FLHT = 0.,  SIGMA = 1.813,  ISRF10 = 1,  CANGLE = 5.,  PERFUL = 50.,  &END
 &MESHES  ICYL = 1,  NKX = 1,  XL = 0.,  210.,  18*0.,  XC = 20.,  19*0.,  NXL = 2,  19*0,  NXR = 10,  19*0,
DXMN = 10.,  19*0.,
  NKY = 1,  YL = 0.,  1020.,  18*0.,  YC = 30.,  19*0.,  NYL = 1,  19*0,  NYR = 33,  19*0,  DYMN = 30.,  19*0.,
&END
 &ASETIN  NOBS = 4,  OA2 = 0.,  1.,  0.,  1.,  16*0.,  OA1 = 20*0.,  OB2 = 0.,  1.,  0.,  1.,  16*0.,  OB1 =
1.,  -420.,  -1.,
  -1620.,  16*0.,  OC2 = 20*0.,  OC1 = -210.,  0.,  810.,  612000.,  16*0.,  IOH = 1,  0,  1,  17*0,  &END
 &THERMS  PSAT = 0.,  PGAS = 20.,  TFLD = 21.,  TGAS = 21.,  QFLBC = 0.,  GSURF = 0.,  GASVOL = 0.,  PGEND =
0.,  CPL = 96000000.,
  FLK = 10000.,  &END
 &TURB  DUMMY = 0.,  &END
 &FEATS  LDRAIN = .F.,  DRANID = 0.,  DRANOD = 0.,  VDRAIN = 0.,  DRANQV = 0.,  LQUNI = .F.,  QUNI = 0.,  LQTOP
= .T.,
  QTOP = 1.3,  LQBOT = .T.,  QBOT = 1.3,  LJET = .T.,  RADJET = 10.,  BOTJET = 60.,  TOPJET = 120.,  VELJET =
4.5,  VOLJET = 0.,
  TMPJET = 18.,  TKEJET = 0.,  EPSJET = 0.,  &END
 &FLOBC  NFLBC = 0,  XEND1 = 10*0.,  XEND2 = 10*0.,  YEND1 = 10*0.,  YEND2 = 10*0.,  XVEL = 10*0.,  YVEL =
10*0.,  TBC = 10*0.,
 &END
1   FOLLOWING VALUES COMPUTED & PRINTED IN <MSHSETS>
 X( 1)= 0.00000E+00  RX( 1)= 0.00000E+00  DELX( 1)= 1.00000E+01 RDX( 1)= 1.00000E-01  XI( 1)=-5.00000E+00  RXI(
1)=-2.00000E-01
 X( 2)= 1.00000E+01  RX( 2)= 1.00000E-01  DELX( 2)= 1.00000E+01 RDX( 2)= 1.00000E-01  XI( 2)= 5.00000E+00  RXI(
2)= 2.00000E-01
 X( 3)= 2.00000E+01  RX( 3)= 5.00000E-02  DELX( 3)= 1.00000E+01 RDX( 3)= 1.00000E-01  XI( 3)= 1.50000E+01  RXI(
3)= 6.66667E-02
 X( 4)= 3.00000E+01  RX( 4)= 3.33333E-02  DELX( 4)= 1.00000E+01 RDX( 4)= 1.00000E-01  XI( 4)= 2.50000E+01  RXI(
4)= 4.00000E-02
 X( 5)= 4.20000E+01  RX( 5)= 2.38095E-02  DELX( 5)= 1.20000E+01 RDX( 5)= 8.33333E-02  XI( 5)= 3.60000E+01  RXI(
5)= 2.77778E-02
 X( 6)= 5.60000E+01  RX( 6)= 1.78571E-02  DELX( 6)= 1.40000E+01 RDX( 6)= 7.14286E-02  XI( 6)= 4.90000E+01  RXI(
6)= 2.04082E-02
 X( 7)= 7.20000E+01  RX( 7)= 1.38889E-02  DELX( 7)= 1.60000E+01 RDX( 7)= 6.25000E-02  XI( 7)= 6.40000E+01  RXI(
7)= 1.56250E-02
 X( 8)= 9.00000E+01  RX( 8)= 1.11111E-02  DELX( 8)= 1.80000E+01 RDX( 8)= 5.55556E-02  XI( 8)= 8.10000E+01  RXI(
8)= 1.23457E-02
 X( 9)= 1.10000E+02  RX( 9)= 9.09091E-03  DELX( 9)= 2.00000E+01 RDX( 9)= 5.00000E-02  XI( 9)= 1.00000E+02  RXI(
9)= 1.00000E-02
 X(10)=  1.32000E+02   RX(10)=  7.57576E-03   DELX(10)=  2.20000E+01  RDX(10)=  4.54545E-02   XI(10)=  1.21000E+02
RXI(10)= 8.26446E-03
 X(11)=  1.56000E+02   RX(11)=  6.41026E-03   DELX(11)=  2.40000E+01  RDX(11)=  4.16667E-02   XI(11)=  1.44000E+02
RXI(11)= 6.94444E-03
 X(12)=  1.82000E+02   RX(12)=  5.49451E-03   DELX(12)=  2.60000E+01  RDX(12)=  3.84615E-02   XI(12)=  1.69000E+02
RXI(12)= 5.91716E-03
 X(13)=  2.10000E+02   RX(13)=  4.76190E-03   DELX(13)=  2.80000E+01  RDX(13)=  3.57143E-02   XI(13)=  1.96000E+02
RXI(13)= 5.10204E-03
 X(14)=  2.38000E+02   RX(14)=  0.00000E+00   DELX(14)=  2.80000E+01  RDX(14)=  3.57143E-02   XI(14)=  2.24000E+02
RXI(14)= 4.46429E-03
1   FOLLOWING VALUES COMPUTED & PRINTED IN <MSHSETS>
 Y( 1)= 0.00000E+00   DELY( 1)= 3.00000E+01   RDY( 1)= 3.33334E-02   YJ( 1)=-1.50000E+01   RYJ( 1)=-6.66667E-02

 Y( 2)= 3.00000E+01   DELY( 2)= 3.00000E+01   RDY( 2)= 3.33334E-02   YJ( 2)= 1.50000E+01   RYJ( 2)= 6.66667E-02

 Y( 3)= 6.00000E+01   DELY( 3)= 3.00000E+01   RDY( 3)= 3.33333E-02   YJ( 3)= 4.50000E+01   RYJ( 3)= 2.22222E-02

 Y( 4)= 9.00000E+01   DELY( 4)= 3.00000E+01   RDY( 4)= 3.33333E-02   YJ( 4)= 7.50000E+01   RYJ( 4)= 1.33333E-02
```

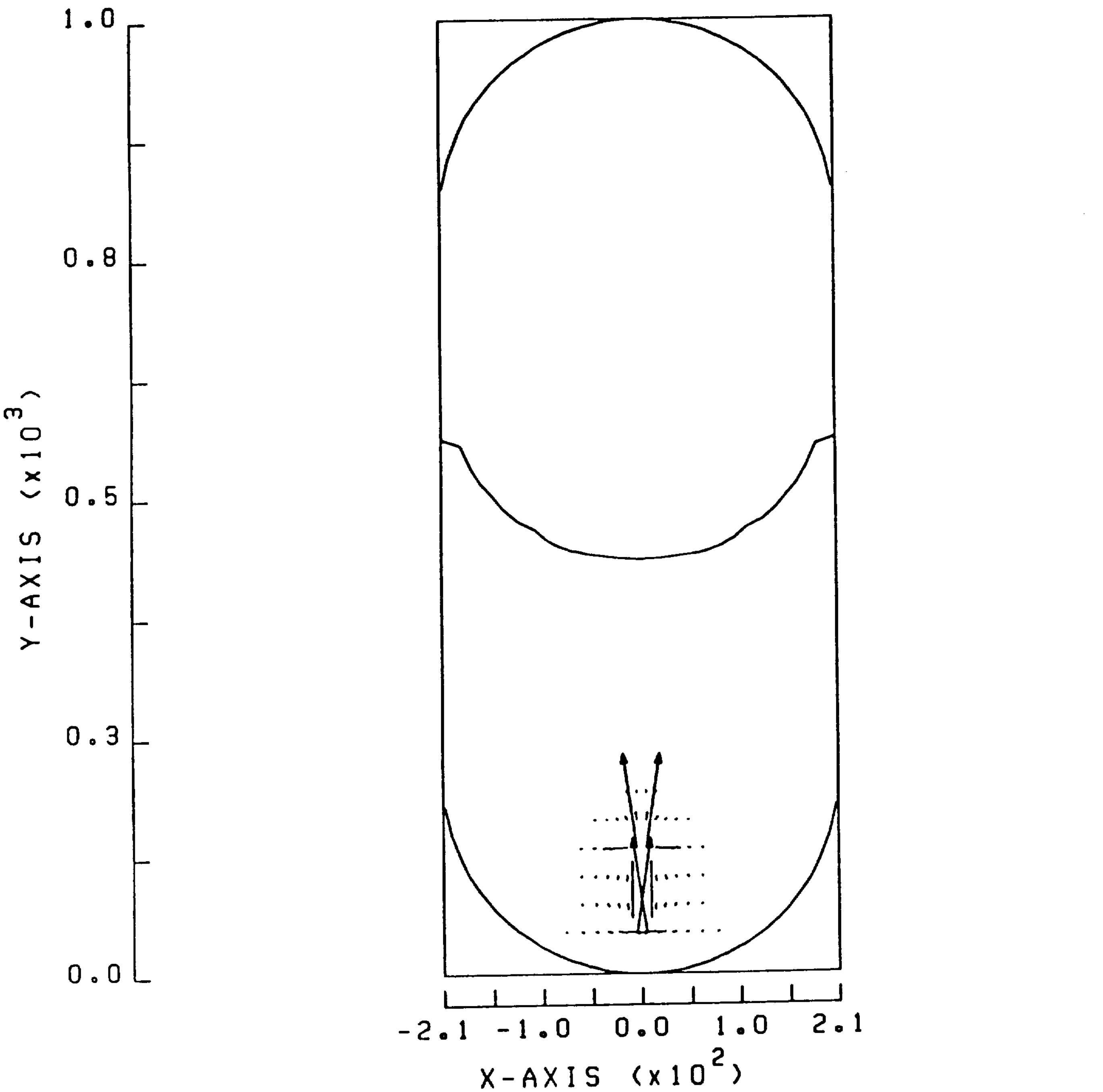
```
 Y( 5)= 1.20000E+02   DELY( 5)= 3.00000E+01   RDY( 5)= 3.33333E-02   YJ( 5)= 1.05000E+02   RYJ( 5)= 9.52381E-03

. . .  data deleted

 Y(34)= 9.90000E+02   DELY(34)= 3.00000E+01   RDY(34)= 3.33333E-02   YJ(34)= 9.75000E+02   RYJ(34)= 1.02564E-03

 Y(35)= 1.02000E+03   DELY(35)= 3.00000E+01   RDY(35)= 3.33333E-02   YJ(35)= 1.00500E+03   RYJ(35)= 9.95025E-04

 Y(36)= 1.05000E+03   DELY(36)= 3.00000E+01   RDY(36)= 3.33333E-02   YJ(36)= 1.03500E+03   RYJ(36)= 9.66184E-04

        --- CONSTANTS COMPUTED IN <SETUP> ---
 BOND NUMBER =  0.0000E+00
1
    I    J        BETA          AC           AR           AT          SINO         COSO
    1    1   0.00000E+00   1.00000E+00   1.00000E+00   1.00000E+00   0.00000E+00   0.00000E+00
    2    1   0.00000E+00   1.00000E-10   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00

. . . .  data has been deleted

    1   35   0.00000E+00   1.00000E-10   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00
    2   35   5.66529E+02   9.96063E-01   9.92060E-01   0.00000E+00   3.18503E-01   9.47922E-01
    3   35   5.66063E+02   9.80121E-01   9.68182E-01   0.00000E+00   9.97444E-01  -7.14526E-02
    4   35   5.95267E+02   9.48192E-01   9.28203E-01   0.00000E+00   9.92884E-01  -1.19082E-01
    5   35   7.94994E+02   8.93388E-01   8.58572E-01   0.00000E+00   9.85184E-01  -1.71498E-01
    6   35   1.03761E+03   8.02547E-01   7.46521E-01   0.00000E+00   9.72363E-01  -2.33474E-01
    7   35   1.26787E+03   6.61117E-01   5.75713E-01   0.00000E+00   9.52351E-01  -3.05005E-01
    8   35   1.39770E+03   4.50134E-01   3.24555E-01   0.00000E+00   9.22444E-01  -3.86131E-01
    9   35   9.87989E+02   1.47401E-01   0.00000E+00   0.00000E+00   8.81387E-01  -4.72394E-01
   10   35  -1.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   8.71557E-02   9.96195E-01
   11   35  -1.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   8.71557E-02   9.96195E-01
   12   35  -1.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   8.71557E-02   9.96195E-01
   13   35  -1.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   8.71557E-02   9.96195E-01
   ITER=     0     TIME=  0.00000E+00     DELT=  1.00000E-02     CYCLE=      0  VCHGT=  1.13791E+00
1
                  OTVJ1: LH2, 50%, 4.5 CM/S

   ITER=     0     TIME=  0.00000E+00     DELT=  1.00000E-02     CYCLE=      0  VCHGT=  1.13791E+00

             NREG=    0
                  K       VOL(K)          PR(K)
   FLUID VOLUME =  6.068951E+07    ON CYCLE      0

   I    J          U             V             P             D             PS            F          NF
   PETA
   1    1     0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   1.00000E+00    0
1.00000E+00
   1    2     0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   1.00000E+00    0
1.00000E+00
   1    3     0.00000E+00   4.50000E+00   0.00000E+00   0.00000E+00   0.00000E+00   1.00000E+00    0
1.00000E+00

. . . data has been deleted

  14   32     0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00    0
1.00000E+00
  14   33     0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00    0
1.00000E+00
  14   34     0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00    0
1.00000E+00
  14   35     0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00    0
1.00000E+00
  14   36     0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00    0
1.00000E+00
1
   ITER=    88     TIME=  1.02000E-02     DELT=  1.02000E-02     CYCLE=      1  VCHGT=  1.03037E+00
1
                  OTVJ1: LH2, 50%, 4.5 CM/S

   ITER=    88     TIME=  1.02000E-02     DELT=  1.02000E-02     CYCLE=      1  VCHGT=  1.03037E+00
```

```
          NREG=    0
                K        VOL(K)           PR(K)
   FLUID VOLUME =  6.068951E+07   ON CYCLE      1

   I     J           U                V                P                D                PS               F              NF
    PETA
   1     1     0.00000E+00     0.00000E+00    -3.45477E+01     0.00000E+00     0.00000E+00     1.00000E+00     0
1.00000E+00
   1     2     0.00000E+00     3.26115E-01    -3.45477E+01     0.00000E+00     0.00000E+00     1.00000E+00     0
1.00000E+00
   1     3     0.00000E+00     4.50000E+00    -1.01785E+02     0.00000E+00     0.00000E+00     1.00000E+00     0
1.00000E+00
   1     4     0.00000E+00     1.83906E-07    -5.84083E+01     0.00000E+00     0.00000E+00     1.00000E+00     0
1.00000E+00
   1     5     0.00000E+00     4.50000E+00     4.59786E+01     0.00000E+00     0.00000E+00     1.00000E+00     0
1.00000E+00
   1     6     0.00000E+00     3.45791E-01     8.84386E+01     0.00000E+00     0.00000E+00     1.00000E+00     0
1.00000E+00
   1     7     0.00000E+00     5.44622E-02     1.71447E+01

 . . . data has been deleted

  14    15     0.00000E+00     3.54901E-06    -3.39962E-03     0.00000E+00     0.00000E+00     1.00000E+00     0
1.00000E+00
  14    16     0.00000E+00     1.43330E-05    -4.13134E-03     0.00000E+00     0.00000E+00     1.00000E+00     0
1.00000E+00
  14    17     0.00000E+00     1.28172E-05    -7.08647E-03     0.00000E+00     0.00000E+00     1.00000E+00     0
1.00000E+00
  14    18     0.00000E+00    -2.88517E-06    -9.72907E-03     0.00000E+00     0.00000E+00     1.00000E+00     0
1.00000E+00
  14    19     0.00000E+00    -7.73684E-05    -9.13422E-03     0.00000E+00     0.00000E+00     1.00000E+00     0
1.00000E+00
  14    20     0.00000E+00     2.30768E-04     6.81733E-03     0.00000E+00     0.00000E+00     9.99999E-01     0
1.00000E+00
  14    21     0.00000E+00    -3.38134E-05    -4.07617E-02     0.00000E+00     0.00000E+00     1.08392E-01     0
1.00000E+00
  14    22     0.00000E+00    -1.40864E-05     0.00000E+00     0.00000E+00     0.00000E+00     0.00000E+00     0
1.00000E+00
  14    23     0.00000E+00    -7.08900E-06     0.00000E+00     0.00000E+00     0.00000E+00     0.00000E+00     0
1.00000E+00
  14    24     0.00000E+00    -4.17370E-06     0.00000E+00     0.00000E+00     0.00000E+00     0.00000E+00     0
1.00000E+00
  14    25     0.00000E+00    -2.75979E-06     0.00000E+00     0.00000E+00     0.00000E+00     0.00000E+00     0
1.00000E+00
  14    26     0.00000E+00    -1.96645E-06     0.00000E+00     0.00000E+00     0.00000E+00     0.00000E+00     0
1.00000E+00
  14    27     0.00000E+00    -1.45080E-06     0.00000E+00     0.00000E+00     0.00000E+00     0.00000E+00     0
1.00000E+00
  14    28     0.00000E+00    -1.05875E-06     0.00000E+00     0.00000E+00     0.00000E+00     0.00000E+00     0
1.00000E+00
  14    29     0.00000E+00    -7.72031E-07     0.00000E+00     0.00000E+00     0.00000E+00     0.00000E+00     0
1.00000E+00
  14    30     0.00000E+00    -5.72324E-07     0.00000E+00     0.00000E+00     0.00000E+00     0.00000E+00     0
1.00000E+00
  14    31     0.00000E+00    -4.17460E-07     0.00000E+00     0.00000E+00     0.00000E+00     0.00000E+00     0
1.00000E+00
  14    32     0.00000E+00     0.00000E+00     0.00000E+00     0.00000E+00     0.00000E+00     0.00000E+00     0
1.00000E+00
  14    33     0.00000E+00     0.00000E+00    -2.66325E-02     0.00000E+00     0.00000E+00     0.00000E+00     0
1.00000E+00
  14    34     0.00000E+00     0.00000E+00     0.00000E+00     0.00000E+00     0.00000E+00     0.00000E+00     0
1.00000E+00
  14    35     0.00000E+00     0.00000E+00     0.00000E+00     0.00000E+00     0.00000E+00     0.00000E+00     0
1.00000E+00
  14    36     0.00000E+00     0.00000E+00     0.00000E+00     0.00000E+00     0.00000E+00     0.00000E+00     0
1.00000E+00
1
    ITER=    76     TIME=  2.05020E-02     DELT=  1.03020E-02     CYCLE=      2  VCHGT=  1.13801E+00
    ITER=    45     TIME=  3.07010E-02     DELT=  1.01990E-02     CYCLE=      3  VCHGT=  1.24622E+00
```

```
    ITER-     7     TIME-  4.07980E-02     DELT-  1.00970E-02     CYCLE-      4  VCHGT-  1.33822E+00
    ITER-     7     TIME-  5.09959E-02     DELT-  1.01980E-02     CYCLE-      5  VCHGT-  1.40368E+00
    ITER-     7     TIME-  6.12959E-02     DELT-  1.02999E-02     CYCLE-      6  VCHGT-  1.43586E+00
    ITER-    15     TIME-  7.16988E-02     DELT-  1.04029E-02     CYCLE-      7  VCHGT-  1.43425E+00
    ITER-    15     TIME-  8.22058E-02     DELT-  1.05070E-02     CYCLE-      8  VCHGT-  1.40883E+00
    ITER-    15     TIME-  9.28178E-02     DELT-  1.06120E-02     CYCLE-      9  VCHGT-  1.37397E+00
    ITER-    15     TIME-  1.03536E-01     DELT-  1.07182E-02     CYCLE-     10  VCHGT-  1.34284E+00
0
 *************************************************
 *************************************************
 * EXITQ CALLED FROM <MAIN>: NORMAL TERMINATION  *

        IN EXITQ,  IO-    6,  DEBUG-    F
 *************************************************
 *************************************************
```


1.0
0.8
0.5
0.3
0.0
Y-AXIS (x10³)
-2.1
-1.0
0.0
1.0
2.1
X-AXIS (x10²)
DTVJ1: LH2, 50%, 4.5 CM/S
TIME = 0.000 CYCLE = 0
2.25E 00


1.0
0.8
0.5
0.3
0.0
Y-AXIS (x10^3)
-2.1
-1.0
0.0
1.0
2.1
X-AXIS (x10^2)
OTVJ1: LH2, 50%, 4.5 CM/S
TIME = 0.102E-01 CYCLE = 1
2.45E 00



OTVJ1: LH2, 50%, 4.5 CM/S
TIME = 0.104E 00 CYCLE = 10

APPENDIX C

"CryoTran Model" Files Part 4

Output File (Model) to Run CSAM

```
# USER=userid              PW=password
# QSUB -r csam                     # jobname
# QSUB -eo                 # Combine error andstandard output
# QSUB -lT      300          # CPU time
# QSUB -lM  1.5Mw      # Memory requested
#     @$                   # End NQS statements
set  -x                    # set echo
ja
### This CRCSAM file,(model), was generated by CRYOTRAN.
cat  >  model  << EOF    # DATA FROM VM, FN FT FM= CSAM TEST1 A
           PDR CFMF DETAILED SUPPLY TANK MODEL
          .19 SCALE TANK OUTFLOW, 0.0% FULL
           HELIUM INERTING/PRESSURIZATON, 8 LBM/HR
 &JOBDAT  NPROP(1) = 1, NPRESS(1) = 1,
  KTCHK=2,
  GPGM(1) = .0001 , 1.E10,
  TKVOL(1) =  22.,
  P(1) =  25.,
  TVNTPGM(1,1) = 10. , 1.E10,
  TVNTPGM(1,2) = 10. , 1.E10,
  TVRATE(1) = 0.05,0.175,
  XMSFRAC(1)=0.99999,
  OUTPGM(1,1)= 0.,120.,70.00,150.,0.,1.E10,
  HETMPG(1)=500.,1.E9,
  PRSPGM(1,1)=45.,150.,5.,1.E10,
  PRATE(1)=2.,
  PLOTT = 1.,
  DPTV(1) = 4., 4.,
  TEND =810.0,
  TSN =0.5, TSX =5.000,
  DTMPMAX = 1.,
  NDTX = 2,
  TPF(1) = 30.,120.,5.,150.,60.,810.,
  NQPF = 10,
  ISTST = 1,      &END
 *NODE
  LIQ-1,  7,  40.000,23.50,  2,  1
  LIQ-2,  7,  40.000, 23.5000 ,  1,  1
  GAS-1,  6,  40.000, .2,  1,  1
  TANK-A,  4,  36.392,  .001
  TANK-B,  4,  36.474,  .001
  TANK-C,  4,  36.565,  .001
  TANK-D,  4,  36.511,  .001
  TANK-E,  4,  36.718,  .001
  TANK-F,  4,  37.057,  .001
  VCS-A,  4,  90.0,  .001
  VCS-B,  4, 120.0,  .001
  VCS-C,  4, 130.0,  .001
  VCS-D,  4, 140.0,  .001
  VCS-E,  4, 145.0,  .001
  VCS-F,  4, 140.0,  .001
  MLI-A,  5,  360.,  .001
  MLI-B,  5,  370.,  .001
  MLI-C,  5,  370.,  .001
  MLI-D,  5,  371.,  .001
  MLI-E,  5,  373.,  .001
  MLI-F,  5,  377.,  .001
  VAC-JKT,  0 ,530.000
  BOT-PEN-A1,    3,   34.0, .0001
  BOT-PEN-B1,    3,   44.0, .0001
  BOT-PEN-2 ,    3,  154.0, .0001
  TOP-PEN-1,     3,  104.0, .0001
  TOP-PEN-2,     3,  164.0, .0001
  BOT-PEN-3 ,    3,  454.0, .0001
  SUPPT-A,       11, 144.0, 0.001
  SUPPT-B,       11, 144.0, 0.001
  TORSLINK ,     11,  44.0, 0.3
  HX-1-1,  120,   37.000,  40., .1175,  .001,  4,  1,  7.5,  1,  0.
  HX-1-1A, 120,   37.000,   5., .1175,  .001,  4,  1,  7.5,  1,  0.
  HX-1-2,  120,   97.000,  36.0,  .1175,  .001,  4,  1
```

```
HX-1-3,  120,  137.000,  144., .1175,  .001,  4,  1
HX-1-4,  120,  137.000,  72.,  .1175,  .001,  4,  1
HX-1-5,  120,  157.000,  12.,  .1175,  .001,  4,  1
HX-2-1,  120,   37.000,  4.0,  .1175,  .001,  4,  2,  7.5,  1,  0.
HX-2-2,  120,  107.000,  8.0,  .1175,  .001,  4,  2
HX-2-3,  120,  137.000,  36.0,  .1175,  .001,  4,  2
HX-2-4,  120,  137.000,  144., .1175,  .001,  4,  2
HX-2-5,  120,  137.000,  72.,  .1175,  .001,  4,  2
HX-2-6,  120,  437.000,  12.,  .1175,  .001,  4,  2
HX-2-7,  120,  437.000,  12.,  .1175,  .001,  4,  2
*CONDUCTOR
LIQ-1,  LIQ-2,  7,  5.277,  0.579,  1
LIQ-2,  GAS-1,  6,  5.277,   0.29,  1
TANK-A,  LIQ-1,  7, 6.33010, .80000,  1
TANK-B,  LIQ-2,  7, 6.33010, .80000,  1
TANK-C,  LIQ-2,  7, 6.33010, .80000,  1
TANK-D,  LIQ-2,  7, 6.33010, .80000,  1
TANK-E,  GAS-1,  6, 6.33010, .80000,  1
TANK-F,  GAS-1,  6, 6.33010, .80000,  1
TANK-A,  TANK-B,  4,  .0305,  1.
TANK-B,  TANK-C,  4,  .03975,  .9
TANK-C,  TANK-D,  4,  .0409,  .75
TANK-D,  TANK-E,  4,  .03975,  .9
TANK-E,  TANK-F,  4,  .0305,  1.
VCS-A,  VCS-B,  4,  .0129,  1.043
VCS-B,  VCS-C,  4,  .0168,  .939
VCS-C,  VCS-D,  4,  .01727,  .7824
VCS-D,  VCS-E,  4,  .0168,  .939
VCS-E,  VCS-F,  4,  .0129,  1.043
MLI-A,  VCS-A,  5,  7.18,  .0521
MLI-B,  VCS-B,  5,  7.18,  .0521
MLI-C,  VCS-C,  5,  7.18,  .0521
MLI-D,  VCS-D,  5,  7.18,  .0521
MLI-E,  VCS-E,  5,  7.18,  .0521
MLI-F,  VCS-F,  5,  7.18,  .0521
VAC-JKT,  MLI-A,  5,  7.68,  .0521
VAC-JKT,  MLI-B,  5,  7.68,  .0521
VAC-JKT,  MLI-C,  5,  7.68,  .0521
VAC-JKT,  MLI-D,  5,  7.68, .0521
VAC-JKT,  MLI-E,  5,  7.68,  .0521
VAC-JKT,  MLI-F,  5,  7.68,  .0521
VAC-JKT,  SUPPT-A, 11, 0.0179,   .26
SUPPT-A,  TANK-C , 11, 0.0179,   .07
VAC-JKT,  SUPPT-B, 11, 0.0179,   .26
SUPPT-B,  TANK-D , 11, 0.0179,   .07
BOT-PEN-2,    BOT-PEN-B1,  3,     0.00108,     0.75
BOT-PEN-B1,  TANK-A,       4,     0.04   ,     1.0
BOT-PEN-2,    BOT-PEN-A1,  3,     0.00108,     0.75
BOT-PEN-A1,  TANK-A,       4,     0.0565 ,     1.0
HX-2-6     ,  HX-2-5 ,     4,     0.000116,    0.67
HX-1-5     ,  HX-1-4 ,     4,     0.000116,    0.42
VAC-JKT    ,  HX-1-5 ,     4,     0.000116,    1.30
TOP-PEN-1 ,  HX-2-2 ,      4,     0.003   ,    0.17
TOP-PEN-1 ,  TANK-F ,      3,     0.00085 ,     0.21
TOP-PEN-2 ,  TOP-PEN-1,    3,     0.00085 ,     0.5
VAC-JKT    ,  TOP-PEN-2,   3,     0.00085 ,     1.3
TOP-PEN-2,   HX-1-5,       4,     0.003   ,    0.17
SUPPT-B  ,   VCS-D  ,     12,     0.0004,       .229
SUPPT-A  ,   VCS-C  ,     12,     0.0004,       .229
BOT-PEN-B1,  HX-2-1,       4,     0.002   ,    0.04
BOT-PEN-A1,  HX-1-1,       4,     0.208   ,    0.0833
VCS-D,  TANK-D,  11,  .11  ,  1.0
VCS-C,  TANK-C,  11,  .11  ,  1.0
VCS-A,  TANK-A,  11,  .05  ,  1.0
VCS-A,  TANK-A,  99,  .25
VCS-B,  TANK-B,  99,  .25
VCS-C,  TANK-C,  99,  .25
VCS-D,  TANK-D,  99,  .25
VCS-E,  TANK-E,  99,  .25
VCS-F,  TANK-F,  99,  .25
```

```
VCS-A,  HX-1-2,  4,  .12000,  .25000
VCS-C,  HX-1-3,  4,  .12000,  .25000
VCS-E,  HX-1-4,  4,  .12000,  .25000
VCS-F,  HX-2-3,  4,  .12000,  .25000
VCS-D,  HX-2-4,  4,  .12000,  .25000
VCS-B,  HX-2-5,  4,  .12000,  .08300
HX-2-2, HX-2-3,  4,  .000116,       1.
HX-2-6, BOT-PEN-2,  4,   0.002,      0.17
BOT-PEN-A1,  TORSLINK ,    4,       0.017,    0.6
HX-1-1A   ,  TORSLINK ,    4,       0.030,    0.042
VAC-JKT   ,  TORSLINK ,   11,       0.007,    0.300
VAC-JKT ,BOT-PEN-3,  3,    0.000108,        .625
BOT-PEN-3 ,BOT-PEN-2,  3,    0.000108,        .625
HX-2-7, BOT-PEN-3,  4,   0.002,      0.17
HX-2-7, VAC-JKT  ,  4,   0.00116,    1.00
HX-2-7, HX-2-6   ,  4,   0.00116,    1.00
*END
EOF
/space/cryolib/crcsam  model
ja   -sclf  #  GET ACCOUNTING INFO
```

APPENDIX D

SUBROUTINE DESCRIPTIONS

SUBROUTINE DESCRIPTIONS

MAIN PROGRAM (No. 0)

The **Main Program** calls on a subroutine to initialize data values and then calls on the menu subroutines for the model definition.

SUBROUTINE CLEARS (no. 01)

Called from various routines.

Subroutine to clear the terminal screen. This routine calls the system dependent subroutine CLEAR.

CALL CMSCMD('VMFCLEAR', 16, IRT)

CALL CLEAR

SUBROUTINE READAL (No. 02)

Called from various routines.

Subroutine to read the input responses from the user and do some validity checks.

READAL...Read n alphabetic characters, n= 1,2,3

This routine has additional entry points:

ENTRY READLC...Read alphabetic characters, no test.

ENTRY READIN...Read integer and test upper and lower bounds.

ENTRY READRE...Read a real number, test for alphabetic characters

SUBROUTINE DOJCL(COMAND) (No. 03)

Called from MAIN, INDAT2 and INSERT.

Subroutine to execute VM system JCL commands from inside a FORTRAN program.

This routine is system dependent; see note above.

This routine calls "CALL SYSCMD(COMAND,IRC)".

SUBROUTINE BLHDRS (No. 04)

Called from SINTRU, CONDRS, SNBLKS, NODES.

Read SINDA block header information and write block headers for each SINDA block.

This subroutine has 14 entry points.

ENTRY BLHDRS
ENTRY RDTITL
ENTRY BLOTTL
ENTRY BL1TTL
ENTRY BL2TTL
ENTRY BL3TTL
ENTRY BL4TTL
ENTRY BL5TTL
ENTRY BL6TTL
ENTRY BL7TTL
ENTRY BL8TTL
ENTRY BL9TTL
ENTRY BLKEND
ENTRY ENDDAT

SUBROUTINES (No. 05)

Called from VMINTR.

A collection of routines (programs) that will be executed interactively on VM from within the system.

SUBROUTINE INITAL (no. 1)

Called from the MAIN.

Subroutine to initialize common data blocks.

SUBROUTINE MENU1 (No. 2)
Called from MAIN.
This subroutine has the user specify the problem type. The problem types are:
1. Thermal/Thermo analysis on a sphere (SINDA).
2. Thermal/Thermo analysis on a cylinder (SINDA).
3. Run an analysis program without generating a SINDA model for the two geometries described above.
This subroutine may need to be changed as new capabilities are added to the program.

SUBROUTINE MENU2 (No. 3)
Called from MAIN.
This subroutine requests input from the user to specify the analysis program that is to be executed, based on the problem type input in MENU1.
This subroutine will need to be changed as new capabilities are added to the program.

SUBROUTINE SINTRU (No. 4)
Called from MAIN.
This subroutine is used to define the geometric regions and then to generate the SINDA model.

SUBROUTINE GETJCL (No. 41)
Called from SINTRU, NOSIND, INDAT1.
Subroutine to obtain CRAY JCL information from the user and then to write this JCL as file 1 on unit 10 (model file).
The other entry points are called from SINTRU and NOSIND to generate the JCL file for the application requested by the user. The entry points are:

ENTRY RITJCL
ENTRY RITJC2
ENTRY RITJC3

If a different computer system is used this subroutine must be changed to reflect the proper JCL of the system used.

SUBROUTINE NOCHRS (No. 411)
Called from GETJCL, NODES.
This subroutine has 2 entry points.

ENTRY NOCHRS
ENTRY NBCD

Entry NOCHRS computes the number of characters in a character string.
Entry NBCD converts an integer into character form.

SUBROUTINE TOLOWC (No. 412)
Called from GETJCL.
Converts character data to lower case.

SUBROUTINE REGN1 (No. 42)
Called from SINTRU.
This subroutine calls the proper subroutine to get region 1 information for the proper geometry.

SUBROUTINE SFEERE (No. 421)
Called from REGN1.
Reads data to define region 1 of a sphere

SUBROUTINE CYLNDR (No. 422)
Called from REGNI.
Reads the measurements for a cylindrical tank.

SUBROUTINE RGNGNL (No. 423)
Called from REGN1, RGN2T5.
Subroutine to input general information for each region: region width, temperature, material, number of layers through the region.

SUBROUTINE MATMNU (No. 4231)
Called from RGNGNL, RGN2T5, SPLINP.
Displays a menu of materials and prompts the user for a material number for each defined region.

SUBROUTINE RGN2T5 (No. 43)
Called from SINTRU.
This subroutine prompts the user to obtain input data to define regions 2, 3, 4 and 5 of the spherical or cylindrical geometry.

SUBROUTINE ULLINP (No. 431)
Called from RGN2T5, ULLGET.
This subroutine prompts the user for ullage information, such as where the ullage is positioned in the tank and what percent of the tank is filled with liquid.
There are 2 entry points in this subroutine.
ENTRY ULLINP
ENTRY ULLIN2

SUBROUTINE ULLGET (No. 432)
Called from RGN2T5, SPHNDS.
If there is ullage in the tank determine where the ullage is and which nodes are ullage and which are liquid.

SUBROUTINE CUBIC (No. 4321)
Called from ULLGET.
Finds the real roots of a cubic equation.

SUBROUTINE READHX (No. 433)
Called from RGN2T5.
This subroutine reads in heat exchanger information if there are any. There may be up to 10 heat exchangers in the model.

SUBROUTINE NODES (No. 44)
Called from SINTRU.
This subroutine calls the proper routines to generate diffusion nodes for the SINDA model. This routine then generates arithmetic and boundary nodes.

SUBROUTINE SPHNDS (No. 441)
Called from NODES.
Subroutine to generate node data on a sphere.

SUBROUTINE SETUPA (No. 4411)
Called from SPHNDS.
Setup data for arithmetic nodes. Checks for heat exchangers; then puts out arithmetic nodes to SINDA model file.

SUBROUTINE SPHDIF (No. 4412)
Called from SPHNDS.
Compute diffusion nodes for all nlay layers of a spherical wedge.

SUBROUTINE ULLCHK (No. 44121)
Called from SPHDIF, RADCON, CIRCON.
Checks the type of ullage for region NR and computes where it starts; i.e. when ct='1', at which theta angle, counting from the south pole, does the ullage start for the current layer LN.

When ct='c', is the current layer ullage or not.

SUBROUTINE CYLNDS (no. 442)
Called from NODES.
Calls one of the following subroutines to generate nodes.
FEND to generate the nodes for a flat end.
SEND to generate the nodes for a spherical end.
FEND to generate the nodes for an elliptical end.
CYLSEC to generate the nodes in the cylindrical section.

SUBROUTINE FEND (No. 4421)
Called from CYLNDS.
Subroutine to generate the nodes for a flat end.

SUBROUTINE SEND (No. 4422)
Called from CYLNDS.
Subroutine to generate the nodes for a spherical end.

SUBROUTINE FEND (no. 4423)
Called from CYLNDS.
Subroutine to generate nodes for an elliptical end.

SUBROUTINE CYLSEC (No. 4424)
Called from CYLNDS.
Subroutine to generate nodes in the cylindrical section.

SUBROUTINE RITNDS (No. 443)
Called from NODES, SPHDIF, FEND, SEND, EEND, CYLSEC, SETUPA.
Writes the node lines to the SINDA model file.

SUBROUTINE SRCDAT (No. 45)
Called from SINTRU.
This subroutine generates the source data block of the SINDA model.

SUBROUTINE AREASP(No. 451)
Called from SRCDAT, SNBLKS, CIRCON, SPHDIF, SPHCDS.
Computes areas on a sphere.
The call parameter NAREA determines which type of area.
If NAREA=1, computes radial area, surface areas.
If NAREA=2, computes circumferential area.

SUBROUTINE CONDRS (No. 46)
Called from SINTRU.
This subroutine calls on the sphere or cylinder conductor generation routine.

SUBROUTINE SPHCDS (No. 461)
Called from CONDRS.
Generates all conductor data for a spherical wedge.

SUBROUTINE RADCON (No. 4611)
Called from SPHCDS
Generates radial conductor data for sphere wedge.

SUBROUTINE SETARY (No. 46111)
Called from RADCON.
Checks for vapor nodes in conductor data and sets switches NYA and NYB equal to 0 or to 200 to change the property table array numbers for a node. This is only done when NR >= 4 and NLGR=1.

SUBROUTINE CIRCON (No. 4612)
Called from SPHCDS.
Generates circumferential conductor for sphere wedge

SUBROUTINE RITCND (No. 4613)
Called from SPHCDS, RADCON, CIRCON, CYLALL, FCND, SCND, ECND.
Writes conductor cards to SINDA model file, unit 10.

SUBROUTINE CYLCDS (No. 462)
Called from CONDRS.
Calls one of the following subroutines to generate conductors:
FCND to generate the conductors for a flat end.
SCND to generate the conductors for a spherical end.
ECND to generate the conductors for an elliptical end.
CYLALL to generate the conductors for the cylinderical section.

SUBROUTINE HXARR (No. 4621)
Called from CYLCDS.
Generates all conductors that involve a heat exchanger.

SUBROUTINE CYLALL (No. 4622)
Called from CYLCDS.
Generates all conductors in the cylindrical section.

SUBROUTINE FCND (No. 4623)
Called from CYLCDS.
Generates all conductors in a flat end.

SUBROUTINE SCND (No. 4624)
Called from CYLCDS.
Generates all conductors in a spherical end.

SUBROUTINE ECND (No. 4625)
Called from CYLCDS.
Generates all conductors in an elliptical end.

SUBROUTINE SNBLKS (No. 47)
Called from SINTRU.
This subroutine reads SINDA constants data.
Generates the constants, array, execution, Variables 1, Variables 2 and output blocks in the SINDA model and writes these blocks to the model file, unit 10.

SUBROUTINE SPLINP (No. 471)
Called from SNBLKS.
Subroutine to read special input data for analyses where ntyp=1 or 2, and regns(4)=false. This data is fluid data inside the tank where the analysis program is solving the thermo problem and there are no SINDA nodes. The data that is prompted for are:
Liquid temperature
Vapor temperature
Liquid flow rate
Liquid fill level, percent full.

SUBROUTINE AREACY (No. 472)
Called from SNBLKS, FCND, CYLSEC, ECND, SCND.
Computes areas on a cylinder.
The call parameter NAREA determines which type of area. If NAREA=1, compute radial area, surface areas. If NAREA=2, compute circumferential area.

SUBROUTINE PRPTBL (No. 473)
Called from SNBLKS.
Put property tables into array data block.

SUBROUTINE MATUSR (No. 4731)
Called from PRPTBL.
Subroutine that gives the user the choice of creating his/her own property.

SUBROUTINE INSERT (No. 474)
Called from SNBLKS.
Subroutine to insert the source code of fluid subroutines into the SINDA model. This is done by:
Filedefing the proper unit using DOJCL.
This file will be called 'CRYOSUBS "XCUT1"'.
This source file must be LRECL=80, RECFM=F
Then open fortran unit 59 on that file.
Read 59 and write into MODU (unit 10).

SUBROUTINE GEOPLT (No. 48)
Called from SINTRU.
This subroutine controls the calls to the plotting routines to produce geometry plots of the SINDA models. This is not for plots of the analysis output, only the geometry. If the geometry is a sphere this routine calls subroutine PLTSPH. If the geometry is cylindrical subroutine PLTCYL is called.

SUBROUTINE PLTSPH (No. 481)
Called from GEOPLT.
Plots the geometry generated for a sphere.

SUBROUTINE PLTCYL (No. 482)
Called from GEOPLT.
Plots the geometry generated for a cylinder

SUBROUTINE VMINTR (No. 5)
Called from MAIN.
This subroutine is the entry to execute analysis routines on VM interactively.
This subroutine must be changed whenever a new interactive analysis program is added to the system.
The names of these programs will be added to the array MAINM and the corresponding value in array NSRUNN will be set =2. For these programs the output will go to both the screen and a disk file named "program output", fortran unit 17.

SUBROUTINE NOSIND (No. 6)
Called from MAIN.
This subroutine sets up the CRAY JCL in a file and then submits it to CRAY to execute an analysis program that is prestored on the CRAY as part of this system.

SUBROUTINE INDAT1 (No. 61)
Called from NOSIND.
Subroutine to get input data for an analysis program. This subroutine has two entry points:
ENTRY INDAT1
ENTRY INDAT2
Entry indat1 interrogates the user as to the source of the input data. If the data is on CRAY, write an access to this data in the model file.
Entry INDAT2 is called if the data is on VM or if the data is to be typed in at the terminal. In this case the data is written inline into the model file.

DISSPLA
Called from PLTSPH, PLTCYL.
Plotting package on the LeRC VM computer used to plot sphere and cylinder SINDA models.

APPENDIX E

CryoTran Program Listings

Part I CRYOTRAN FORTRAN

```
C0OMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
      PROGRAM CRTRAN
CCC   PROGRAM CRYOTRAN, A PROGRAM TO
CCC   READ INPUT DATA,  DETERMINE GEOMETRY TYPE.
CCC   THE INPUT DATA IS ECHOED TO FORTRAN UNIT INPEKO
CCC        FILENAME -  CRYOTRAN INPUTEKO
CCC   GENERATE A SINDA MODEL ON UNIT   MODU. NMOD SET BELOW.
CCC   INCLUDING CALLS TO SUBROUTINES FROM EXECUTION BLOCK,
CCC   VARIABLES 1, VARIABLES 2, AND OUTPUT BLOCKS.
CCC   OR GENERATE A RUNSTREAM TO RUN AN ANALYSIS PROGRAM WITHOUT
CCC   A SINDA THERMAL ANALYSIS.
CCC   A LIBRARY OF SUBROUTINES WILL RESIDE ON CRAY.
CCC   THIS LIBRARY WILL CONTAIN ONLY SUBROUTINES, NO MAIN PROGRAMS.
CCC   THE MAIN PROGRAM FOR ANY ANALYSIS WILL BE GENERATED EITHER BY
CCC   THIS PROGRAM OR BY THE SINDA PREPROCESSOR.
CCC
CCC   THIS PROGRAM MAY BE ACCESSED AND PUT INTO EXECUTION BY
CCC   LINKING TO THE D DISK OF USERLIB CRYOLIB, AND THEN
CCC   INVOKING THE VM EXEC 'RUNCRYO', AS FOLLOWS:
CCC     LINK CRYOLIB 200 NNN RR        (NNN MAY BE ANY NO. THE USER
CCC     ACCESS NNN M                         DOES NOT HAVE DEFINED)
CCC     RUNCRYO              (ON THE ACCESS NNN MUST BE THE "M" DISK)
CCC
CCC   USER MAY EDIT THE SINDA MODEL AT ANY TIME TO TAILOR IT TO A
CCC   A SPECIFIC NEED; TO ADD A CAPABILITY NOT AVAILABLE IN
CCC   THIS PROGRAM; OR TO RUN PARAMETRIC STUDIES.
CCC
CCC   A FORTRAN CALL TO CLEAR THE SCREEN 'CALL CLEAR' IS USED IN
CCC   THIS PROGRAM. THIS ROUTINE IS ON THE AMDAHL/VM SYSTEM AT LERC.
CCC   THIS ROUTINE, (CLEAR), IS CALLED FROM A SUBROUTINE IN THIS
CCC   PROGRAM CALLED CLEARS, (CLEAR SCREEN).
CCC   ON ANOTHER SYSTEM THAT DOES NOT HAVE THIS ROUTINE THE USER
CCC   MAY COMMENT OUT THE CALL TO CLEAR IN SUBROUTINE CLEARS,
CCC   OR ACCESS A SUBSTITUTE ROUTINE.
CCC   TO USE AT LERC, USER MUST DO 'FTNLIB' PRIOR
CCC   TO LOAD IN ORDER TO ACCESS THE ROUTINE;
CCC   OR DO  'ADDLIB FTNLIB', (LERC LOCAL COMMAND).
CCC   SEE VM EXEC 'RUNCRYO'
CCC
CCC NOTE:  CALL SYSCMD ... USED IN SUBROUTINE DOJCL (C03)
CCC                                    AND     MAIN  (0)
CCC   IS A LOCAL LERC SUBROUTINE TO PERFORM VM JCL REQUESTS FROM
CCC   INSIDE A FORTRAN PROGRAM.
CCC   ON ANOTHER SYSTEM THAT DOES NOT HAVE THIS ROUTINE THE USER
CCC   MAY COMMENT OUT THE CALL TO SYSCMD IN SUBROUTINE DOJCL,
CCC   OR ACCESS A SUBSTITUTE ROUTINE.
CCC
CCC  MAIN PROGRAM
C
      CALL MAINPG
      CALL PLTDUN
      STOP
      END
      SUBROUTINE MAINPG
      COMMON/GEOMTY/ NTYP,NAN,GEOM(2)
      COMMON/UNITS/ MODU, INPEKO, ISCRCH, SINDA
      COMMON/SUBRTS/ SPLIPT, XCUT1,XCUT2,VBLBL1,VBLBL2,OUTBLK
C
      LOGICAL SPLIPT
      LOGICAL SINDA
C
      CHARACTER*1 YN
      CHARACTER*6 XCUT1,XCUT2,VBLBL1,VBLBL2,OUTBLK,MAINNM
      CHARACTER*12 EXMOD
      CHARACTER*20 FNFTFM
      CHARACTER*27 CHGN1, CHGN2, CHGN3
      CHARACTER*47 RENAME
C
      DATA CHGN1/'RENAME CRYOTRAN INPUTEKO A '/
      DATA CHGN2/'RENAME CRYOTRAN MODEL A    '/
```

```
      DATA CHGN3/'RENAME PROGRAM OUTPUT A    '/
C
C   CALL SUBROUTINE ERRSET TO SUPPRESS ERROR MESSAGES FOR ERROR
C   NO. 108. THIS ERROR OCCURS WHEN A  NONEXESTENT VM FILE IS
C   SPECIFIED AS A DATA FILE WHEN RUNNING A TYPE 3 PROGRAM
C   (A PRESTORED PROGRAM ON THE CRAY). SEE VS FORTRAN VERSION 2
C   LANGUAGE AND LIBRARY REFERENCE, IBM SC26-4221-2,  PAGE 311.
C
      CALL ERRSET(108,256,-1,1,1,109)
C
CALL        INITIALIZE COMMON BLOCKS                          INITAL (1)
    1 CALL INITAL
C
CALL        GET PROBLEM TYPE FROM MENU 1                      MENU1   (2)
      CALL MENU1
C
CALL  GET ANALYSIS SUBROUTINE (VARIABLES 1 OR STAND ALONE)  MENU2 (3)
      CALL MENU2(NRUNON)
      EXMOD='SINDA'
      IF(NTYP .EQ. 3) THEN
        EXMOD(1:6)= XCUT2
        EXMOD(7:12)=VBLBL1
      ENDIF
C
      IF(SINDA)THEN
CALL                                                          SINTRU (4)
        CALL SINTRU
C
        CALL CLEARS
        PRINT 2010
        PRINT 2011
C   CLOSE UNIT MODU, REWIND, AND EXIT PREPRO PROGRAM.
        PRINT 2012
        PRINT 2013, EXMOD
        PRINT 2050
        PRINT 2060
      ELSE
        IF(NRUNON .EQ. 2) THEN
          MAINNM=XCUT1
CALL                                                          VMINTR (5)
          CALL VMINTR(MAINNM)
          PRINT 2020
          PRINT 2015
CALL                                                          READAL (02)
          CALL READAL(1,YN)
          IF(YN .EQ. 'N') THEN
            GO TO 999
          ELSE
            GO TO 997
          ENDIF
        ELSE
CALL                                                          NOSIND (6)
          CALL NOSIND(NRUNON)
        ENDIF
C
        CALL CLEARS
        PRINT 2010
        PRINT 2012
      ENDIF
      ENDFILE MODU
      REWIND MODU
C   GO TO TOP OR STOP????
  998 PRINT 2015
CALL                                                          READAL (02)
      CALL READAL(1,YN)
  997 IF(YN .EQ. 'Y') THEN
        CALL CLEARS
        PRINT 2016
        PRINT 2017
        CALL READAL(1,YN)
```

```
      IF(YN .EQ. 'Y') THEN                                              CRY01410
        PRINT 20181                                                     CRY01420
        PRINT 2017                                                      CRY01430
        CALL READAL(1,YN)                                               CRY01440
        IF(YN .EQ. 'Y') THEN                                            CRY01450
          PRINT 2019                                                    CRY01460
          CALL READAL(3,FNFTFM)                                         CRY01470
          RENAME=CHGN1//FNFTFM                                          CRY01480
C   CLOSE UNIT INPEKO, REWIND, CHANGE NAME                              CRY01490
          ENDFILE INPEKO                                                CRY01500
          REWIND INPEKO                                                 CRY01510
          CALL DOJCL(RENAME)                                            CRY01520
        ENDIF                                                           CRY01530
        IF(NRUNON .EQ. 1) THEN                                          CRY01540
          CALL CLEARS                                                   CRY01550
          PRINT 20182                                                   CRY01560
          PRINT 2017                                                    CRY01570
          CALL READAL(1,YN)                                             CRY01580
          IF(YN .EQ. 'Y') THEN                                          CRY01590
            PRINT 2019                                                  CRY01600
            CALL READAL(3,FNFTFM)                                       CRY01610
            RENAME=CHGN2//FNFTFM                                        CRY01620
C   CLOSE UNIT MODU, REWIND, CHANGE NAME                                CRY01630
            CALL DOJCL(RENAME)                                          CRY01640
          ENDIF                                                         CRY01650
        ENDIF                                                           CRY01660
        IF(NRUNON .EQ. 2) THEN                                          CRY01670
          CALL CLEARS                                                   CRY01680
          PRINT 20183                                                   CRY01690
          PRINT 2017                                                    CRY01700
          CALL READAL(1,YN)                                             CRY01710
          IF(YN .EQ. 'Y') THEN                                          CRY01720
            PRINT 2019                                                  CRY01730
            CALL READAL(3,FNFTFM)                                       CRY01740
            RENAME=CHGN3//FNFTFM                                        CRY01750
C   CLOSE UNIT INPEKO,(17),  PROGRAM OUTPUT, CHANGE NAME                CRY01760
            ENDFILE INPEKO                                              CRY01770
            CALL DOJCL(RENAME)                                          CRY01780
          ENDIF                                                         CRY01790
        ENDIF                                                           CRY01800
      ENDIF                                                             CRY01810
      GO TO 1                                                           CRY01820
    ENDIF                                                               CRY01830
    CALL CLEARS                                                         CRY01840
    PRINT 2011                                                          CRY01850
    PRINT 2012                                                          CRY01860
    PRINT 2013, EXMOD                                                   CRY01870
    PRINT 2050                                                          CRY01880
    PRINT 2060                                                          CRY01890
    IF(NTYP .EQ. 3 .AND. NAN .EQ. 4) PRINT 2061, EXMOD                  CRY01900
    IF(SINDA) THEN                                                      CRY01910
      EXMOD='SINDA MODEL'                                               CRY01920
      PRINT 2062, EXMOD                                                 CRY01930
    ENDIF                                                               CRY01940
  999 RETURN                                                            CRY01950
C                                                                       CRY01960
C  FORMATS                                                              CRY01970
C                                                                       CRY01980
 2005 FORMAT('     NOW GET INPUT DATA FOR THE SELECTED ANALYSIS PROGRAM'/CRY01990
     1       '     IS THE ANALYSIS INPUT DATA:'/                        CRY02000
     2       '     1  STORED ON THE CRAY COMPUTER.'/                    CRY02010
     3       '     2  STORED ON THE VM COMPUTER.'/                      CRY02020
     4       '     3  TO BE TYPED IN NOW.'/                             CRY02030
     5       '     TYPE IN  1,  2,  OR  3')                             CRY02040
 2010 FORMAT('     END OF CRYOTRAN PREPROCESSOR PROGRAM,')              CRY02050
 2011 FORMAT('      ON TO ANALYSIS PROGRAM')                            CRY02060
 2012 FORMAT('     THE OUTPUT FILE IS CALLED "CRYOTRAN MODEL".')        CRY02070
 2013 FORMAT('     THIS "CRYOTRAN MODEL" FILE IS A ',A12,' MODEL.')     CRY02080
 2015 FORMAT(/'    DO YOU WANT TO GO TO BEGINNING OF CRYOTRAN OR  QUIT?'/CRY02090
     1       '       TYPE  Y  TO GO BACK TO BEGINNING OF CRYOTRAN,'/    CRY02100
```

```
     2        '    OR TYPE  N  TO QUIT CRYOTRAN.')
 2016 FORMAT('  BEFORE CONTINUING YOU MAY WANT TO CHANGE THE NAME'/
     1  '  OF SOME OF THE OUTPUT FILES. IF YOU DO NOT CHANGE THE NAME'/
     2  '  OF THE MODEL FILE, THE NEW MODEL OUTPUT OF THE NEW RUN'/
     3  '  WILL OVERWRITE THE MODEL OUTPUT OF THE PREVIOUS RUN.'//
     4  '  DO YOU WANT TO CHANGE THE NAME OF ANY OF YOUR OUTPUT'/
     5  '  FILES FROM THIS RUN BEFORE CONTINUING?')
 2017 FORMAT(/'      TYPE IN   Y   OR   N')
20181 FORMAT('    CHANGE THE NAME OF THE FILE    "CRYOTRAN INPUTEKO"?')
20182 FORMAT('    CHANGE THE NAME OF THE FILE    "CRYOTRAN MODEL"?')
20183 FORMAT('    CHANGE THE NAME OF THE FILE    "PROGRAM OUTPUT"?')
 2019 FORMAT(/' TYPE IN THE NEW    FILE NAME;  FILE TYPE;  FILE MODE'/
     1   '  YOU MUST TYPE IN ALL THREE PARTS OF NAME       FN FT FM')
 2020 FORMAT(/'    INTERACTIVE PROGRAM ',A6, 'COMPLETED')
 2050 FORMAT(//'     USER MAY NOW SUBMIT THE FILE   "CRYOTRAN MODEL"'/
     1        '      TO THE CRAY COMPUTER FOR EXECUTION,'/
     2   '      OR MAKE ANY DESIRED MODIFICATIONS WITH AN EDITOR'/
     3   '      PRIOR TO SUBMITTING IT TO THE CRAY.')
 2060 FORMAT(//'     TO SUBMIT THE FILE TO CRAY,'/
     1   '      ON THE VM SYSTEM TYPE:       CRSUBMIT CRYOTRAN MODEL')
 2061 FORMAT(//'   UPON COMPLETION OF THE CRAY EXECUTION OF ',A12/
     1        '   USER MAY PLOT THESE RESULTS BY TYPING:'//
     2        '                   DOECLPLT SOLA PLOTFILE')
 2062 FORMAT(//'   IF USER HAS REQUESTED A GEOMETRY PLOT OF THE ',A12/
     1        '   THE PLOT DATA IS IN FILE NAMED  "QMS PLOTDATA" '//
     2        '   USER MAY PLOT THESE RESULTS BY TYPING:    PLOTQA')
      END
C01SSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSS
      SUBROUTINE CLEARS
C                                   CALLED FROM VARIOUS ROUTINES
C  SUBROUTINE TO CLEAR THE TERMINAL SCREEN
C  THIS ROUTINE IS SYSTEM DEPENDENT; SEE NOTE IN MAIN PROGRAM.
C
C     CALL CMSCMD('VMFCLEAR        ',16,IRT)
C
      CALL CLEAR
      RETURN
      END
C02SSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSS
      SUBROUTINE READAL(N,ALF)
CALLED FROM                                   VARIOUS ROUTINES
C   SUBROUTINE TO READ THE INPUT FROM USER
C   DO SOME VALIDITY CHECKING
C
C     N = 1  ALPHABETIC  1  CHARACTER
C     N = 2  ALPHABETIC  N  CHARACTERS
C     N = 3  ALPHABETIC  N  CHARACTERS NO CHECKING FOR Q,
C            AND CONVERT TO LOWER CASE. CALLED VIA ENTRY  READLC
C
      COMMON/UNITS/ MODU, INPEKO, ISCRCH, SINDA
C
      CHARACTER*(*) ALF, ALF2
      CHARACTER*1  ALFIN(25), ALFLC(25), INTLO, INTHI
      CHARACTER*25  ALPHA, ALOWC
C
      EQUIVALENCE (ALPHA,ALFIN(1)), (ALOWC,ALFLC(1))
C
      DATA INTLO/'0'/,  INTHI/'9'/
C
      M=N
      GO TO 10
      ENTRY READLC(ALF,ALF2)
C  READ N ALPHABETIC CHARACTERS, NO CHECK FOR Q, CONVERT TO LOWER CASE.
      M=3
   10 GO TO (100,200,200),M
C  1 CHARACTER ALPH INPUT
  100 READ(5,1001)ALFIN
      WRITE(INPEKO,1001) ALFIN(1)
      IF(ALFIN(1) .EQ. 'Q') GO TO 999
      ALF=ALFIN(1)
```

```
      RETURN
  200 CONTINUE
C   N  CHARACTER ALPHABETIC, TEST THAT INPUT IS NOT BLANK
  210 READ(5,1001)ALFIN
      IF(ALFIN(1) .EQ. 'Q' .AND. ALFIN(2) .EQ. ' ' .AND. M .NE. 3)THEN
        GO TO 999
      ENDIF
      IF(ALPHA .EQ. ' ') THEN
        PRINT 2001
        GO TO 210
      ENDIF
      WRITE(INPEKO,1001) ALFIN
      ALF=ALPHA
      IF(M .EQ. 3) THEN
        call tolowc(25,alpha,alowc)
        ALF2=ALOWC
      ENDIF
      RETURN
C
      ENTRY READIN(INT,LL,LU)
C  READ INTEGER AND TEST UPPER AND LOWER BOUNDS
  310 READ(5,1001) ALFIN
      IF(ALFIN(1) .EQ. 'Q') GO TO 999
      DO 315 I=1,25
      IF(ALFIN(I) .EQ. ' ') GO TO 315
      IF(ALFIN(I) .LT. INTLO .OR. ALFIN(I) .GT. INTHI) THEN
        PRINT 3001,ALPHA,LL,LU
        PRINT 3000
        GO TO 310
      ENDIF
  315 CONTINUE
      REWIND ISCRCH
      WRITE(ISCRCH,1001)ALFIN
      REWIND ISCRCH
      READ(ISCRCH,*) INT
      IF(INT .LT. LL .OR. INT .GT. LU) THEN
        PRINT 3001,INT,LL,LU
        PRINT 3000
        GO TO 310
      ENDIF
      WRITE(INPEKO,*) INT
      RETURN
C
      ENTRY READRE(VAL)
C  READ REAL NUMBER   TEST FOR ALPHEBETIC CHARACTERS
  410 READ(5,1001) ALFIN
      IF(ALFIN(1) .EQ. 'Q') GO TO 999
      DO 415 I=1,25
      IF(ALFIN(I) .EQ. ' ') GO TO 415
      IF(ALFIN(I) .EQ. '.') GO TO 415
      IF(ALFIN(I) .EQ. '+') GO TO 415
      IF(ALFIN(I) .EQ. '-') GO TO 415
      IF(ALFIN(I) .EQ. 'E') GO TO 415
      IF(ALFIN(I) .LT. INTLO .OR. ALFIN(I) .GT. INTHI) THEN
        PRINT 3002,ALPHA,ALFIN(I),I
        PRINT 3000
        GO TO 410
      ENDIF
  415 CONTINUE
      REWIND ISCRCH
      WRITE(ISCRCH,1001)ALFIN
      REWIND ISCRCH
      READ(ISCRCH,*) VAL
      WRITE(INPEKO,*) VAL
      RETURN
C
  999 CALL CLEARS
      PRINT 2015
      READ(5,1001)ALFIN
      IF(ALFIN(1) .EQ. 'Q') THEN
```

```
        STOP
      ELSE
        REWIND MODU
        REWIND INPEKO
        CALL MAINPG
      ENDIF
C  FORMAT STATEMENTS
C
 1001 FORMAT(25A1)
 2001 FORMAT(/'  *** ERROR'/
     1        '   THE INPUT TYPED IN IS BLANK, IT MUST NOT BE BLANK.'/
     2        '   RETYPE THE LAST INPUT.')
 2015 FORMAT(///'   DO YOU REALLY WANT TO QUIT CRYOTRAN?  OR'/
     1        '    GO BACK TO THE BEGINNING OF THE PROGRAM?'//
     2        '      TYPE  Q  TO QUIT CRYOTRAN,'/
     3        '  OR TYPE  Y  TO GO BACK TO BEGINNING OF CRYOTRAN ')
 3000 FORMAT( '   RE-ENTER THIS NUMBER.')
 3001 FORMAT(/'  *** ERROR'/
     1        '   INPUT VALUE OUT OF RANGE, INPUT VALUE = ',A25/
     2        '   THIS INPUT VALUE MUST BE AN INTEGER BETWEEN ',I4,
     3        ' AND ',I4)
 3002 FORMAT(/'  *** ERROR'/
     1        '   INPUT VALUE CONTAINS AN ILLEGAL CHARACTER'/
     2        '   THIS INPUT VALUE MUST BE A REAL NUMBER'/
     3        '   THE INPUT VALUE = ',A25/
     4        '   THE ILLEGAL CHARACTER IS  ',A1,'  AT POSITION ',I2)
      END
C03SSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSS
      SUBROUTINE DOJCL(COMAND)
CALLED FROM     MAIN (00)     INDAT2 (61)      INSERT (474)
C  SUBROUTINE TO EXECUTE VM SYSTEM JCL COMMANDS FROM INSIDE FORTRAN
C  THIS ROUTINE IS SYSTEM DEPENDENT; SEE NOTE IN MAIN PROGRAM.
C
      CHARACTER* (*) COMAND
      CALL SYSCMD(COMAND,IRC)
        WRITE(6,*) 'JCL COMMAND - IRC=',COMAND,IRC
      RETURN
      END
C04SSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSS
      SUBROUTINE BLHDRS
CALLED  FROM                                           SINTRU  (4)
CALLED  FROM                                           NODES   (44)
CALLED  FROM                                           CONDRS  (46)
CALLED  FROM                                           SNBLKS  (47)
C  SUBROUTINE TO READ INFO FOR SINDA MODEL BLOCK HEADERS
C  AND TO WRITE THE SINDA MODEL BLOCK HEADERS, OTHER BLOCK INFO
C  AND END STATEMENTS.
C
      COMMON /REGION/ NTHETA,NBETAS,BETA,RIN,TVOL,ROUT(9),
     1                REGNS(9),NLAYRS(9),TEMPS(9),THICK(9),
     2                THKLAY(9),MATRLS(9),MATNMS(9),RGNNMS(9)
      COMMON/UNITS/ MODU, INPEKO, ISCRCH, SINDA
      COMMON/TITL / TITLE,TITLE0
      COMMON/GEOMTY/ NTYP,NAN,GEOM(2)
C
      LOGICAL REGNS,SINDA
C
      CHARACTER*16  MATNMS
      CHARACTER*25  RGNNMS
      CHARACTER*8  GEOM
      CHARACTER*50 TITLE0
      CHARACTER*80 TITLE
      CHARACTER*40 TITL1,TITL2
      CHARACTER    BLANK
C
      EQUIVALENCE (TITL1,TITLE), (TITL2,TITLE(41: ))
      DATA BLANK/' '/
C
      RETURN
C
```

```
C04AEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE
C
      ENTRY RDTITL
C  READ TITLE FOR SINDA BLOCK 0
C
C
C  GET THE TITLE LINE
      CALL CLEARS
    9 PRINT 1998
      READ(5,1001,ERR=10,END=10)  TITLE
      WRITE(INPEKO,1001)  TITLE
      RETURN
C
   10 PRINT 1111
 1111 FORMAT('  ERROR MADE IN INPUTTING THE TITLE, TRY AGAIN')
      GO TO 9
C04BEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE
      ENTRY BL0TTL
C
C BLOCK 0,  ID BLOCK
C
C        WRITE BLANK CARD, ID BLOCK, NODE BLOCK TITLE CARDS
C
      WRITE(MODU,2001)
      WRITE(MODU,20011)
      WRITE(MODU,20012) GEOM(NTYP),TITLE0
      WRITE(MODU,20013) BETA
      WRITE(MODU,2002)  TITL1,TITL2
      WRITE(MODU,3000)
      RETURN
C
C04CEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE
      ENTRY BL1TTL
C  WRITE TITL FOR BLOCK 1, NODE DATA BLOCK
      WRITE(MODU,2101)
      WRITE(MODU,2102) MATNMS(9)
      RETURN
C
C04DEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE
      ENTRY BL2TTL
C  WRITE TITL FOR BLOCK 2, SOURCE DATA BLOCK
      WRITE(MODU,2201)
      RETURN
C04EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE
      ENTRY BL3TTL
C WRITE TITL FOR BLOCK 3,  CONDUCTOR DATA BLOCK
C
      WRITE  (MODU,2301)
      RETURN
C04FEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE
      ENTRY BL4TTL
C  WRITE TITL FOR BLOCK 4, CONSTANTS DATA BLOCK
      WRITE(MODU,2401)
      RETURN
C
C04GEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE
      ENTRY BL5TTL
C  WRITE TITL FOR BLOCK 5, ARRAY DATA BLOCK
      WRITE(MODU,2501)
      RETURN
C04HEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE
      ENTRY BL6TTL
C WRITE TITL FOR BLOCK 6,  EXECUTION DATA BLOCK
C
      WRITE (MODU,2601)
      RETURN
C04IEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE
      ENTRY BL7TTL
C  WRITE TITL FOR BLOCK 7, VARIABLES 1 BLOCK
      WRITE(MODU,2701)
```

```
      RETURN
C
C04JEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE
      ENTRY BL8TTL
C  WRITE TITL FOR BLOCK 8, VARIABLES 2 BLOCK
      WRITE(MODU,2801)
      RETURN
C04KEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE
      ENTRY BL9TTL
C WRITE TITL FOR BLOCK 9,  OUTPUT BLOCK
C
      WRITE  (MODU,2901)
      RETURN
C04LEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE
      ENTRY BLKEND
C  ENTRY TO WRITE END --  FOR END OF BLOCK.
C
      WRITE(MODU,3000)
      RETURN
C04MEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE
C   WRITE END OF DATA LINE
C
      ENTRY ENDDAT
      WRITE(MODU,3001)
      RETURN
C
C  FORMAT STATEMENTS
C
 1001 FORMAT(A80)
C
 1998 FORMAT(///'    NOW A TITLE FOR THIS PROBLEM.'//
     1        '    THE TITLE LINE MAY BE UP TO 80 CHARACTERS LONG.'/
     2        '    TYPE IN THE TITLE.')
C
 2001 FORMAT(80X   /
     1        7X, 'BCD 3THERMAL LPCS')
20011 FORMAT('C',6X, 'REM  THIS SINDA MODEL WAS GENERATED BY CRYOTRAN')
20012 FORMAT('C',6X, 'REM  ',A8,' --- ',A50)
20013 FORMAT('C',6X, 'REM  ',10X,'WEDGE ANGLE-BETA =',F4.1,' RADIANS')
 2002 FORMAT(7X, 'BCD 9',A40/7X, 'BCD 9',A40)
 2101 FORMAT(7X, 'BCD 3NODE DATA    ')
 2102 FORMAT(7X, 'REM  NODE TEMPERATURES ARE IN (DEG ',A1,')'/
     1        7X, 'REM  DIMENSIONS ARE IN (IN.),  TIME IS IN (SECS)')
 2201 FORMAT(7X, 'BCD 3SOURCE DATA ')
 2301 FORMAT(7X, 'BCD 3CONDUCTOR DATA')
 2401 FORMAT(7X, 'BCD 3CONSTANTS DATA  ')
 2501 FORMAT(7X, 'BCD 3ARRAY DATA    ')
 2601 FORMAT(7X, 'BCD 3EXECUTION     ')
 2701 FORMAT(7X, 'BCD 3VARIABLES 1')
 2801 FORMAT(7X, 'BCD 3VARIABLES 2')
 2901 FORMAT(7X, 'BCD 3OUTPUT CALLS')
 3000 FORMAT(7X, 'END')
 3001 FORMAT(7X,'BCD 3END OF DATA')
      END
C1SSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSS
      SUBROUTINE INITAL
CALLED FROM                                              MAIN (00)
C   SUBROUTINE TO INITIALIZE COMMON DATA BLOCKS
C
      COMMON/TITL / TITLE,TITLEO
      COMMON/GEOMTY/ NTYP,NAN,GEOM(2)
      COMMON/UNITS/ MODU, INPEKO, ISCRCH, SINDA
      COMMON /REGION/ NTHETA,NBETAS,BETA,RIN,TVOL,ROUT(9),
     1                REGNS(9),NLAYRS(9),TEMPS(9),THICK(9),
     2                THKLAY(9),MATRLS(9),MATNMS(9),RGNNMS(9)
      COMMON/STUFF/ NHTT,PI,CONVY,CONVR,THETAO,DTHETA,NBASOS,ROUTSF,
     1  BNCOEF(2)
      COMMON/ULLAGE/ NLUL4,NLUL5,NTHU41,RINMHH,PCTFUL,RADULG,TVULFT,
     1              CT,LG(3),LIQVAP(3)
      COMMON /HTXGRS/ NHX,HXTEMP(10),NRHX(10),NLHX(10),
```

```
     1                NTHHX(10),LNGTHX(10)
      COMMON/SUBRTS/ SPLIPT, XCUT1,XCUT2,VBLBL1,VBLBL2,OUTBLK
C
      LOGICAL REGNS,SINDA
      LOGICAL SPLIPT
C
      CHARACTER*1   CT,LG
      CHARACTER*6   LIQVAP
      CHARACTER*6   XCUT1, XCUT2, VBLBL1, VBLBL2, OUTBLK
      CHARACTER*8   GEOM
      CHARACTER*16  MATNMS
      CHARACTER*25  RGNNMS
      CHARACTER*50  TITLE0
      CHARACTER*80  TITLE
C
C   SET UNIT NUMBER FOR MODU, MODEL OUTPUT UNIT.
      MODU=  10
      INPEKO= 9
      ISCRCH=35
C
C USE UNIT ISCRCH, (35) AS A SCRATCH FILE FOR INPUT TESTING
C  AND FORMAT CONVERSION IN SUBROUTINE READAL
C
C   UNIT NO. 36 IS USED IN SUBROUTINES INSERT AND INDAT1.
C   THIS UNIT IS USED TO READ DATA FROM A VM FILE,
C    USER WILL BE ASKED THE NAME OF THE FILE, PROGRAM THEN
C    DOES A FILEDEF ON THAT FILE, THEN OPENS THE FILE AS UNIT 36.
C    THE CLOSE IS DONE WHEN THE READ IS COMPLETED.
C
      PI=3.14159265
      TITLE0='             '
      TITLE ='             '
      NTHETA=0
      THETA0=PI/2.
      NBETAS=1
      BETA=1.
      RIN=0.
      DO 10 I=1,9
      REGNS(I)=.FALSE.
      NLAYRS(I)=0
      MATRLS(I)=0
      ROUT(I)=0.0
      THICK(I)=0.0
      TEMPS(I)=0.0
      MATNMS(I)='        '
      RGNNMS(I)='        '
   10 CONTINUE
C
      BNCOEF(1)=0.0
      BNCOEF(2)=0.0
C
C   INITIALIZE REGION NAMES IN ARRAY RGNNMS(I)
      RGNNMS(1)='TANKWALL'
      RGNNMS(2)='OUTSIDE LAYER 1'
      RGNNMS(3)='OUTSIDE LAYER 2'
      RGNNMS(4)='INSIDE TANK AT WALL'
      RGNNMS(5)='INSIDE TANK AT CENTER'
C
C  INITIALIZE ULLAGE VARIABLES
C
      LG(1)='L'
      LG(2)=' '
      LG(3)='G'
      LIQVAP(1)='LIQUID'
      LIQVAP(2)=' '
      LIQVAP(3)='VAPOR'
      NLUL4=0
      NLUL5=0
      NTHU41=0
      PCTFUL=0.0
```

```
      CT=' '
C
C   INITIALIZE HEAT EXCHANGER COMMON BLOCK TO 0.0
C
      NHX=0
      DO 30 I=1,10
      HXTEMP(I)=0.0
      NRHX(I)  =0
      NLHX(I)  =0
      NTHHX(I) =0
      LNGTHX(I)=0
   30 CONTINUE
C
C  INITIALIZE SUBROUTINE NAMES COMMON BLOCK TO BLANKS
C
      XCUT1=' '
      XCUT2=' '
      VBLBL1=' '
      VBLBL2=' '
      OUTBLK=' '
C
      GEOM(1)='SPHERE'
      GEOM(2)='CYLINDER'
C
      RETURN
      END
C2SSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSS
      SUBROUTINE MENU1
CALLED FROM                                             MAIN (00)
C  THIS SUBROUTINE MAY NEED TO BE CHANGED AS
C  NEW CAPABILITIES ARE ADDED TO THE PROGRAM.
C
C  MAIN MENU -- MENU FOR PROBLEM TYPE -- CALLED FROM MAIN
C
      COMMON/UNITS/ MODU, INPEKO, ISCRCH, SINDA
      COMMON/GEOMTY/ NTYP,NAN,GEOM(2)
C
      CHARACTER*8   GEOM
C
      LOGICAL SINDA, LTEST
C
      DATA  NTYPES /3/
C
  100 CALL CLEARS
      PRINT 2000
  200 PRINT 2001
      PRINT 2002
      PRINT 2003
      PRINT 2004
      CALL READIN(NTYP,1,NTYPES)
      SINDA=.TRUE.
      IF(NTYP .EQ. 3) SINDA=.FALSE.
      RETURN
C  FORMATS
 2000 FORMAT(//'   WELCOME TO CRYOTRAN'/
     1          '   YOU WILL BE PROMPTED FOR ALL NECESSARY INPUT.'/
     2          '   READ THE INSTRUCTIONS CAREFULLY.'/
     3          '   TYPE IN THE INPUT DATA CAREFULLY TO AVOID TROUBLE,'/
     4          '   YOU MAY QUIT THE PROGRAM AT ANY INPUT PROMPT BY',
     5          ' TYPING A  "Q"  (QUIT)')
 2001 FORMAT(///'  ENTER THE NUMBER FOR THE DESIRED PROBLEM TYPE'/
     1 '    THE PROBLEM TYPES ARE AS FOLLOWS:')
 2002 FORMAT(/'  1 -  THERMO/THERMAL SINDA ANALYSIS ON A SPHERE.')
 2003 FORMAT('  2 -  THERMO/THERMAL SINDA ANALYSIS ON A CYLINDER.')
 2004 FORMAT('  3 -  RUN A PRESTORED ANALYSIS PROGRAM')
 2050 FORMAT('***** ERROR, THE PROBLEM TYPE YOU INPUT IS OUT OF RANGE'/
     1  '*****  PROBLEM TYPE MUST BE FROM 1 TO ',I3/
     2  '***** RE-ENTER PROBLEM TYPE *****')
      END
C3SSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSS
```

```
      SUBROUTINE MENU2(NRUNON)
CALLED FROM                                                        MAIN (00)
C
C  THIS SUBROUTINE WILL NEED TO BE CHANGED AS
C  NEW CAPABILITIES ARE ADDED TO THE PROGRAM.
C
C   MENU 2 ANALYSIS SUBROUTINES
C
C  FOR NTYP, (FROM MENU1), = 1,2;  A SINDA MODEL WILL BE GENERATED.
C                    NTYP= 1  (SPHERE)
C                    NTYP= 2  (CYLINDER)
C  FOR NTYP                 = 3  NO SINDA MODEL GENERATED BY THIS PROGRAM.
C  THE CURRENT ANALYSIS PROGRAMS ARE:
C   ANALT1 OR ANALT5 = 1
C             A SINDA MODEL OF A 1 RADIAN WEDGE.
C             UP TO 5 REGIONS MAY BE DEFINED.
C             REGIONS 4 AND 5 ARE USUALLY LIQUID OR VAPOR
C             AND ARE FULLY NODALIZED WITH SINDA NODES. CURRENTLY
C             THESE REGIONS HAVE CONDUCTION CONNECTORS, BUT
C             CONVECTION CONNECTORS WILL BE ADDED SO THAT ONE MAY
C             HAVE CONDUCTION ONLY, CONVECTION ONLY, OR BOTH
C             CONDUCTION AND CONVECTION IN REGIONS 4 AND 5.
C   ANALT1 OR ANALT5 = 2
C             A SINDA MODEL OF A 1 RADIAN WEDGE.
C             ONLY REGIONS 1, 2, AND 3 WILL BE NODALIZED WITH SINDA
C             NODES. REGIONS 4 AND 5 ARE NOT MODELED WITH SINDA
C             NODES, BUT ARE MODELED BY ANALYTICAL SUBROUTINES.
C             THESE SUBROUTINES ARE CALLED FROM THE EXECUTION AND
C             VARIABLES 1 AND 2 BLOCKS IN SINDA.
C             THE WRITER OF THESE ANALYTICAL ROUTINES IS SUPPLIED
C             WITH THE FOLLOWING COMMON BLOCKS AND ARRAYS.
C             COMMON/USER1/ NTHETA, NBETAS, NTUNIT, BETA, RIN, TNKVOL
C             COMMON/USER2/ TIMEO, DTIMEU, FFLOW, TLIQ, TGAS
C             COMMON/INSA /SARIN (NN), INSIDE TANK SURFACE AREA, INPUT
C             COMMON/OUTSA/SAROUT(NN), OUTSIDE SURFACE AREA, INPUT
C             COMMON/SURFT/TSURF (NN), INSIDE TANK SURFACE TEMP, INPUT
C             COMMON/BNDYT/TBDY  (NN), TANK LIQ OR VAP TEMP, OUTPUT
C             COMMON/HTRCO/HCOEF (NN), HEAT TR COEFF, NOT SURE NEEDED
C             COMMON/SURFG/GSURF (NN), TANK TO SURF G VALUE, OUTPUT
C             COMMON/SURFQ/QSURF (NN), INSIDE SURF Q, OUTPUT
C                            WHERE NN IS THE DIMENSION  NTHETA
C
C  PRESENTLY THE PROGRAM IS SETUP TO HANDLE UP TO 15 ANALYSIS
C  PROGRAMS (NAN)  FOR EACH OF THE SIX(6) GEOMETRIES BELOW
C
C  NTYP=1   (SPHERE)
C  ANALT1 - NAN= 1-15 - SPHERE MODELED BY WEDGES, RADIAL MESH,       2D
C  ANALT2 - NAN=15-30 - SPHERE MODELED BY WEDGES, RADIAL MESH,       3D
C  ANALT3 - NAN=31-45 - SPHERE MODELED BY WEDGES, RECTANGULAR MESH, 2D
C  ANALT4 - NAN=46-60 - SPHERE MODELED BY WEDGES, RECTANGULAR MESH, 3D
C
C  NTYP=2   (CYLINDER)
C  ANALT5 - NAN= 1-15 - CYLINDER WEDGE MODEL,      RADIAL MESH,      2D
C  ANALT6 - NAN=16-30 - CYLINDER WEDGE MODEL,      RADIAL MESH,      3D
C
C  ANALNS -- A CANNED ANALYSIS PROGRAM WITHOUT SINDA.
C
C  ANALT5, 6 -- ARE CYLINDER MODELS, HAVING A MESH OF WEDGES
C              RADIALLY AND TOP TO BOTTOM,
C              A 3D MODEL WOULD BE A SERIES OF WEDGES CIRCUMFERENTIALLY
C       WHERE USER CAN SPECIFY ANY COMBINATIONS OF
C            SPHERICAL ENDS
C            SQRT2 ELLIPTICAL ENDS
C            FLAT ENDS
C            OPEN ENDS
C
C  THE GEOMETRY MAY BE DEFINED BY AS MANY AS 5 REGIONS AS FOLLOWS:
C   REGION 1. TANK WALL
C          2. A LAYER ON OUTSIDE OF TANK WALL; E.G. INSULATION
C          3. A 2ND LAYER OUTSIDE, ON TOP OF REGION 2.
```

```
C         4. THE FIRST LAYER INSIDE OF THE TANK, ADJACENT TO
C            THE TANK WALL. (SEE DESCRIPTION BELOW)
C         5. THE 2ND LAYER INSIDE OF THE TANK, MEASURED FROM
C            LAYER 4 TOWARD THE CENTER OF THE TANK.
C            (SEE DESCRIPTION BELOW)
C       THE INSIDE OF THE TANK IS DETERMINED BY THE ANALYSIS ROUTINE.
C       SOME ANALYSIS ROUTINES WILL HAVE THE INTERIOR OF THE TANK
C       NODALIZED WITH SINDA NODES, SOME WILL NOT. THIS IS SPECIFIED
C       BY THE VARIABLE  REG45. IF REG45 = TRUE, THE INTERIOR WILL BE
C       NODALIZED; IF REG45 = FALSE, THE INTERIOR WILL NOT BE NODALIZED
C       AND THE THERMODYNAMICS OF THE INTERIOR OF THE TANK WILL BE
C       COMPLETELY MANAGED BY THE ANALYSIS SUBROUTINES.
C       WHEN THE INSIDE OF THE TANK IS DEFINED, (NODALIZED), IT MAY BE
C       1 OR 2 REGIONS. THESE ARE DEFINED AS REGIONS 4 AND 5.
C       REGION 5 IS OPTIONAL. REGION 4 MAY BE DEFINED ALONE
C       OR BOTH REGIONS 4 AND 5 MAY BE DEFINED. THIS MAY BE USED TO
C       DEFINE 2 DIFFERENT MATERIALS INSIDE OF TANK, OR, IN ORDER TO
C       HAVE TWO MESH SPACINGS OF A SINGLE MATERIAL INSIDE OF THE TANK
C       IN THE RADIAL DIRECTION.
C
C
C   REG45 IS A LOGICAL VARIABLE SUCH THAT,
C   REG45(I,J)= .TRUE. IF THE CORRESPONDING ANALT(J)(I) IS AN
C   ANALYSIS ROUTINE THAT WANTS THE INSIDE OF THE TANK (REGIONS 4 & 5),
C   TO BE NODALIZED WITH SINDA NODES.
C   REG45(I,J)= FALSE IF NO SINDA NODES ARE NEEDED FOR THE CORRESPONDING
C   ANALT(J)(I).
C
C  GLOBAL VARIABLES DEFINED IN COMMON STATEMENTS
C
      COMMON/UNITS/ MODU, INPEKO, ISCRCH, SINDA
      COMMON/TITL / TITLE,TITLEO
      COMMON/GEOMTY/ NTYP,NAN,GEOM(2)
      COMMON /REGION/ NTHETA,NBETAS,BETA,RIN,TVOL,ROUT(9),
     1                REGNS(9),NLAYRS(9),TEMPS(9),THICK(9),
     2                THKLAY(9),MATRLS(9),MATNMS(9),RGNNMS(9)
      COMMON/SUBRTS/ SPLIPT, XCUT1,XCUT2,VBLBL1,VBLBL2,OUTBLK
C
      LOGICAL SPLIPT
      LOGICAL REGNS
C
      CHARACTER*8  GEOM
      CHARACTER*50 TITLEO
      CHARACTER*80 TITLE
      CHARACTER*16  MATNMS
      CHARACTER*25  RGNNMS
      CHARACTER*6 XCUT1, XCUT2, VBLBL1, VBLBL2, OUTBLK
C
C  LOCAL VARIABLES
C
      LOGICAL SINDA
      LOGICAL REG45(15,6)
      LOGICAL SPECIN(15,2)
C
      CHARACTER*50 ANALT1(15),ANALT2(15),ANALT3(15),ANALT4(15)
      CHARACTER*50 ANALT5(15),ANALT6(15),ANALNS(15)
      CHARACTER*6 EXEC1(15,6), EXEC2(15,6), VBL1(15,6),
     1           VBL2(15,6), OUT(15,6), MAINNM(15)
      CHARACTER*1 INP
C
      DIMENSION NSRUNM(15)
C
C  NTYP WILL BE = 1 (SPHERE), 2 (CYLINDER) OR 3(NO SINDA)
C   COMBINATION OF VARIABLES  (NTYP AND NAN) WILL DETERMINE
C   THE GEOMETRY AND MESH TO BE GENERATED.
C
C  DATA FOR NTYP=1, SPHERE
      DATA ANALT1/'2D WEDGE WITH INSIDE OF TANK NODALIZED',
     2           '2D WEDGE SHELL - NO NODES INSIDE OF TANK',
     3           '2D WEDGE SHELL - THICK WALL FILL ANALYSIS',
```

```
     G          12*' '/
      DATA ANALT2/ 15*' '/
      DATA ANALT3/ 15*' '/
      DATA ANALT4/ 15*' '/
      DATA NALT1/3/, NALT2/0/, NALT3/0/, NALT4/0/
      DATA (SPECIN(I,1),I=1,15)/.FALSE.,.FALSE.,.TRUE., 12* .FALSE./
C
C  DATA FOR NTYP=2, CYLINDER
      DATA ANALT5/'2D WEDGE WITH INSIDE OF TANK NODALIZED',
     2            '2D WEDGE SHELL - NO NODES INSIDE OF TANK',
     G          13*' '/
      DATA ANALT6/ 15*' '/
      DATA NALT5/2/, NALT6/0/
      DATA (SPECIN(I,2),I=1,15)/ 15* .FALSE./
C
C  DATA STATEMENT FOR REGIONS 4 AND 5,REG45(1,N),N=1,2,3,4 (SPHERE)
C                                    REG45(1,N),N=5,6     (CYLINDER)
C  IF REGIONS 4/5 ARE NODALIZED WITH SINDA NODES, REG45=TRUE
C  IF REGIONS 4/5 ARE NOT NODALIZED WITH SINDA NODES, REG45=FALSE
      DATA REG45 /   .TRUE., .FALSE., .FALSE., 12*.FALSE.,
     2             15*.FALSE.,
     3             15*.FALSE.,
     4             15*.FALSE.,
     5               .TRUE., .FALSE., 13*.FALSE.,
     6             15*.FALSE./
C
C
C  NAMES OF ANALYSIS SUBROUTINES FOR SINDA RUNS TO BE CALLED FROM
C  EXECUTION, VARIABLES, AND OUTPUT BLOCKS
C  THESE ROUTINES ARE IN FILES ON THE VM COMPUTER AND ARE COPIED
C  INTO THE BLOCKS (INTO THE MODEL) BY THE SYSTEM. THEY WILL THEN
C  BE COMPILED WITH THE GENERATED SINDA ROUTINES AND EXECUTED.
C  THEY ARE IN THE MODEL SO THE USER MAY MODIFY THEM IF DESIRED.
C
      DATA EXEC1/ '      ', '      ', 'THWSE1', 12*' ',
     2            15*' ',
     3            15*' ',
     4            15*' ',
     5            '      ', '      ', 13*' ',
     6            15*' ' /
C
      DATA EXEC2/ '      ', '      ', 'THWSE2', 12*' ',
     2            15*' ',
     3            15*' ',
     4            15*' ',
     5            15*' ',
     6            15*' ' /
C
C
      DATA VBL1 / '      ', '      ', 'THWSV1', 12*' ',
     2            15*' ',
     3            15*' ',
     4            15*' ',
     5            '      ', '      ', 13*' ',
     6            15*' ' /
C
      DATA VBL2 / '      ', '      ', 'THWSV2',12*' ',
     2            15*' ',
     3            15*' ',
     4            15*' ',
     5            '      ', '      ', 13*' ',
     6            15*' ' /
C
      DATA OUT / '      ', '      ', 'THWSOU',12*' ',
     2            15*' ',
     3            15*' ',
     4            15*' ',
     5            '      ', '      ', 13*' ',
     6            15*' ' /
C
```

```
C
C  DATA STATEMENTS THAT NEED TO BE CHANGED WHEN A NEW PROGRAM OF
C  NTYP = 3 IS ADDED TO THE SYSTEM. THAT IS A PROGRAM PRESTORED
C  ON CRAY OR VM.
C  DATA FOR NTYP=3, SPECIAL PROGRAMS
C
      DATA ANALNS/'NOVENT FILL', 'CHILL TO TEMP', 'TARGET FOR NVFILL',
     1             'SOLA-ECLIPSE',      'CSAM',      10*' '/
      DATA  NALNS/5/
C
C
C
C  NAMES OF NOSINDA ANALYSIS 'MAIN' SUBROUTINES
C  AND WHICH COMPUTER THEY ARE DESIGNED TO RUN ON.
C  IF  NSRUNM  = 1    RUN ON CRAY
C                2    RUN ON VM IN INTERACTIVE MODE,
C                      BY MEANS OF A SUBROUTINE CALL FROM  NOSIND.
C                3    RUN ON VM IN BATCH MODE,
C                      BY MEANS OF CALL TO SUB DOJCL.
C
      DATA MAINNM/'NVFILL', 'CHILL', 'TARGET',
     2             'SOLECL', 'CRCSAM',
     3          10*' '/
      DATA NSRUNM/ 2, 2, 2, 1, 1,  10*0/
C
      CALL CLEARS
      SPLIPT=.FALSE.
      PRINT 2001
      PRINT 2002
      IF(SINDA) THEN
      IF(NTYP .EQ. 1) THEN
        IF(NALT1 .GT. 0)  PRINT 2003,(I    ,ANALT1(I),I=1,NALT1)
        IF(NALT2 .GT. 0)  PRINT 2003,(I+15,ANALT2(I),I=1,NALT2)
        IF(NALT3 .GT. 0)  PRINT 2003,(I+30,ANALT3(I),I=1,NALT3)
        IF(NALT4 .GT. 0)  PRINT 2003,(I+45,ANALT4(I),I=1,NALT4)
      ENDIF
      IF(NTYP .EQ. 2) THEN
        IF(NALT5 .GT. 0)  PRINT 2003,(I    ,ANALT5(I),I=1,NALT5)
        IF(NALT6 .GT. 0)  PRINT 2003,(I+15,ANALT6(I),I=1,NALT6)
      ENDIF
      ELSE
         PRINT 2003,(I     ,ANALNS(I),I=1,NALNS)
      ENDIF
      NRUNON=0
      CALL READIN(NAN,1,60)
C  FOR NTYP=1  SPHERE  ALL MODELS ARE WEDGES
C              MESHING  RAD = RADIALLY   RECT = RECTANGULAR
C                   2D-RAD     3D-RAD     2D-RECT    3D-RECT
C
C              _________  _________  _________  _________
C              I        I I        I I        I I        I
C    NAN       = 1,2,...,15;16,...,30;31,...,45;46,...,  60; ...
C    NC WILL BE =     0,          1,          2,          3
C    NANAL     =     1,          2,          3,          4
C    NPROG     =1,2,...,15
C  FOR NTYP=2  CYLINDER   ALL MODELS ARE WEDGES
C                   2D-RAD     3D-RAD
C
C              _________  _________
C              I        I I        I
C    NAN       = 1,2,...,15;16,...,30; ...
C    NC WILL BE =     0,          1
C    NANAL     =     5,          6
C    NPROG     =1,2,...,15
C
      NC=NAN/16
      NANAL=NC+1
      IF(NTYP .EQ. 2) NANAL=NANAL+4
      NPROG=NAN-NC*15
C  PUT ANALTNAN INTO TITLEO
      IF(NANAL .EQ. 1) TITLEO=ANALT1(NPROG)
      IF(NANAL .EQ. 2) TITLEO=ANALT2(NPROG)
```

```
      IF(NANAL .EQ. 3) TITLE0=ANALT3(NPROG)
      IF(NANAL .EQ. 4) TITLE0=ANALT4(NPROG)
      IF(NANAL .EQ. 5) TITLE0=ANALT5(NPROG)
      IF(NANAL .EQ. 6) TITLE0=ANALT6(NPROG)
C  SET BETA=1 RADIAN  AND NBETAS=1  FOR VERSION 1.0 OF PROGRAM
      IF(NC .EQ. 0) THEN
        BETA=1.0
        NBETAS=1
      ENDIF
      IF(SINDA) THEN
        XCUT1=EXEC1(NPROG,NANAL)
        XCUT2=EXEC2(NPROG,NANAL)
        VBLBL1=VBL1(NPROG,NANAL)
        VBLBL2=VBL2(NPROG,NANAL)
        OUTBLK=OUT(NPROG,NANAL)
        SPLIPT=SPECIN(NAN,NTYP)
      ELSE
        XCUT1=MAINNM(NAN)
        XCUT2=ANALNS(NAN)(1:6)
        VBLBL1=ANALNS(NAN)(7:12)
      ENDIF
      NRUNON=1
      IF(NTYP .EQ. 3) NRUNON=NSRUNM(NAN)
C
C INITIALIZE ARRAY REGNS TO .FALSE.; SET REGNS(4) FROM DATA REG45
C
      REGNS(1)=.FALSE.
      IF(SINDA) REGNS(1)=.TRUE.
      REGNS(2)=.FALSE.
      REGNS(3)=.FALSE.
      REGNS(4)=REG45(NPROG,NANAL)
      REGNS(5)=.FALSE.
      RETURN
C  FORMAT STATEMENTS
 1001 FORMAT(A1)
 2001 FORMAT(///'      CHOOSE THE ANALYSIS PROGRAM YOU WISH TO USE.')
 2002 FORMAT('      TYPE IN THE NUMBER OF THE DESIRED ANALYSIS.')
 2003 FORMAT(I6,     4X,A50)
      END
C4SSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSS
      SUBROUTINE SINTRO
CALLED FROM                                                MAIN (00)
C  SUBROUTINE TO DEFINE THE GEOMETRIC REGIONS, THEN GENERATE
C  THE SINDA MODEL.
C
      COMMON/GEOMTY/ NTYP,NAN,GEOM(2)
C
      CHARACTER*8   GEOM
CALL      GET THE TITLE LINE RDTITL (04)
      CALL RDTITL
CALL      GET CRAY JCL INFO                               GETJCL (41)
      CALL GETJCL(UNICOS)
CALL      WRITE CRAYJCL TO UNIT MODU                      RITJCL (41)
      CALL RITJCL
      CALL RITJC2
CALL                                                      REGN1 (42)
      CALL REGN1
CALL                                                      RGN2T5 (43)
      CALL RGN2T5
CALL                                                      BLOTTL (04)
      CALL BLOTTL
C                                                         NODES (44)
      CALL NODES

C                                                         SRCDAT (45)
      CALL SRCDAT
C                                                         CONDRS (46)
      CALL CONDRS
C                                                         SNBLKS (47)
      CALL SNBLKS
```

```
C                                                          RITJC4 (41)
      CALL RITJC4(0)
C                                                          GEOPLT (48)
      CALL GEOPLT
      RETURN
      END
C41SSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSS
      SUBROUTINE GETJCL(UNICOS)
CALLED FROM                                                SINTRU (4)
C
C   SUBROUTINE TO GET JCL INFO FROM USER AND THEN TO WRITE THE
C     JCL AS FILE 1 ON UNIT 10 (MODEL FILE) TO EXECUTE PROBLEM.
C
C   GET CRAY UID, ETC. TO GENERATE CRAY JCL FILE
C
C   IF A DIFFERENT COMPUTER SYSTEM IS USED THIS SUBROUTINE
C    MUST BE CHANGED TO REFLECT THE PROPER JCL OF THE SYSTEM USED.
C
C   THIS ROUTINE HAS 2 ENTRY POINTS,
C   THE DATA THEN CAN REMAIN LOCAL.
C
      COMMON/UNITS/ MODU, NPEKO, ISCRCH, SINDA
      COMMON/SUBRTS/ SPLIPT, XCUT1,XCUT2,VBLBL1,VBLBL2,OUTBLK
C
      LOGICAL SPLIPT
      LOGICAL SINDA
      LOGICAL UNICOS
C
      CHARACTER*6 XCUT1, XCUT2, VBLBL1, VBLBL2, OUTBLK
      CHARACTER*15 CRAUID,CRAAPW,JOBNAM
      CHARACTER*15 UIDLC, APWLC, JNAMLC
      CHARACTER*15 FILNAM, FILNLC
      CHARACTER*2  NCBCD
      CHARACTER*1  YN
      CHARACTER*48 FMTJOB, FMTACC
C
      DATA FMTJOB/'(''JOB,JN='',A7,'',T='',I8,'',MFL='',I7,''.'')  '/
      DATA FMTACC/'(''ACCOUNT,AC='',A15,'',APW='',A15,''.'')         '/
C
  101 CALL CLEARS
      PRINT 2000
      PRINT 2006
      CALL READAL(1,YN)
      UNICOS=.FALSE.
      IF(YN .EQ. 'U') UNICOS=.TRUE.
      call clears
  111 PRINT 2001
      CALL READLC(CRAUID,UIDLC)
  115 PRINT 2002
      CALL READLC(CRAAPW,APWLC)
      PRINT 2003
      CALL READIN(KRATIM,1,99999)
      IF(KRATIM .LE. 10) KRATIM=60
      KRAMFL=1500000
      IF(SINDA) THEN
        PRINT 2004
        CALL READIN(KRAMFL,1,4000000)
      ENDIF
      IF(KRAMFL .LT. 1500000) KRAMFL=1500000
  119 PRINT 2005
      CALL READLC(JOBNAM,JNAMLC)
      CALL CLEARS
      IF(UNICOS) THEN
        PRINT 1996,UIDLC,APWLC,KRATIM,KRAMFL,JNAMLC
      ELSE
        PRINT 1996,CRAUID,CRAAPW,KRATIM,KRAMFL,JOBNAM
      ENDIF
      CALL READAL(1,YN)
      IF(YN .EQ. 'N') GO TO 101
      RETURN
```

```
C41AEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE         CRY11210
C   ENTRY TO WRITE THE FIRST PART OF CRAY JCL TO UNIT 10, FILE 1        CRY11220
CALLED FROM                                              SINTRU(4)      CRY11230
CALLED FROM                                              NOSIND(6)      CRY11240
      ENTRY RITJCL                                                      CRY11250
      REWIND MODU                                                       CRY11260
      IF(UNICOS) THEN                                                   CRY11270
C   CRAY JCL FOR UNICOS, PART 1 OF FILE                                 CRY11280
        WRITE(MODU,3010) UIDLC, APWLC                                   CRY11290
        WRITE(MODU,3011) JNAMLC                                         CRY11300
        WRITE(MODU,3012)                                                CRY11310
        WRITE(MODU,3013) KRATIM                                         CRY11320
        store=kramfl                                                    CRY11330
        store=store/1000000.                                            CRY11340
        WRITE(MODU,3014) store                                          CRY11350
        WRITE(MODU,3015)                                                CRY11360
        IF(SINDA) THEN                                                  CRY11370
          WRITE(MODU,3016)                                              CRY11380
        ELSE                                                            CRY11390
          WRITE(MODU,3018) XCUT1                                        CRY11400
        ENDIF                                                           CRY11410
      ELSE                                                              CRY11420
C  GENERATE CRAY JCL, (COS),  (FILE 1 OF INPUT FILE)                    CRY11430
C  GENERATE JOB CARD                                                    CRY11440
call                                                       nochrs (40)  CRY11450
        CALL NOCHRS(JOBNAM,'JOBNAM',7,NC,NCBCD)                         CRY11460
        FMTJOB(13:13)=NCBCD(1:1)                                        CRY11470
        WRITE(MODU,FMTJOB) JOBNAM,KRATIM,KRAMFL                         CRY11480
C  GENERATE  ACCOUNT CARD                                               CRY11490
C    GET USERID                                                         CRY11500
        CALL NOCHRS(CRAUID,'USERID',15,NC,NCBCD)                        CRY11510
        FMTACC(17:18)=NCBCD(1:2)                                        CRY11520
C   GET PASSWORD   APW                                                  CRY11530
        CALL NOCHRS(CRAAPW,'APW',15,NC,NCBCD)                           CRY11540
        FMTACC(29:30)=NCBCD(1:2)                                        CRY11550
        WRITE(MODU,FMTACC) CRAUID,CRAAPW                                CRY11560
        WRITE(MODU,3003)                                                CRY11570
        IF(SINDA) WRITE(MODU,3004)                                      CRY11580
        IF(SINDA) WRITE(MODU,3005)                                      CRY11590
      ENDIF                                                             CRY11600
      RETURN                                                            CRY11610
C                                                                       CRY11620
C  ENTRY POINT TO PUT LAST PART OF CRAY COS JCL TO UNIT MODU, FILE 1    CRY11630
CALLED FROM                                              SINTRU(4)      CRY11640
CALLED FROM                                              NOSIND(6)      CRY11650
      ENTRY RITJC2                                                      CRY11660
      IF(UNICOS) THEN                                                   CRY11670
      ELSE                                                              CRY11680
        WRITE(MODU,3006)                                                CRY11690
        WRITE(MODU,3007)                                                CRY11700
        WRITE(MODU,3008)                                                CRY11710
C  END OF CRAY COS FILE 1 (JCL) GENERATION.                             CRY11720
      ENDIF                                                             CRY11730
      RETURN                                                            CRY11740
C                                                                       CRY11750
      ENTRY RITJC3(NINPD,FILNAM)                                        CRY11760
C  INSERT THE UNICOS JCL (cat STATEMENT) TO GET THE MODEL DATA.         CRY11770
C  THE ACTUAL MODEL DATA WILL FOLLOW THIS LINE OF JCL.                  CRY11780
      IF(NINPD .EQ. 1) THEN                                             CRY11790
        IF(FILNAM .NE. ' ') CALL TOLOWC(15,FILNAM,FILNLC)               CRY11800
        WRITE(MODU,3017) FILNLC,FILNAM                                  CRY11810
      ENDIF                                                             CRY11820
      IF(NINPD .EQ. 2) WRITE(MODU,30161) FILNAM                         CRY11830
      IF(NINPD .EQ. 3) WRITE(MODU,30162) FILNAM                         CRY11840
      RETURN                                                            CRY11850
C                                                                       CRY11860
      ENTRY RITJC4(NINPD)                                               CRY11870
C  INSERT THE LAST PART OF UNICOS JCL FOR SINDA MODEL.                  CRY11880
C  FOR UNICOS THIS IS WRITTEN FOLLOWING THE MODEL DATA.                 CRY11890
      IF(UNICOS) THEN                                                   CRY11900
```

```
        IF(SINDA) THEN
          WRITE(MODU,3020)
          WRITE(MODU,3021)
        ELSE
          IF(NINPD .GE. 2) THEN
            WRITE(MODU,3020)
          ENDIF
          CALL TOLOWC(6,XCUT1,FILNLC)
          WRITE(MODU,3023) FILNLC
        ENDIF
        WRITE(MODU,3022)
C  END OF CRAY UNICOS JCL GENERATION FOR SINDA MODEL.
      ENDIF
      RETURN
C  FORMAT STATEMENTS
 1001 FORMAT(A15)
 1996 FORMAT(////'   THE CRAY JCL THAT WAS INPUT IS AS FOLLOWS:'/
     1        '   USERID            = ',A15/
     2        '   PASSWORD          = ',A15/
     3        '   CPU TIME REQUEST  = ',I9, ' SECS.'/
     4        '   MEMORY REQUEST    = ',I9,'  words'/
     5        '   JOB  NAME         = ',A15//
     6        '   ARE THESE ALL CORRECT?  TYPE   Y   OR   N',
     7        '   OR   Q    TO QUIT')
 2000 FORMAT(///'    THIS TASK IS BEING SET UP FOR THE CRAY,'/
     1      '   NOW INPUT NECESSARY CRAY INFO.')
 2001 FORMAT(/'    TYPE IN YOUR  CRAY  USERID.')
 2002 FORMAT(////'    TYPE IN YOUR  CRAY  PASSWORD.')
 2003 FORMAT(/'    TYPE IN NO. OF CRAY CPU SECONDS TO BE USED.'/
     1 '   IF NUMBER OF SECONDS REQUESTED IS < 10,   60 WILL BE USED.')
 2004 FORMAT(/'    TYPE AMOUNT OF CRAY MEMORYTO BE REQUESTED,'/
     1     '    IF AMOUNT REQUESTED IS < 1,500,000,   1,500,000 WILL BE
     2 USED.')
 2005 FORMAT(/'    NOW GIVE YOUR JOB A NAME, TYPE IN THE NAME,'/
     1      '    1 - 7 ALPHEBETIC CHARACTERS.')
 2006 FORMAT(//'    WHICH CRAY SYSTEM  COS  OR  UNICOS'/
     1      '      TYPE IN   C   OR   U')
C
C  FORMAT STATEMENTS TO GENERATE CRAY  COS  JCL
C
 3003 FORMAT('ACCESS,DN=CRYOLIB,PDN=CRYOTRANLIB,ID=CFTO,OWN=CRYOLIB.')
 3004 FORMAT('ACCESS,DN=$PROC,PDN=RUNSINDA,ID=SINDA,OWN=XXCRAY.')
 3005 FORMAT('RUNPRE.'/  'RUNEXEC.')
 3006 FORMAT('**************************************************'/
     1      '*                                                *'/
     2      '*             NORMAL   JOB   TERMINATION          *'/
     3      '*                                                *'/
     4      '**************************************************'/
     5      'EXIT.')
 3007 FORMAT('**************************************************'/
     1      '*                                                *'/
     2      '*               JOB    BOMBED!!!!!!!              *'/
     3      '*                                                *'/
     4      '**************************************************'/
     5      'DUMPJOB.'/
     6      'DEBUG.')
 3008 FORMAT('/EOF.')
C
C  FORMAT STATEMENTS TO GENERATE CRAY  UNICOS  JCL
C
 3010 FORMAT('# USER=',A15,3X,'PW=',A15)
 3011 FORMAT('# QSUB -r ',A15, '        # jobname')
 3012 FORMAT('# QSUB -eo                # Combine error and',
     1      'standard output')
 3013 FORMAT('# QSUB -lT ',I8,'         # CPU time')
 3014 FORMAT('# QSUB -lM ',F4.1,'Mw     # Memory requested')
 3015 FORMAT('#      @$                 # End NQS statements'/
     1      'set  -x                   # set echo'/
     2      'ja     ')
 3016 FORMAT('cat  >  model  << EOF     # SINDA MODEL TO FOLLOW')
```

```
30161 FORMAT('cat  >  model  << EOF    # DATA FROM VM, FN FT FM= ',A15)
30162 FORMAT('cat  >  model  << EOF    # DATA FROM THE TERMINAL')
 3017 FORMAT('cat $HOME/',a15,'  >> model # DATA FROM CRAY, FILENAME= ',
     1        A15)
 3018 FORMAT('### This ',A6,' file,(model), was generated by CRYOTRAN.')
 3020 FORMAT('EOF')
 3021 FORMAT('cossinda  model')
 3022 FORMAT('ja   -sclf  #  GET ACCOUNTING INFO')
 3023 FORMAT('/space/cryolib/',A6,'  model')
      END
C411SSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSS
      SUBROUTINE NOCHRS(STRING,SNAME,NOK,NC,NCBCD)
CALLED FROM                                         GETJCL (41)
CALLED FROM                                         NODES  (44)
C
      CHARACTER*1 BLNK, STRING(15)
      CHARACTER*2 NCBCD, NUMS(15)
      CHARACTER*7 SNAME
C
      DATA BLNK/' '/
      DATA NUMS/'1 ','2 ','3 ','4 ','5 ','6 ','7 ','8 ','9 ',
     1          '10','11','12','13','14','15'/
C
  200 N=0
      DO 201 I=1,15
      IF(STRING(I) .EQ. BLNK) GO TO 220
      N=N+1
  201 CONTINUE
  220 IF(N .LE. 0 .OR. N .GT. NOK) THEN
        IF (N .LE. 0)PRINT 2001,CRPRM, CRPRM
        IF (N .GT. NOK)PRINT 2003,CRPRM, CRPRM
        PRINT 2002, CRPRM, NOK
        READ(5,1001) STRING
        WRITE(INPEKO,1001) STRING
        GO TO 200
      ENDIF
      NC=N
      NCBCD=NUMS(N)(1:2)
      RETURN
C  ENTRY INTO THIS SUBROUTINE TO CONVERT AN INTEGER TO CHARACTER FORM
      ENTRY NBCD(NC,NCBCD)
      IF(NC .GE. 1 .AND. NC .LE. 15) THEN
        NCBCD=NUMS(NC)
      ELSE
        NCBCD=BLNK
      ENDIF
      RETURN
 1001 FORMAT(15A1)
 2001 FORMAT('    CRAY ', A7,' IS BLANK, MUST HAVE A NON-BLANK ',  A7)
 2002 FORMAT('    TYPE IN ',  A7,';  UP TO ',I2,' CHARACTERS')
 2003 FORMAT('    CRAY ', A7,' IS TOO LONG, MUST BE ',A7,
     1       ' CHARACTERS OR LESS')
      END
C412SSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSS
      SUBROUTINE TOLOWC(NN,ALF,ALFLOW)
CALLED FROM                                         GETJCL (41)
C  SUBROUTINE TO CONVERT ALPHABETIC DATA TO LOWER CASE
      CHARACTER * (*) ALF, ALFLOW
      CHARACTER*1   ALFIN(25), ALFLC(25)
      CHARACTER*25  ALPHA, ALOWC
C
      EQUIVALENCE (ALPHA,ALFIN(1)), (ALOWC,ALFLC(1))
C
      ALPHA=ALF
        DO 220 I=1,NN
        NCHARP=ICHAR(ALFIN(I))
        IF(NCHARP .LT. 193 .OR. NCHARP .GT. 233) THEN
          ALFLC(I)=ALFIN(I)
        ELSE
          NCHARP=NCHARP-64
```

```
         ALFLC(I)=CHAR(NCHARP)
       ENDIF
  220  CONTINUE
      ALFLOW=ALOWC
      RETURN
      END
C42SSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSS
      SUBROUTINE REGN1
CALLED FROM                                              SINTRU(4)
C  SUBROUTINE TO GET GEOMETRY FOR REGION 1.
C  REGION 1 IS TANK
C
      COMMON/GEOMTY/ NTYP,NAN,GEOM(2)
C
      CHARACTER*8   GEOM
C
CALL                                                     SPHERE   (421)
      IF(NTYP .EQ. 1) CALL SFEERE
CALL                                                     CYLNDR   (422)
      IF(NTYP .EQ. 2) CALL CYLNDR(NAN)
CALL                                                     RGNGNL  (423)
      CALL RGNGNL(1)
      RETURN
      END
C423SSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSS
      SUBROUTINE RGNGNL(NR)
CALLED FROM                                              REGN1  (42)
CALLED FROM                                              RGN2T5  (43)
C  SUBROUTINE TO INPUT INFO FOR EACH REGION.
C    REGION WIDTH, TEMP, MATERIAL, NO. LAYERS THRU
C
C  TEMPERATURES ... TEMPS(1-5)   TEMP OF REGION 1-5
C                   TEMPS(6)     OUTSIDE ATMOSPHERE TEMP
C                   TEMPS(7)     OUTSIDE ATMOSPHERE TEMP
C                   TEMPS(8)
C                   TEMPS(9)     INSIDE OF TANK WHEN REGNS(4)=FALSE
C  TEMPERATURE UNITS DESIGNATOR, NTUNIT,  SAVED IN MATRLS(9)
C     AND THE VALUE OF THESE UNITS, ('F' OR 'R'), IN MATNMS(9)
C       IF INPUT TEMPERATURES ARE TO BE DEG F  MATRLS(9) = 1
C       IF INPUT TEMPERATURES ARE TO BE DEG R  MATRLS(9) = 2

C  DESIGNATOR FOR OUTSIDE BOUNDARY COEFFICIENTS WILL BE SAVE IN
C     NLAYRS(8) AND NLAYRS(9) FOR OUTSIDE TO BOUNDARY CONDUCTORS
C     1 AND 2 RESPECTIVELY.
C    IF NLAYRS(8/9) = 1  BNCOEF(1/2) IS A CONVECTION CONDUCTOR
C    IF NLAYRS(8/9) = 2  BNCOEF(1/2) IS A RADIATION CONDUCTOR
C     IF EITHER OF THE ABOVE COEFFICIENTS IS A RADIATION CONDUCTOR
C     AND IF THE NTUNIT IS DEG R, THEN CHANGE ALL TEMPERATURES TO DEG F.
C     THOSE TO BE CHANGED: TEMPS(1-9), HXTEMP(1-10)
C
      COMMON /REGION/ NTHETA,NBETAS,BETA,RIN,TVOL,ROUT(9),
     1                REGNS(9),NLAYRS(9),TEMPS(9),THICK(9),
     2                THKLAY(9),MATRLS(9),MATNMS(9),RGNNMS(9)
      COMMON/GEOMTY/ NTYP,NAN,GEOM(2)
C
      LOGICAL REGNS
C
      CHARACTER*8   GEOM
      CHARACTER*16  MATNMS
      CHARACTER*25  RGNNMS
      CHARACTER*1   RF
C
C
C  REMAINING INPUT FOR REGION 1, AND INPUT FOR REGIONS 2, 3, 4 AND 5.
C
  100 IF(NR .GT. 1) CALL CLEARS
      PRINT 2000,NR,RGNNMS(NR)
      NTHII=0
      IF(NR .GT. 1) THEN
C  THICKNESS (WIDTH) FOR REGIONS 2, 3, 4 AND 5
```

```
         IF(NR .EQ. 5) THEN
           THICK(5)=RIN-THICK(4)
           ROUT(5)=THICK(5)
           IF(THICK(5) .LE. 0.0) THEN
             PRINT 3003
             CALL READIN(IGO,1,2)
             IF(IGO .EQ. 1) THEN
               NR=4
               GO TO 100
             ENDIF
             IF(IGO .EQ. 2) THEN
               REGNS(5)=.FALSE.
               RETURN
             ENDIF
           ENDIF
           GO TO 200
         ENDIF
         IF(NR .EQ. 4) THEN
           ROUT(4)=RIN
           IF(REGNS(5)) THEN
             PRINT 2005,GEOM(NTYP),GEOM(NTYP),GEOM(NTYP),RIN
           ELSE
             THICK(4)=RIN
             GO TO 200
           ENDIF
         ENDIF
C  DOES USER WANT TO INPUT REGION THICKNESS OR LAYER THICKNESS.
C   DETERMINE THIS THEN READ THE APPROPRIATE VALUE.
  150    PRINT 2007,NR
         CALL READIN(NTHII,1,2)
         CALL CLEARS
         IF(NTHII .EQ. 1) THEN
           PRINT 2001,NR
           CALL READRE(THICK(NR))
         ENDIF
         IF(NTHII .EQ. 2) THEN
           PRINT 2008,NR
           CALL READRE(THKLAY(NR))
         ENDIF
       ENDIF
C
C  GET NO. OF LAYERS, (NO. OF NODES THU THIS REGION)
  200 PRINT 2002,NR
      CALL READIN(NLAY,1,30)
      NLAYRS(NR)=NLAY
      ENLAY=NLAY
C   COMPUT EITHER THE LAYER THICKNESS OR THE REGION THICKNESS.
      IF(NTHII .LE. 1) THKLAY(NR)=THICK(NR)/ENLAY
      IF(NTHII .EQ. 2) THICK(NR)=THKLAY(NR)*ENLAY
      IF(NR .EQ. 2) ROUT(2)=ROUT(1)+THICK(2)
      IF(NR .EQ. 3) ROUT(3)=ROUT(2)+THICK(3)
      IF(NR .EQ. 4) THEN
        IF(THICK(4) .GT. RIN) THEN
          PRINT 3002,RIN
          GO TO 150
        ENDIF
      ENDIF
C  GET MAX RADIUS OF THE MODEL, --  STORE IT IN  ROUT(6)
      IF(ROUT(NR) .GT. ROUT(6)) ROUT(6)=ROUT(NR)
C
C   NOW GET INITIAL TEMPERATURE FOR THIS REGION
      IF(NR .EQ. 1) THEN
   45   PRINT 2006
        CALL READAL(1,RF)
        IF(RF .NE. 'R' .AND. RF .NE. 'F')THEN
          CALL CLEARS
          PRINT 3001
          GO TO 45
        ENDIF
        MATRLS(9)=1
```

```
        MATNMS(9)='F'
        IF(RF .EQ. 'R') THEN
          MATRLS(9)=2
          MATNMS(9)='R'
        ENDIF
      ENDIF
      PRINT 2003,MATNMS(9)
      CALL READRE(TEMPS(NR))
C
C   NOW GET MATERIAL NUMBER FOR PROPERTIES OF THIS REGION
      CALL CLEARS
CALL                                                   MATMNU (4231)
      CALL MATMNU(NR)
C
      RETURN
 1001 FORMAT(A1)
 1002 FORMAT(I1)
 2000 FORMAT(///'    INPUTTING DATA FOR REGION',I3,',      ',A25)
 2001 FORMAT(/'   TYPE IN THICKNESS (WIDTH) OF REGION ',I2,' (IN.)')
 2002 FORMAT(/'   TYPE IN THE NO. OF LAYERS OF NODES THRU REGION',I2)
 2003 FORMAT(/'   TYPE IN THE INITIAL TEMPERATURE FOR THIS REGION',
     1      '   (DEG ',A1,')')
 2005 FORMAT(/'   REGION 4 IS PART OF THE DISTANCE INSIDE THE ',A8,
     1      ' ALONG THE RADIUS,'/
     2 '   FROM THE INSIDE TANK WALL TOWARD THE CENTER OF THE ',A8,/
     3      '    WHERE RIN, (THE INSIDE ',A8,' RADIUS) =',F8.3)
 2006 FORMAT(/'    TEMPERATURES MAY BE IN DEGF OR DEGR IF NO',
     1      ' RADIATION IS PRESENT.'/
     2 '    THE TEMPERATURES WILL BE INPUT IN WHAT UNITS  F  OR  R?'/
     3  '    TYPE IN   F  OR  R')
 2007 FORMAT(///'   NOW NEED TO SPECIFY THICKNESS OF REGION',I2/
     1          '   AND THE NUMBER OF LAYERS THRU THE REGION.'/
     2          '   TO DEFINE THE REGION THICKNESS THE INPUT MAY BE:'/
     3          '      1.  THE REGION THICKNESS (IN.)'/
     4          ' OR   2.  THE THICKNESS OF EACH LAYER IN THE REGION'/
     5          '      TYPE IN    1   OR   2')
 2008 FORMAT(/'   TYPE IN THICKNESS (WIDTH) OF EACH LAYER OF REGION '
     1      ,I2,' (IN.)')
 3001 FORMAT(///'   ERROR IN TYPING TEMPERATURE UNITS,'/
     1          '     THEY MUST BE  F  OR  R'/
     2          '     TRY AGAIN')
 3002 FORMAT(///'  ERROR IN REGION 4 THICKNESS, INPUT VALUE IS TOO',
     1      ' LARGE'/'    MUST BE < INSIDE RADIUS, RIN=',F7.1/
     2      '   RETYPE REGION 4 THICKNESS')
 3003 FORMAT(///'  ERROR IN REGION 5 THICKNESS, REGION 5 IS DEFINED'/
     1      '   BUT REGION 4 THICKNESS = RIN.'/
     2      '   THE OPTIONS ARE:'/
     3      '      1.  CHANGE THE WIDTH OF REGION 4.'/
     4      '      2.  ELIMINATE REGION 5 FROM THE GEOMETRY.'/
     5      '     TYPE IN  1  OR  2')
      END
C4231SSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSS
C     SUBROUTINE MATMNU(NR)
CALLED FROM                                          RGNGNL (423)
CALLED FROM                                          SPLINP (471)
C
C    THIS ENTRY IS TO PRINT THE MATERIAL NAMES AS A MENU FOR THE USER
C    TO PICK MATERIAL NUMBERS OF THE MODEL.
C  THIS ROUTINE IS NOW IN EHABS LIB OF ROUTINES
C  LEAVE THIS IN AS DOCUMENTATION ONLY; USE SUBROUTINE FROM FILE
C  CRYO2.
C  COMMENT OUT ALL LINES OF THIS ROUTINE......
C
C    THE NAMES AND MATERIAL NUMBERS IN THIS ROUTINE MUST CORRESPOND
C    TO THE NAMES AND NUMBERS IN THE DATA BASE.
C    THE MATERIAL NUMBERS CORRESPOND TO THE ORDER IN WHICH THE NAMES
C    ARE LISTED IN THIS PROGRAM, IN VECTOR   MENU.
C
C    THE MATERIAL NUMBERS ARE:
C   1XX   LIQUID MATERIALS
```

```
C   2XX   SOLIDS
C   3XX   GASEOUS MATERIALS
C
C   THE ARRAY DATA FOR MATERIAL PROPERTIES ARE:
C  ARRAY NO.     DESCRIPTION                         SYMBOL    UNITS
C   1NXX  SPECIFIC HEAT * DENSITY OF MATERIAL NXX  Cp*RHO  Btu/in3-degf
C   2NXX  SPECIFIC HEAT OF MATERIAL NXX            Cp      Btu/lbm-degf
C   3NXX  DENSITY OF MATERIAL NXX                  RHO     lb/in3
C   4NXX  VISCOSITY OF MATERIAL NXX                MU      lb hr/in2
C   5NXX  ENTHALPY OF MATERIAL NXX                 h       Btu/lb
C   6NXX  THERMAL CONDUCTIVITY OF MATERIAL NXX     k       Btu/hr-in-degf
C43SSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSS
      SUBROUTINE RGN2T5
CALLED FROM                                                SINTRU(4)
C  SUBROUTINE TO DEFINE THE GEOMETRY FOR REGIONS 2, 3, 4 AND 5.
C       INPUT FOR REGIONS 2, 3, 4, 5
C        REG 2  -- LAYER ON OUTSIDE OF TANK.
C        REG 3  -- 2ND LAYER ON OUTSIDE OF TANK,ON TOP OF LAYER 1(REG 2).
C        REG 4  -- INSIDE TANK, STARTING AT TANK WALL TOWARD CENTER.
C        REG 5  -- INSIDE TANK, STARTING AT REG 3 TO CENTER.
C
C
      COMMON /REGION/ NTHETA,NBETAS,BETA,RIN,TVOL,ROUT(9),
     1                REGNS(9),NLAYRS(9),TEMPS(9),THICK(9),
     2                THKLAY(9),MATRLS(9),MATNMS(9),RGNNMS(9)
      COMMON /HTXGRS/ NHX,HXTEMP(10),NRHX(10),NLHX(10),
     1                NTHHX(10),LNGTHX(10)
      COMMON/STUFF/ NHTT,PI,CONVY,CONVR,THETAO,DTHETA,NBASOS,ROUTSF,
     1  BNCOEF(2)
      COMMON/ULLAGE/ NLUL4,NLUL5,NTHU41,RINMHH,PCTFUL,RADULG,TVULFT,
     1              CT,LG(3),LIQVAP(3)
C
      LOGICAL REGNS, VPCSHD
C
      CHARACTER*1 YN, CT, LG
      CHARACTER*6 LIQVAP
      CHARACTER*16  MATNMS
      CHARACTER*25  RGNNMS
C
      NTUNIT=MATRLS(9)
C
C  GET INPUT INFO FOR REGION 2, (INSULATION) IF ANY
C
      CALL CLEARS
      PRINT 2201
      PRINT 2001
      CALL READAL(1,YN)
      IF(YN .EQ. 'Y') THEN
         REGNS(2)=.TRUE.
CALL                                                  RGNGNL (423)
         CALL RGNGNL(2)
      ELSE
         GO TO 400
      ENDIF
C
C  REGION 3 INPUT
      CALL CLEARS
      PRINT 2301
      PRINT 2001
      CALL READAL(1,YN)
      IF(YN .EQ. 'Y') THEN
         REGNS(3)=.TRUE.
         CALL RGNGNL(3)
      ENDIF
C
C GET REGION INPUT FOR REGIONS 4 AND 5 IF ANY
  400 IF(REGNS(4))THEN
        CALL CLEARS
        PRINT 2401
      CALL READIN(NINSR,1,2)
```

```
      IF(NINSR .EQ. 2) REGNS(5)= .TRUE.
CALL                                                      RGNGNL   (423)
      CALL RGNGNL(4)
      IF(MATRLS(4) .LT. 200) THEN
        CT='L'
      ELSE
        IF(MATRLS(4) .LT. 300) THEN
          CT='F'
          PCTFUL=100.
        ELSE
          CT='0'
          PCTFUL=0.0
        ENDIF
      ENDIF
  501 IF(REGNS(5)) THEN
        NR=5
        CALL RGNGNL(NR)
        IF(NR .NE. 5) GO TO 501
  509   CT=' '
  510   IF(MATRLS(4) .LT. 200 .AND. MATRLS(5) .LT. 200) THEN
          CT='L'
          IF(MATRLS(4) .NE. MATRLS(5)) THEN
            CALL CLEARS
            PRINT 3006,MATNMS(4),MATRLS(4),MATNMS(5),MATRLS(5)
  520       PRINT 3007
            CALL READIN(N45,0,45)
            IF(N45 .EQ. 0) THEN
            ELSE
              IF(N45 .EQ. 4) THEN
                CALL MATMNU(4)
                GO TO 509
              ELSE
                IF(N45 .EQ. 5) THEN
                  CALL MATMNU(5)
                  GO TO 509
                ELSE
                  IF(N45 .EQ. 45) THEN
                    CALL MATMNU(4)
                    CALL MATMNU(5)
                    GO TO 509
                  ELSE
                    PRINT 3008
                    GO TO 520
                  ENDIF
                ENDIF
              ENDIF
            ENDIF
          ENDIF
        ENDIF
C  CHECK ON MATERIALS OF REGIONS 4 AND 5.
C   IF BOTH ARE LIQUID; SET CT='L', AND CALL ULLAGE ROUTINES.
C       THIS IS DONE ABOVE.
C   IF BOTH ARE NOT LIQUID, THEY COULD BE:
C     1.  BOTH SOLID,              CT=F,  PCTFUL=100.
C     2.  BOTH VAPOR,              CT=0,  PCTFUL=0.0
C     3.  1 LIQUID AND 1 VAPOR,    CT=M,  PCTFUL=100.
C     4.  1 LIQUID AND 1 SOLID,    CT=M,  PCTFUL=100.
C     5.  1 VAPOR  AND 1 SOLID,    CT=M,  PCTFUL=100.
C
        IF(CT .NE. 'L') THEN
          IF(MATRLS(4) .LT. 300 .AND. MATRLS(5) .LT. 300) THEN
C    BOTH SOLID
            CT='F'
            PCTFUL=100.0
          ELSE
            IF(MATRLS(4) .GE. 300 .AND. MATRLS(5) .GE. 300) THEN
C    BOTH VAPOR
              CT='0'
              PCTFUL=0.0
            ELSE
```

```
C   MATERIALS ARE MIXED
                 CT='M'
                 PCTFUL=100.0
               ENDIF
             ENDIF
           ENDIF
         ENDIF
C
C
C   CHECK ON HEAT TRANSFER MECHANISMS FOR REGIONS 4 AND 5.
C   PROMPT USER FOR 1. CONDUCTION ONLY; 2. CONVECTION ONLY;
C   OR 3. BOTH COND. AND CONV.
C   THEN IF RESPONSE IS 2 OR 3, PROMPT USER FOR CONV. COEFFICIENTS;
C   CIRCUMFERENTIAL AND/OR RADIAL
C
         NHTT=0
         CALL CLEARS
         PRINT 2402
         CALL READIN(NHTT,1,3)
C
         IF(NHTT .GE. 2) THEN
           CONVY=0.0
           PRINT 2403
           PRINT 2001
           CALL READAL(1,YN)
           IF(YN .EQ. 'Y') THEN
             PRINT 2404
             CALL READRE(CONVY)
             CONVY=CONVY/144.
           ENDIF
           CONVR=0.0
           PRINT 2405
           PRINT 2001
           CALL READAL(1,YN)
           IF(YN .EQ. 'Y') THEN
             PRINT 2404
             CALL READRE(CONVR)
             CONVR=CONVR/144.
           ENDIF
         ENDIF
C  END OF IFBLOCK NHTT >= 2
C
C  GET %  TANK IS FILLED, & WHERE IS ULLAGE.
C    IF      PCTFUL = 100     CT='F'  TANK IS FULL    NO ULLAGE
C    IF      PCTFUL = 0       CT='0'  TANK IS EMPTY, ALL NODES ARE VAPOR
C    IF 0 < PCTFUL < 100             TANK HAS ULLAGE, WHERE IS IT?
C                             CT='1'  1-G  ANALYSIS, FLAT ULLAGE ON TOP
C                             CT='C'  0-G ANALYSIS, ULLAGE AT CENTER
C                             CT='T'  0-G ANALYSIS, ULLAGE AT TOP W/ FILM
C
         IF(CT .EQ. 'L') THEN
CALL                                                    ULLINP  (431)
           CALL ULLINP
         ENDIF
       ENDIF
C  END OF IFBLOCK REGNS(4) STARTING AT IFN 400
C
C   INPUT INFO ABOUT HEAT EXCHANGERS,  MAX NO. = 10
       CALL CLEARS
       NHX=0
       PRINT 2601
       PRINT 2001
       CALL READAL(1,YN)
  700  IF(YN .EQ. 'Y')THEN
         NHX=NHX+1
         CALL CLEARS
         PRINT 26021
         N=NHX
CALL                                                    READHX  (433)
  710    NERR=0
```

```
      CALL READHX(N,NERR)
      IF(NERR .GT. 0) THEN
        YN = 'N'
        GO TO 715
      ENDIF
      CALL CLEARS
      PRINT 26081, NHX,NLHX(NHX),NRHX(NHX),NTHHX(NHX),
     1            LNGTHX(NHX),HXTEMP(NHX)
      PRINT 2001
    CALL READAL(1,YN)
 715  IF(YN .EQ. 'N') THEN
        PRINT 26082, NHX
        PRINT 2001
    CALL READAL(1,YN)
        IF(YN .EQ. 'Y') THEN
          CALL CLEARS
          GO TO 710
        ELSE
          NHX=NHX-1
          GO TO 770
        ENDIF
      ENDIF
C
C  TEST THIS NEW HX FOR :  OTHER HX'S IN SAME REGION,
C                          OTHER HX'S IN SAME LAYER OF SAME REGION,
C
      NHXM1=NHX-1
 750  DO 760 I=1,NHXM1
      IF(NRHX(NHX) .EQ. NRHX(I)) THEN
C       HX(NHX) IS IN SAME REGION AS HX(I)
        IF(NLHX(NHX) .EQ. NLHX(I))THEN
C         HX(NHX) ALSO ON SAME LAYER AS HX(I)
          NOVLAP=0
          IF(NTHHX(NHX) .LE. NTHHX(I)) THEN
C           HX(NHX) STARTS AT SMALLER THETA THAN HX(I)
C           TEST FOR OVERLAP
            IF(NTHHX(NHX)+LNGTHX(NHX)-1 .GE. NTHHX(I)) THEN
C             THESE 2 HX'S OVERLAP; ERROR
C             WRITE ERROR MESSAGE AND CHANGE AN HX OR DELETE A HX.
              NOVLAP=1
            ENDIF
          ELSE
C           HX(NHX) STARTS AT LARGER THETA THAN HX(I)
C           TEST FOR OVERLAP

            IF(NTHHX(I)+LNGTHX(I)-1 .GE. NTHHX(NHX)) THEN
C             THESE 2 HX'S OVERLAP; ERROR 2
C             WRITE ERROR MESSAGE AND CHANGE AN HX OR DELETE HX.
              NOVLAP=2
            ENDIF
            IF(NOVLAP .GT. 0) THEN
              NHXEND=NTHHX(NHX)+LNGTHX(NHX)-1
              IEND  =NTHHX(I)   +LNGTHX(I)   -1
              IF(NOVLAP .EQ. 1)PRINT 3001,NHX,I,NHX,NTHHX(NHX),
     1                  NHXEND,I,NTHHX(I),IEND
              IF(NOVLAP .EQ. 2)PRINT 3001,I,NHX,I,NTHHX(I),IEND,
     1                  NHX,NTHHX(NHX),NHXEND
              CALL READAL(1,YN)
              IF(YN .EQ. 'Y') THEN
 752            PRINT 3002, NHX,I
                CALL READIN(NNNHX,-9990,99990)
                IF(NNNHX .NE. NHX .OR. NNNHX .NE. I) THEN
                  PRINT 3003, NNNHX
                  GO TO 752
                ELSE
                  HNX=HNX-1
                  GO TO 770
                ENDIF
              ELSE
                YN='N'
```

```
               N=NNNHX                                                CRY18210
               GO TO 715                                              CRY18220
             ENDIF                                                    CRY18230
           ENDIF                                                      CRY18240
         ENDIF                                                        CRY18250
       ENDIF                                                          CRY18260
     ENDIF                                                            CRY18270
  760   CONTINUE                                                      CRY18280
 C                                                                    CRY18290
  770   IF(NHX .LT. 10) THEN                                          CRY18300
          PRINT 26083                                                 CRY18310
          CALL READAL(1,YN)                                           CRY18320
          IF(YN .EQ. 'Y') GO TO 700                                   CRY18330
        ENDIF                                                         CRY18340
      ENDIF                                                           CRY18350
 C   VAPOR COOLED SHIELDS INPUT                                       CRY18360
 C   9/29 88                                                          CRY18370
 C  PRESENTLY THE VAPOR COOLED SHIELDS OPTION IS NOT IN THE SYSTEM.   CRY18380
 C  VAPOR COOLED SHIELDS ARE NOT WELL DEFINED.                        CRY18390
 C  HEAT EXCHANGERS CAN BE SUBSTITUTED FOR VAPOR COOLED SHIELDS       CRY18400
 C  FOR THE PRESENT. THIS CAPABILITY MAY BE WORKED ON AT A LATER DATE. CRY18410
 C                                                                    CRY18420
 C  OUTSIDE ATMOSPHERE BOUNDARY NODES, 2 POSSIBLE                     CRY18430
 C  THESE MAY BE CONVECTION OR RADIATION                              CRY18440
 C  NLAYRS(8/9) WILL BE SET TO 1 FOR CONVECTION OR TO 2 FOR RADIATION CRY18450
 C  IF EITHER OF THESE NODES IS DEFINED AS A RADIATION NODE           CRY18460
 C  AND IF THE INITIAL TEMPERATURES ARE IN DEG R,                     CRY18470
 C  THEN THE INITIAL TEMPERATURES WILL BE CONVERTED TO DEG F.         CRY18480
 C                                                                    CRY18490
      TEMPS(6)=-9999.9                                                CRY18500
      TEMPS(7)=-9999.9                                                CRY18510
      IBN=0                                                           CRY18520
      CALL CLEARS                                                     CRY18530
      PRINT 2901                                                      CRY18540
      PRINT 2001                                                      CRY18550
      CALL READAL(1,YN)                                               CRY18560
      IF(YN .EQ. 'Y') THEN                                            CRY18570
  920   PRINT 2902,MATNMS(9)                                          CRY18580
        IBN=IBN+1                                                     CRY18590
        CALL READRE(TEMPS(IBN+5))                                     CRY18600
  930   PRINT 2903                                                    CRY18610
        CALL READAL(1,YN)                                             CRY18620
        IF(YN .EQ. 'C') THEN                                          CRY18630
C   OUTSIDE BOUNDARY NODE, CONVECTION TO SURFACE, INPUT H(BTU/HR-FT2)  CRY18640
C   CONVERT  H TO BTU/HR-IN2-DEG,      H=H/144                        CRY18650
C   COMPUTE  G=H*A                                                    CRY18660
C   SET NLAYRS(8/9) = 1 DENOTING CONVECTION.                          CRY18670
          PRINT 2904                                                  CRY18680
          CALL READRE(BNCOEF(IBN))                                    CRY18690
          BNCOEF(IBN)=BNCOEF(IBN)/144.                                CRY18700
          NLAYRS(7+IBN)=1                                             CRY18710
        ELSE                                                          CRY18720
          IF(YN .EQ. 'R') THEN                                        CRY18730
C   OUTSIDE BOUNDARY NODE, RADIATION TO SURFACE                       CRY18740
C   TYPE IN RADIATION COEF   (EPS*FORMF)                              CRY18750
C   PROGRAM WILL MULTIPLY BY STEFAN-BOLTZMAN*AREA TO                  CRY18760
C            GET G=SIG*(EPS*F)*A   (BTU/HR)                           CRY18770
C   STEFAN-BOLTZMAN CONSTANT, (SIGMA)=0.1712E-8  (BTU/HR-FT2-DEGR4)   CRY18780
C   SET NLAYRS(8/9) = 2 DENOTING RADIATION.                           CRY18790
          PRINT 2905                                                  CRY18800
          CALL READRE(BNCOEF(IBN))                                    CRY18810
          BNCOEF(IBN)= BNCOEF(IBN)*0.1712E-8/144.                     CRY18820
          NLAYRS(7+IBN)=2                                             CRY18830
          ELSE                                                        CRY18840
C   WRONG REPLY, REPLY MUST BE 'C' OR 'R', TRY AGAIN                  CRY18850
            PRINT 3005                                                CRY18860
            GO TO 930                                                 CRY18870
          ENDIF                                                       CRY18880
        ENDIF                                                         CRY18890
        CALL CLEARS                                                   CRY18900
```

```
        IF(IBN .LT. 2) THEN
          PRINT 2906
          PRINT 2001
          CALL READAL(1,YN)
          IF(YN .EQ. 'Y') THEN
            GO TO 920
          ENDIF
        ENDIF
      ENDIF
C  CHECK FOR RADIATION CONDUCTOR AND DEGR.
C  INDICATER  'F'  OR 'R'  IS IN MATNMS(9)
C  IF TRUE CHANGE THE INPUT TEMPERATURES TO DEG F.
C     THOSE TO BE CHANGED: TEMPS(1-9), HXTEMP(1-10)
C
      IF(MATNMS(9) .EQ. 'R') THEN
        IF(NLAYRS(8) .EQ. 2 .OR. NLAYRS(9) .EQ. 2) THEN
          CALL CLEARS
          PRINT 2909
          MATNMS(9)='F'
          MATRLS(9)=1
          IBNT=IBN+5
          DO 950 I=1,IBNT
          TEMPS(I)=TEMPS(I)-460.0
  950     CONTINUE
          DO 955 I=1,NHX
          HXTEMP(I)=HXTEMP(I)-460.0
  955     CONTINUE
        ENDIF
      ENDIF
      RETURN
C
C FORMAT STATEMENTS
C
 1001 FORMAT(A1)
 2001 FORMAT('    TYPE IN Y OR N')
 2201 FORMAT(///'  IS THERE TO BE A REGION ON THE OUTSIDE',
     1       ' OF THE TANKWALL?'/
     2      '   EG. INSULATION.')
 2301 FORMAT(///'  IS THERE TO BE A 2ND REGION OUTSIDE OF',
     1      ' THE TANKWALL?'/
     2       '    EG. MORE OR DIFFERENT INSULATION.')
 2401 FORMAT(///'   FOR THIS ANALYSIS THE INSIDE OF THE TANK',
     1       ' WILL BE NODALIZED'/
     2      '   HOW MANY REGIONS INSIDE OF THE TANK ?   1  OR  2')
 2402 FORMAT(//'    THE HEAT TRANSFER MECHANISM INSIDE THE TANK,'/
     1       '       I.E. REGIONS 4 AND 5,  IS TO BE:'/
     2       '     1.   CONDUCTION ONLY'/
     3       '     2.   CONVECTION ONLY'/
     4       '     3.   CONDUCTION AND CONVECTION'/
     5       '       TYPE IN   1    2     OR   3')
 2403 FORMAT('   CONVECTION IN THE Y, (CIRCUMFERENTIAL), DIRECTION?')
 2404 FORMAT('  TYPE IN THE CONVECTION COEFFICIENT, (BTU/(HR-FT2-DEGF)')
 2405 FORMAT('   CONVECTION IN THE RADIAL DIRECTION?')
 2601 FORMAT(///'   ARE THERE TO BE ANY HEAT EXCHANGERS?')
26021 FORMAT(///'   HEAT EXCHANGER INFO, MAX NO. =10')
26081 FORMAT(///'    HEAT EXCHANGER NO.',I3,' SPECIFIED '/
     1       '    ON TOP OF LAYER',I3,' OF REGION',I2,
     2       '    STARTING AT THETA ANGLE',I3,' FOR ',I3,' NODES,',
     3       '  WITH TEMPERATURE =',F7.2,/
     4       '    IS THIS CORRECT?')
26082 FORMAT(//'   DO YOU WANT TO RE-SPECIFY OR DELETE',
     1        ' HEAT EXCHANGER ',I3,'?'/
     2        '   TYPE  Y  TO RE-SPECIFY  OR   N  TO DELETE.')
26083 FORMAT('   MORE HEAT EXCHANGERS?   TYPE     Y   OR   N')
 2701 FORMAT(///'   ARE THERE TO BE VAPOR COOLED SHIELDS?')
 2702 FORMAT('    TYPE IN NUMBER OF SHIELDS    1 OR 2')
 2703 FORMAT('   TYPE IN THE REGION NUMBER WHERE THE 1ST SHIELD GOES.')
 2704 FORMAT('   THE SHIELD IS ON TOP OF WHICH LAYER OF THE REGION?'/
     1       '    TYPE IN THE LAYER NO.')
 2705 FORMAT('   TYPE IN THE THETA ANGLE WHERE THE VCS STARTS.'/
```

```
     1         '    COUNT UP FROM THE SOUTH POLE.')                         CRY19610
  2706 FORMAT('   TYPE IN THE NUMBER OF THETAS THE',                         CRY19620
     1         '      VCS IS TO COVER.')                                     CRY19630
  2707 FORMAT('   TYPE IN THE VAPOR COOLED SHIELD 1',                        CRY19640
     1         ' TEMPERATURE (DEG ',A1,')')                                  CRY19650
  2801 FORMAT('   TYPE IN THE REGION NUMBER WHERE THE 2ND SHIELD GOES.') CRY19660
  2807 FORMAT('   TYPE IN THE VAPOR COOLED SHIELD 2',                        CRY19670
     1         ' TEMPERATURE (DEG ',A1,')')                                  CRY19680
  2901 FORMAT(///'  THERE MAY BE UP TO TWO BOUNDARY NODES ON THE ',        CRY19690
     1         ' OUTSIDE OF THE TANKWALL.'/                                  CRY19700
     2         '   EG. OUTSIDE ATMOSPHERE.'/                                 CRY19710
     3         '   DO YOU WANT ONE OR MORE OF THESE BOUNDARY NODES?')      CRY19720
  2902 FORMAT('   TYPE IN THE OUTSIDE ATMOSPHERE',                           CRY19730
     1         ' TEMPERATURE (DEG ',A1,')')                                  CRY19740
  2903 FORMAT('  THE HEAT TRANSFER TO THIS OUTSIDE TEMPERATURE IS TO BE'/CRY19750
     1         '               CONVECTION OR RADIATION?'/                    CRY19760
     2         '   TYPE IN    C        OR   R')                              CRY19770
  2904 FORMAT(/'   TYPE IN THE CONVECTION COEFFICIENT, (BTU/HR-FT2-DEG)')CRY19780
  2905 FORMAT(/'   TYPE IN  THE RADIATION FACTOR  (EPS*F)  ')              CRY19790
  2906 FORMAT(//'   DO YOU WANT A 2ND OUTSIDE BOUNDARY NODE?')              CRY19800
  2909 FORMAT(//'   ONE OR MORE OF THE OUTSIDE BOUNDARY CONDUCTORS',        CRY19810
     1         '  IS A RADIATION CONDUCTOR,'/                                CRY19820
     2         '   ALL TEMPERATURES  HAVE BEEN CONVERTED TO DEG F.')       CRY19830
  3001 FORMAT('  ***ERROR*** HX ',I2,' AND HX ',I2,' OVERLAP; HX''S',       CRY19840
     1         ' CANNOT OVERLAP.'/                                           CRY19850
     2         '  RESPECIFY ONE OF THESE OR DELETE HX ',I2/                 CRY19860
     3'   TYPE  Y  TO  RESPECIFY  OR  N  TO DELETE')                         CRY19870
  3002 FORMAT('  WHICH HX DO YOU WANT TO RESPECIFY? ',I4,'  OR',I4)         CRY19880
  3003 FORMAT( I4,'  IS AN INCORRECT RESPONSE;  TRY AGAIN.')                CRY19890
  3005 FORMAT('   WRONG REPLY, REPLY MUST BE   C   OR   R , TRY AGAIN.') CRY19900
  3006 FORMAT(//'  ***POSSIBLE ERROR***'/                                   CRY19910
     1         '   REGION 4 AND REGION 5 MATERIALS ARE BOTH LIQUIDS'/       CRY19920
     2         '   BUT THEY ARE NOT THE SAME LIQUIDS.'/                      CRY19930
     3         '   REGION 4 IS LIQUID ',A16,',   MATERIAL NO.',I5/          CRY19940
     4         '   REGION 5 IS LIQUID ',A16,',   MATERIAL NO.',I5/          CRY19950
     5         '   IS THIS  O.K. OR DO YOU WANT TO MAKE A CHANGE?')         CRY19960
  3007 FORMAT('  TYPE IN   0(ZERO) FOR O.K., CONTINUE;'/                    CRY19970
     1         '             4   TO CHANGE MATERIAL 4;'/                     CRY19980
     1         '             5   TO CHANGE MATERIAL 5;'/                     CRY19990
     1         '          OR 45  TO CHANGE BOTH MATERIALS.')                CRY20000
  3008 FORMAT('  ***ERROR***'/                                               CRY20010
     1         '   ERROR IN TYPING INPUT, THE ONLY VALID RESPONSES ARE'/   CRY20020
     2         '    0(ZERO),  4,   5,   OR  45   TRY AGAIN,',               CRY20030
     3         '  OR TYPE  Q  TO QUIT')                                      CRY20040
      END                                                                    CRY20050
C431SSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSS            CRY20060
      SUBROUTINE ULLINP                                                      CRY20070
CALLED FROM                                               RGN2T5 (43)    CRY20080
C  GET % TANK IS FILLED, & WHERE IS ULLAGE.                                  CRY20090
C    IF     PCTFUL = 100     CT='F'  TANK IS FULL   NO ULLAGE               CRY20100
C    IF     PCTFUL = 0       CT='0'  TANK IS EMPTY, ALL NODES ARE VAPOR   CRY20110
C    IF 0 < PCTFUL < 100           TANK HAS ULLAGE, WHERE IS IT?          CRY20120
C                           CT='1'  1-G  ANALYSIS, FLAT ULLAGE ON TOP     CRY20130
C                           CT='C'  0-G ANALYSIS, ULLAGE AT CENTER        CRY20140
C                           CT='T'  0-G ANALYSIS, ULLAGE AT TOP W/ FILM CRY20150
C                                                                            CRY20160
      COMMON/ULLAGE/ NLUL4,NLUL5,NTHU41,RINMHH,PCTFUL,RADULG,TVULFT,        CRY20170
     1              CT,LG(3),LIQVAP(3)                                       CRY20180
C                                                                            CRY20190
      CHARACTER*1 CT,LG                                                      CRY20200
      CHARACTER*6 LIQVAP                                                     CRY20210
C                                                                            CRY20220
        CALL CLEARS                                                          CRY20230
        PRINT 2501                                                           CRY20240
        ENTRY ULLIN2                                                         CRY20250
        CALL READRE(PCTFUL)                                                  CRY20260
        IF(PCTFUL .LT. 99.99) THEN                                           CRY20270
          IF(PCTFUL .GT. 0.0) THEN                                           CRY20280
  605       PRINT 2503                                                       CRY20290
            CALL READAL(1, CT)                                               CRY20300
```

```
          IF(CT .EQ. '0' .OR. CT .EQ. 'O') THEN
  610       PRINT 2502
            CALL READAL(1,CT)
            IF(CT .EQ. 'C' .OR. CT .EQ. 'T') THEN
            ELSE
              PRINT 3004
              GO TO 610
            ENDIF
          ELSE
            IF(CT .NE. '1') THEN
              PRINT 3005
              GO TO 605
            ENDIF
          ENDIF
        ELSE
C  TANK HAS REGION(S) 4,(5) DEFINED BUT %FULL=0.
C  HENCE THE TANK IS EMPTY. ALL NODES SHOULD BE DEFINED AS VAPOR NODES.
C
          CT='0'
        ENDIF
      ELSE
C  TANK HAS REGION(S) 4,(5) DEFINED BUT %FULL=100.
C  HENCE THE TANK IS COMPLETELY FULL. ALL NODES ARE LIQUID NODES.
        CT='F'
      ENDIF
      RETURN
C
C   FORMAT STATEMENTS
C
 2501 FORMAT(///'  TYPE IN % TANK IS FULL OF LIQUID.')
 2502 FORMAT(/'   WHERE IS THE ULLAGE?  CENTER OR TOP?'/
     1        '   TYPE IN  C  OR  T')
 2503 FORMAT(/'   IS THIS ANALYSIS A LOW-G  OR  1-G ANALYSIS?'/
     1        '   TYPE IN   0   OR   1')
 3004 FORMAT('   ULLAGE MUST BE SPECIFIED AS CENTER  C  OR TOP   T'/
     1       '   RESPECIFY  C    OR    T')
 3005 FORMAT('   WRONG REPLY, REPLY MUST BE   0   OR   1 , TRY AGAIN.')
      END
C433SSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSS
      SUBROUTINE READHX(NNHX,NERR)
CALLED FROM                                       RGN2T5 (43)
      COMMON /REGION/ NTHETA,NBETAS,BETA,RIN,TVOL,ROUT(9),
     1                REGNS(9),NLAYRS(9),TEMPS(9),THICK(9),
     2                THKLAY(9),MATRLS(9),MATNMS(9),RGNNMS(9)
      COMMON /HTXGRS/ NHX,HXTEMP(10),NRHX(10),NLHX(10),
     1                NTHHX(10),LNGTHX(10)
C
      LOGICAL REGNS
C
      CHARACTER*16  MATNMS
      CHARACTER*25  RGNNMS
      CHARACTER*1 YN
C     CALL CLEARS
      PRINT 26022,NNHX
      PRINT 2603
      CALL READIN(NRHX(NNHX))
C     HX NO. NNHX IS IN REGION NRHX; TEST IF REGN NRHX EXISTS
      NNNN=NRHX(NNHX)
      IF(.NOT. REGNS(NNNN)) THEN
C     REGN NRHX IS FALSE, ERROR, CANNOT BE A HX, REGN DOES NOT EXIST;
C     UNLESS NRHX = 4 AND NLAYER=1, (INSIDE TANK WALL)
        IF(NNNN .EQ. 4) THEN
C         THIS HX IS ON THE INSIDE TANK WALL
          NLHX(NNHX)=1
          GO TO 730
        ELSE
          PRINT 3002, NNHX,NNNN
          NERR=1
          RETURN
        ENDIF
```

```
      ENDIF
C GET THE LAYER NO. OF THE DESIGNATED REGION THAT CONTAINS THE HX.
C  THE HX IS ON TOP OF THE SPECIFIED LAYER.
C  COUNT LAYER FROM OUTSIDE TOWARD CENTER OF SHPERE FOR ALL REGIONS.
        NREGHX=NRHX(NNHX)
        IF(NLAYRS(NREGHX) .LE. 1) THEN
          NLHX(NNHX) = 1
        ELSE
  720     PRINT 2604, NRHX(NNHX)
          CALL READIN(NLHX(NNHX),1,NLAYRS(NREGHX))
        ENDIF
  730   PRINT 2605
        CALL READIN(NTHHX(NNHX),1,NTHETA)
        PRINT 2606
        CALL READIN(LNGTHX(NNHX),1,NTHETA)
        IF(NTHHX(NNHX)+LNGTHX(NNHX)-1 .GT. NTHETA) THEN
          PRINT 3003,NNHX,NTHHX(NNHX),LNGTHX(NNHX),NTHETA
          NERR=10
          RETURN
        ENDIF
        PRINT 2607, MATNMS(9)
        CALL READRE(HXTEMP(NNHX))
      RETURN
C
C  FORMAT STATEMENTS
C
26022 FORMAT('  INPUT FOR HEAT EXCHANGER NO.',I2)
 2603 FORMAT('     TYPE IN THE REGION NUMBER WHERE THE',
     1       ' HEAT EXCHANGER GOES.')
 2604 FORMAT('     THE HEAT EXCHANGER IS ON TOP OF',
     1       ' WHICH LAYER OF REGION',I3,'?'/
     2   '     TYPE IN THE LAYER NO., COUNT LAYERS FROM OUTSIDE'/
     3   ' TOWARD THE CENTER.')
 2605 FORMAT('     TYPE IN THE THETA ANGLE WHERE',
     1                   ' THE HEAT EXCHANGER STARTS'/
     2       '     COUNT UP FROM THE SOUTH POLE.')
 2606 FORMAT('     TYPE IN THE NUMBER OF THETAS THAT',
     1              ' THE HEAT EXCHANGER COVERS.')
 2607 FORMAT('     TYPE IN THE HEAT EXCHANGER TEMPERATURE (DEG ',A1,')')
 3001 FORMAT(//'  **** ERROR ***'/
     1       '  YOU SPECIFIED LAYER NO. ',I3, 'FOR THE HEAT EXCHANGER'/
     2     '  BUT REGION',I2,'  HAS ONLY',I3,' LAYERS.'/
     3     '  RETYPE THE LAYER NO.')
 3002 FORMAT(//'  HEAT EXCHANGER NO. ',I2,' DEFINED IN REGION ',I3/
     1         '  BUT REGION ',I3, ' DOES NOT EXIST.'/
     2         '  CHANGE OR DELETE THIS HEAT EXCHANGER')
 3003 FORMAT(//'  **** ERROR ***'/
     1        '    FOR HEAT EXCHANGER NUMBER',I3/
     2        '    THE STARTING POSITION, (THETA= ',I3,') PLUS'/
     3        '    THE LENGTH OF THE HX, (',I3,')'/
     4        '    EXCEEDS THE NUMBER OF THETAS IN THE SPHERE, (',I3,')'/
     5        '    RESPECIFY OR DELETE THIS HEAT EXCHANGER')
C
      END
C44SSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSS
      SUBROUTINE NODES
CALLED FROM                                          SINTRU(4)
C  GENERATE NODE DATA BLOCK
C
C GENERATE ALL THE NODES FOR THE SINDA MODEL
C 1. REG 1 TANK    -- 2 SURFACES     (ARITH NODES), N1 LAYERS(DIFF NODES)
C 2. REG 2 IF ANY -- 1 OUTSIDE SURF (ARITH NODES), N2 LAYERS(DIFF NODES)
C 3. REG 3 IF ANY -- 1 OUTSIDE SURF (ARITH NODES), N3 LAYERS(DIFF NODES)
C 4. REG 4 IF ANY --    N4 LAYERS(DIFF NODES)
C 5. REG 5 IF ANY --    N5 LAYERS(DIFF NODES)
C 6. INSIDE TANK WHEN REGNS(4)= .FALSE. --1 BNDY NODE AT EACH THETA
C 7. HEAT EXCHANGERS       ---1 BNDY NODE FOR EACH HEAT EXCHANGER
C 8. OUTSIDE ATMOSPHERE    ---1 BNDY NODE
C 9. VAPOR COOLED SHIELDS ---1 BNDY NODE FOR EACH SHIELD(NOT IN PGM)
C
```

```
C GENERATED NODE NUMBER SERIES, (NODEBASE), FOR EACH REGION IN MODEL
C 1. REG 1 TANK   -- SURF1 - 1000;  DIF -  2000;  SURF2 - 3000
C 2. REG 2 IF ANY --                DIF -  4000;  SURF  - 5000
C 3. REG 3 IF ANY --                DIF -  6000;  SURF  - 7000
C 4. REG 4 IF ANY --                DIF -  8000
C 5. REG 5 IF ANY -- SURF  - 9000;  DIF - 10000
C 6. INSIDE TANK WHEN REGNS(4)=.F.  BDY - 18000
C 7. HEAT EXCHANGERS                BDY - 20001, 20002, ETC.
C 8. OUTSIDE ATMOSPHERE             BDY - 20301
C 9. VAPOR COOLED SHIELDS           BDY - 20101, 20102, ETC.
C
      COMMON/UNITS/ MODU, INPEKO, ISCRCH, SINDA
      COMMON /REGION/ NTHETA,NBETAS,BETA,RIN,TVOL,ROUT(9),
     1                REGNS(9),NLAYRS(9),TEMPS(9),THICK(9),
     2                THKLAY(9),MATRLS(9),MATNMS(9),RGNNMS(9)
      COMMON /HTXGRS/ NHX,HXTEMP(10),NRHX(10),NLHX(10),
     1                NTHHX(10),LNGTHX(10)
      COMMON/STUFF/ NHTT,PI,CONVY,CONVR,THETA0,DTHETA,NBASOS,ROUTSF,
     1  BNCOEF(2)
      COMMON/SUBRTS/ SPLIPT, XCUT1,XCUT2,VBLBL1,VBLBL2,OUTBLK
      COMMON/ULLAGE/ NLUL4,NLUL5,NTHU41,RINMHH,PCTFUL,RADULG,TVULFT,
     1              CT,LG(3),LIQVAP(3)
      COMMON/GEOMTY/ NTYP,NAN,GEOM(2)
C
      LOGICAL REGNS,SINDA
      LOGICAL SPLIPT
C
      CHARACTER*1   CT,LG
      CHARACTER*2   NUMBR
      CHARACTER*6   LIQVAP
      CHARACTER*6   XCUT1,XCUT2,VBLBL1,VBLBL2,OUTBLK
      CHARACTER*8   GEOM
      CHARACTER*15  HXGBCD
      CHARACTER*16  MATNMS
      CHARACTER*17  HXLABL
      CHARACTER*25  RGNNMS
C
      DATA HXGBCD/'HEAT EXCHANGER '/
CALL    WRITE NODE BLOCK TITLE                           BL1TTL (04)
      CALL BL1TTL
C  NTYP=1, SPHERE
CALL                                                    SPHNDS  (441)
      IF(NTYP .EQ. 1)  CALL SPHNDS
C
C  NTYP=2, 2D-CYLINDER
CALL                                                    CYLNDS  (442)
      IF(NTYP .EQ. 2) CALL CYLNDS
C
C  TEST FOR BNDY NODES (18000) INSIDE TANK
C  IF SUB VBLBL1 EXISTS OR IF USER WANTS THESE NODES, GENERATE THEM HERE
C  USE REGNS(9) AS A FLAG FOR NODES 18000
C
      IF(.NOT. REGNS(4)) THEN
        IF(VBLBL1 .NE. ' ') THEN
          REGNS(9)=.TRUE.
        ELSE
          CALL CLEARS
          PRINT 2001
          CALL READIN(ICT,1,3)
          IF(ICT .GT. 1) THEN
            REGNS(9)=.TRUE.
            CALL CLEARS
            IF (ICT .EQ. 2) PRINT 20021,MATNMS(9)
            IF (ICT .EQ. 3) PRINT 20022,MATNMS(9)
            CALL READRE(TEMPS(9))
            IF(ICT .EQ. 3) THEN
              PRINT 20023,MATNMS(9)
              CALL READRE(THICK(9))
  301         PRINT 2003
              CALL READRE(PCTFUL)
```

```
            IF(PCTFUL .LE. 0.0 .OR. PCTFUL .GE. 100.) THEN
              PRINT 3000
              GO TO 301
            ENDIF
            CT='1'
            THKLAY(4)=RIN
            IF(NTYP .EQ. 1) CALL ULLGET
            IF(NTYP .EQ. 2) CALL ULL1G
          ENDIF
        ENDIF
      ENDIF
      IF(REGNS(9)) THEN
        WRITE(MODU,2000)
        IF(THICK(9) .EQ. 0.0) THEN
         CALL RITNDS(NTHETA,3,18001,1,1,TEMPS(9),1,'INSIDE TANK    ')
        ELSE
         NLN=NTHU41-1
         CALL RITNDS(NLN,3,18001,1,1,TEMPS(9),1,'IN TANK, LIQUID ')
          NVN=NTHETA-NLN
          NNODE=18001+NLN
          CALL RITNDS(NVN,3,NNODE,1,1,THICK(9),1,'IN TANK, VAPOR  ')
        ENDIF
      ENDIF
      CALL CLEARS
    ENDIF
C
C IF NHX > 0, DEFINE HEAT EXCHANGER NODES, NODE NOS. 20001,20002,ETC.
      IF(NHX .GT. 0) THEN
        DO 600 I=1,NHX
        NODNO=20000+I
        CALL NBCD(I,NUMBR)
        HXLABL=HXGBCD//NUMBR
CALL                                                     RITNDS (443)
        CALL RITNDS(1,3,NODNO,1,1,HXTEMP(I),1.0,HXLABL)
  600   CONTINUE
      ENDIF
C  GET NODEBASE AND RADIUS FOR OUTSIDE SURFACE
C
      NS=1
      DO 101 J=2,3
      IF(REGNS(J)) NS=J
  101 CONTINUE
      ROUTSF=ROUT(NS)
      NBASOS=2000*NS+1000
C
C  OUTPUT NODES FOR VAPOR COOLED SHIELDS
C  THIS SECTION PRESENTLY NOT ACTIVATED, VAPOR COOLED SHIELDS
C  NOT WELL DEFINED. PRESENTLY USE HEAT EXCHANGERS AS SUBSTITUTE.
C
C OUTSIDE ATMOSPHERE NODE(BOUNDARY NODE)
CALL                                                     RITNDS (443)
      IF(TEMPS(6) .NE. -9999.9) THEN
        CALL RITNDS(1,3,20301,1,1,TEMPS(6),1.0,'OUTSIDE ATMOS 1 ')
      ENDIF
      IF(TEMPS(7) .NE. -9999.9) THEN
        CALL RITNDS(1,3,20302,1,1,TEMPS(7),1.0,'OUTSIDE ATMOS 2 ')
      ENDIF
      CALL BLKEND
      RETURN
C  FORMAT STATEMENTS
 2000 FORMAT(7X,'REM  CONSTANT VALUE BOUNDARY NODES; REGION 4, ',
     1          'INSIDE OF TANK')
 2001 FORMAT(///'  FOR THIS MODEL, REGION 4 (INSIDE OF TANK),'/
     1          '  IS NOT NODALIZED WITH SINDA NODES;'/
     2          '   DO YOU WANT CONSTANT TEMPERATURE BOUNDARY NODES'/
     3          '   TO CONNECT TO INSIDE OF TANK WALL, OR NOT?'/
     4          '   YOU MAY HAVE:'/
     5          '    1.    NO CONSTANT TEMPERATURE BOUNDARY NODES.'/
     6          '    2.    A SINGLE SET OF CONSTANT TEMPERATURE NODES.'/
     7          '    3.    2 SETS OF CONSTANT TEMPERATURE NODES TO '/
```

```
     8          '            TO SIMULATE LIQUID AND VAPOR IN  1-G.'//
     9          '        TYPE IN  1    2    OR  3')
20021 FORMAT(/'   TYPE IN THE TEMPERATURE OF THESE BNDY NODES',
     1         '  DEG(',A1,')')
20022 FORMAT(/'   TYPE IN THE TEMPERATURE OF THE LIQUID BNDY NODES',
     1         '  DEG(',A1,')')
20023 FORMAT(/'   TYPE IN THE TEMPERATURE OF THE VAPOR BNDY NODES',
     1         '  DEG(',A1,')')
 2003 FORMAT(/'   TYPE IN % TANK IS FULL OF LIQUID.')
 3000 FORMAT(/'   ERROR IN TYPING % FULL;'/
     1         '  % FULL MUST BE > 0.0  AND < 100.0;  TRY AGAIN.')
      END
C443SSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSS
      SUBROUTINE RITNDS(NN,NODTYP,NNO,NDEL,NARY,TEMP,VOL,MLABL)
CALLED FROM     NODES (44)SETUPA(4411)   SPHDIF(4412)
CALLED FROM     FEND  (4421)  SEND (4422)    EEND (4423)  CYLSEC (4424)
C    WRITE CARDS FOR NODE DATA BLOCK AND SOURCE DATA BLOCK
C        NN     - NO. NODES
C        NODTYP- TYPE NODE,(1-DIFF., 2-ARITH, 3-BNDY, 4-SOURCE
C        NNO    - BEGINNING NODE NO.
C        NDEL   - NODE INCREMENT FOR GENERATION OF MULTIPLE NODES
C        NARY   - ARRAY NO. FOR MATERIAL PROPERTY   (CP*RHO)
C        TEMP   - INITIAL NODE TEMPERATURE
C        VOL    - VOLUME
C        MLABL - MATERIAL NAME, TO GO ON EACH NODE LINE AS AN ID.
C
      COMMON/UNITS/ MODU, INPEKO, ISCRCH, SINDA
C
      CHARACTER*16 MLABL
C
      LOGICAL SINDA
C
      NNODE=NNO
      IF(NODTYP .EQ. 4) GO TO 400
      IF(NODTYP .EQ. 1) THEN
C   DIFFUSION NODES
         IF(NN .EQ. 1) THEN
           WRITE(MODU,2103) NNODE,TEMP,NARY,VOL, MLABL
           ELSE
           WRITE(MODU,2104) NNODE,NN,NDEL,TEMP,NARY,VOL, MLABL
         ENDIF
      ELSE
         IF(NODTYP .EQ. 2) THEN
C  ARITHMETIC NODES
            CVOL=-1.0
         ELSE
C  BOUNDARY NODES
            NNODE=-NNO
            CVOL=1.0
         ENDIF
           IF(NN .EQ. 1) THEN
             WRITE(MODU,2101) NNODE,TEMP,CVOL,MLABL
           ELSE
             WRITE(MODU,2102) NNODE,NN,NDEL,TEMP,CVOL, MLABL
           ENDIF
      ENDIF
  199 RETURN
C   WRITE SOURCE CARDS IN SOURCE BLOCK
  400 IF(NN .EQ. 1) THEN
      WRITE(MODU,2201) NNODE,TEMP,VOL,MLABL
      ELSE
      WRITE(MODU,2202) NNODE,NN,NDEL,TEMP,VOL,MLABL
      ENDIF
      RETURN
C
 2101 FORMAT(11X,I6,',',8X,F7.1,',',F12.6,10X,' $ ',A16)
 2102 FORMAT(7X, 'GEN ',I6,',',I3,',',I3,',',F7.1,',',8X,
     1        F12.6,' $ ',A16)
 2103 FORMAT(7X, 'SIV ',I6,',',8X,F7.1,', A',I4,', ',
     1        F12.6, ' $ ',A16)
```

```
 2104 FORMAT(7X, 'SIM ',I6,',',I3,',',I3,',',F7.1,', A',I4,', ',
     1       F12.6, ' $ ',A16)
 2201 FORMAT(11X,      I6, ',', 8X,
     1       1PE11.4,' $ Q(BTU/HR) BASED ON',0PF6.2,A16)
 2202 FORMAT(7X,'GEN ',I5, ',', I2, ',', I2, ',',
     1       1PE11.4,' $ Q(BTU/HR) BASED ON ',0PF6.2,A16)
      END
C453SSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSS
      SUBROUTINE SRCDAT
CALLED  FROM                                                SINTRU(4)
C BLOCK 2,  SOURCE DATA BLOCK  --  GENERATE NS SOURCE LINES
C     NODE NO.,    Q(BTU/HR.),      QIN=(BTU/HR.-IN2)
C
C  THIS SUBROUTINE TESTS FOR Q INTO THE OUTSIDE SURFACE,
C  READS IN THE VALUE. THEN A SOURCE DATA BLOCK IS GENERATED.
C
      COMMON /REGION/ NTHETA,NBETAS,BETA,RIN,TVOL,ROUT(9),
     1                REGNS(9),NLAYRS(9),TEMPS(9),THICK(9),
     2                THKLAY(9),MATRLS(9),MATNMS(9),RGNNMS(9)
      COMMON/STUFF/ NHTT,PI,CONVY,CONVR,THETA0,DTHETA,NBASOS,ROUTSF,
     1  BNCOEF(2)
      COMMON/OUTSRC/ NQIN,QEFF
      COMMON/GEOMTY/ NTYP,NAN,GEOM(2)
C
      LOGICAL REGNS
C
      CHARACTER*8   GEOM
      CHARACTER*16  MATNMS
      CHARACTER*25  RGNNMS
C
      CHARACTER*16 QUNITS(3)
      CHARACTER*1 YN,YES
      DATA QUNITS/'(BTU/(HR-FT2))',  '(BTU/(HR-IN2))',
     1     'BTU/HR ON SPHERE'/
      DATA YES/'Y'/
C
C   CHECK TO SEE IF THERE IS A Q TERM INTO THE OUTSIDE SURFACE.
C
      NQIN=0
      CALL CLEARS
      PRINT 2001
      CALL READAL(1,YN)
      IF(YN .EQ. 'Y') THEN
 100    PRINT 2002
        CALL READIN(NQIN,1,3)
        QIN=0.0
        PRINT 2003, QUNITS(NQIN)
        CALL READRE(QIN)
C  WRITE THE HEADER FOR THE SOURCE DATA BLOCK
        CALL BL2TTL
C  WRITE THE SOURCE DATA LINES TO UNIT 10
C
        NNODE=NBASOS
        R=ROUT(6)
C  CONVERT QIN TO   BTU/(HR-IN2)
        GO TO (110,120,130),NQIN
 110    QEFF=QIN/144.
        GO TO 140
 120    QEFF=QIN
        GO TO 140
 130    QEFF=QIN/4./PI/R/R
 140    CONTINUE
C
        IF(NTYP .EQ. 1) THEN
          DO 200 J=1,NTHETA,2
          NNODE=NNODE+1
          JJJ=J/2
CALL                                                   AREASP (451)
          CALL AREASP(1,JJJ,R,1.,AREA)
          QQ=QEFF*AREA
```

```
         NMANY=2
         NJ=NTHETA-J
         IF(NJ .LE. 0) NMANY=1
         CALL RITNDS(NMANY,4,NNODE,NJ,1,QQ,QIN,QUNITS(NQIN))
 200     CONTINUE
        ELSE
         NMANY=1
         NJ=1
         DO 205 J=1,NTHETA
         NNODE=NNODE+1
                                                      AREACYL (472)
CALL
         CALL AREACYL(1,J,0.0,0,AREA,-2)
         QQ=QEFF*AREA
         CALL RITNDS(NMANY,4,NNODE,NJ,1,QQ,QIN,QUNITS(NQIN))
 205     CONTINUE
        ENDIF
        CALL BLKEND
      ENDIF
      RETURN
 1001 FORMAT(A1)
 2001 FORMAT(//'   IS THERE TO BE A CONSTANT Q INPUT, (SOURCE TERM)'/
     1        '   INTO THE OUTSIDE SURFACE OF THE MODEL?'/
     2        '    TYPE  Y  OR  N')
 2002 FORMAT('    THE VALUE OF Q MAY BE SPECIFIED IN 3 WAYS:'/
     1          '  1  CONSTANT Q PER UNIT AREA,   (BTU/(HR-FT2)'/
     2          '  2  CONSTANT Q PER UNIT AREA,   (BTU/(HR-IN2)'/
     3        '  3  Q BASED ON BTU/HR OVER THE ENTIRE SPHERE SURFACE'/
     4          '   TYPE 1,   2,   OR  3')
 2003 FORMAT('   TYPE IN THE VALUE OF Q IN ',A16)
      END
C451SSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSS
      SUBROUTINE AREASP(NAREA,JPOS,R,TH,AREA)
CALLED FROM         SRCDAT (45)      SNBLKS (47)      SPHCDS (461)
CALLED FROM         SPHDIF (4412)    CIRCON (4612)
C  SUBROUTINE TO COMPUTE AREAS ON SPHERE.
C
C  AREAS FOR NODES TO COMPUTE NODAL VOLUMES.
C  OUTSIDE AREAS FOR SOURCE TERMS (IF ANY)
C  AREAS FOR CONDUCTOR PATHS.
C
C   WHERE:  NAREA = 1, 2      RADIAL AREA,   CIRCUMFERENTIAL AREA
C           JPOS  -  POSITION OF THETA ANGLE COUNTING FROM SOUTH POLE
C           R     -  RADIUS TO AREA SURFACE
C           TH    -  LAYER THICKNESS
C           AREA  -  VALUE RETURNED TO CALLING PROGRAM
C
      COMMON/STUFF/ NHTT,PI,CONVY,CONVR,THETA0,DTHETA,NBASOS,ROUTSF,
     1  BNCOEF(2)
      COMMON /REGION/ NTHETA,NBETAS,BETA,RIN,TVOL,ROUT(9),
     1                REGNS(9),NLAYRS(9),TEMPS(9),THICK(9),
     2                THKLAY(9),MATRLS(9),MATNMS(9),RGNNMS(9)
C
      LOGICAL REGNS
C
      CHARACTER*8   GEOM
      CHARACTER*16  MATNMS
      CHARACTER*25  RGNNMS
C
      THETA1=THETA0-JPOS*DTHETA
      THETA2=THETA1-DTHETA
      IF(NAREA .EQ. 1) THEN
        AREA =BETA*R*R*(COS(THETA1)+COS(THETA2))*DTHETA/2.
      ELSE
C   AREA IN Y DIRECTION,  (CIRCUMFERENTIAL)
        AREA =BETA*R*(COS(THETA1)+COS(THETA2))*TH/2.
      ENDIF
      RETURN
      END
C46SSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSS
      SUBROUTINE CONDRS
```

```
CALLED FROM                                               SINTRU(4)
C  SUBROUTINE TO GENERATE CONDUCTOR DATA
C
      COMMON/UNITS/ MODU, INPEKO, ISCRCH, SINDA
      COMMON/REGION/ NTHETA,NBETAS,BETA,RIN,TVOL,ROUT(9),
     1               REGNS(9),NLAYRS(9),TEMPS(9),THICK(9),
     2               THKLAY(9),MATRLS(9),MATNMS(9),RGNNMS(9)
      COMMON/GEOMTY/ NTYP,NAN,GEOM(2)
C
      LOGICAL REGNS,SINDA
C
      CHARACTER*8   GEOM
      CHARACTER*16  LABLE
      CHARACTER*16  MATNMS
      CHARACTER*25  RGNNMS
C
C  GENERATE CONDUCTOR DATA
      CALL BL3TTL
CALL                                                SPHCDS (461)
      IF(NTYP .EQ. 1)  CALL SPHCDS
CALL                                                CYLCDS (462)
      IF(NTYP .EQ. 2) CALL CYLCDS
      IF(.NOT. REGNS(4)) THEN
C   REGN$(4)= FALSE; GENERATE NTHETA BOUNDARY CONDUCTORS, FOR
C    CONVECTION FROM TANK TO INSIDE TANK WALL, (NODES 1800N TO 100N)
C                                              N=1,NTHETA
        IF(REGNS(9)) THEN
        WRITE(MODU,2006)
        LABLE='TANK TO WALL    '
        ENDIF
CALL                                                RITCND  (4613)
        CALL RITCND(3,18001,NTHETA,1,18001,1,1001,1,0,0,1.0,1.0,LABLE)
      ENDIF
      CALL BLKEND
      RETURN
 2006 FORMAT(7X,'REM  CONVECTION CONDUCTORS; INSIDE TANK TO TANK WALL')
      END
C4613SSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSS
      SUBROUTINE RITCND(NTP,NG,NGS,IG,NA,IA,NB,IB,NAA,NAB,FA,FB,MLABL)
CALLED FROM     SPHCDS (461)    RADCON (4611)  CIRCON (4612)
CALLED FROM     CYLALL (4622)  FCND (4623)     SCND  (4624)    ECND  (4625)
C  SUBROUTINE TO WRITE CONDUCTOR CARDS TO UNIT 10
C
C                  8,9,10
C   NODTYP= 1  3 BLANKS   G#, NA, NB, GVALUE   STANDARD CONDUCTOR.
C           2   CAL  G#, NA, NB, W, X, Y, Z     G=W*X*Y/Z
C           3   GEN  G#, #G, IG, NA, INA, NB, INB, W, X, Y, Z
C           4   SIV  G#, NA, NB, AP, F
C           5   SIM  G#, #G, IG, NA, INA, NB, INB, AP, F
C           6   DIV  G#, NA, NB, APA, FA, APB, FB
C           7   DIM  G#, #G, IG, NA, INA, NB, INB, APA, FA, APB, FB
C
C   FOR  CAL AND GEN OPTIONS  PUT W, X, Y, Z INTO  NAA, NAB, FA, FB
C
      COMMON/UNITS/ MODU, INPEKO, ISCRCH, SINDA
      CHARACTER*16 MLABL
C
      EQUIVALENCE (INAA,RNAA), (INAB,RNAB)
C
      LOGICAL SINDA
C
      INAA=NAA
      INAB=NAB
      IF(NTP .EQ. 7) THEN
        WRITE(MODU,2307) NG,NGS,IG,NA,IA,NB,IB,NAA,FA,NAB,FB
      ELSE
C
      IF(NTP .EQ. 6) THEN
        WRITE(MODU,2306) NG,NA,NB,NAA,FA,NAB,FB
      ELSE
```

```
C
      IF(NTP .EQ. 4) THEN
        WRITE(MODU,2304) NG,NA,NB,NAA,FA
      ELSE
C
      IF(NTP .EQ. 5) THEN
        WRITE(MODU,2305) NG,NGS,IG,NA,IA,NB,IB,NAA,FA
      ELSE
C
      IF(NTP .EQ. 1) THEN
        WRITE(MODU,2301) NG,NA,NB,RNAA,RNAB,FA,FB
      ELSE
C
      IF(NTP .EQ. 2) THEN
        WRITE(MODU,2302) NG,NA,NB,RNAA,RNAB,FA,FB
      ELSE
C
      IF(NTP .EQ. 3) THEN
        WRITE(MODU,2303) NG,NGS,IG,NA,IA,NB,IB,RNAA,RNAB,FA,FB
      ENDIF
      ENDIF
      ENDIF
      ENDIF
      ENDIF
      ENDIF
      ENDIF
C
      RETURN
 2301 FORMAT(11X,I6,',', I6,',', I6,',', 1PE13.6)
 2302 FORMAT(7X, 'CAL ',I5,',', 2X, I5,',', 1PE13.6,
     1       ',', 1PE13.6,',', 1PE13.6,',', 1PE13.6)
 2303 FORMAT(7X, 'GEN ',I5,',', I3,',', I1,',', I5,',', I2,',',
     1       I5,',', I2,',', 1PE11.5,',',
     2       1PE11.5,',', 0PF5.2,',', F5.2)
 2304 FORMAT(7X, 'SIV ',I5,',', 6X,I5,',', 3X,I5,',',3X,
     1                  ' A',I4, ',', 1PE13.6)
 2305 FORMAT(7X, 'SIM ',I5,',', I3,',', I1,',', I5,',', I2,',',
     1       I5,',', I2,',', ' A',I4, ',', 1PE13.6)
 2306 FORMAT(7X, 'DIV ',I5,',', 6X,I5,',', 3X,I5,',',3X,
     1                  'A',I4, ',', 1PE13.6,',',
     2                  'A',I4, ',', 1PE13.6)
 2307 FORMAT(7X, 'DIM ',I5,',', I3,',', I1,',', I5,',', I2,',',
     1       I5,',', I2,',', 'A',I4, ',', 1PE13.6,',',
     2                        'A',I4, ',', 1PE13.6)
      END
C47SSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSS
        SUBROUTINE SNBLKS
CALLED FROM                                                   SINTRU(4)
C
C  SUBROUTINE TO READ SINDA CONSTANTS AND GENERATE THE REMAINING
C   BLOCKS. (CONSTANTS, ARRAY, EXECUTN, VBLES1, VBLES2, OUTPUT)
C
      COMMON/UNITS/ MODU, INPEKO, ISCRCH, SINDA
      COMMON/GEOMTY/ NTYP,NAN,GEOM(2)
      COMMON/SUBRTS/ SPLIPT, XCUT1,XCUT2,VBLBL1,VBLBL2,OUTBLK
      COMMON/ULLAGE/ NLUL4,NLUL5,NTHU41,RINMHH,PCTFUL,RADULG,TVULFT,
     1              CT,LG(3),LIQVAP(3)
      COMMON /REGION/ NTHETA,NBETAS,BETA,RIN,TVOL,ROUT(9),
     1                REGNS(9),NLAYRS(9),TEMPS(9),THICK(9),
     2                THKLAY(9),MATRLS(9),MATNMS(9),RGNNMS(9)
C
      LOGICAL SPLIPT
      LOGICAL REGNS,SINDA
      LOGICAL TRNSNT,STDYST
C
      CHARACTER*1   YN
      CHARACTER*1   CT,LG
      CHARACTER*3   TUNITS
      CHARACTER*6   LIQVAP
      CHARACTER*6   XCUT1,XCUT2,VBLBL1,VBLBL2,OUTBLK
```

```
      CHARACTER*7   ARRY12(2)
      CHARACTER*6   BLNK, EXECNS(3)
      CHARACTER*8   GEOM
      CHARACTER*16  MATNMS
      CHARACTER*25  RGNNMS
C
C   GET VALUES FOR THE SINDA CONSTANTS
C     TIMEO, TIMEND, DTIMEI, DRLXCA, ARLXCA, NLOOP, OUTPUT
C
C   GET TYPE(S) OF EXECUTION ROUTINES TO BE USED. SS OR TRAN.
C   USE (FWDBCK) FOR TRANSIENT, AND  (STDSTL) FOR STEADY STATE
C
C    UNITS TO BE USED IN SINDA -- DEGR, IN., HRS., LBS., BTU
C
C     COMMON / DATA/ RIN, ROUT, NLAY, NTHETA, TIMEND, OUTPUT, FFLOW,
C    1  TGAS, TLIQ, TWALL, DTIMEI, DRLXCA, ARLXCA, NLOOP
C
      DIMENSION SAREA(200)
C
      DATA NLOOP,DTIMEI,DRLXCA,ARLXCA/ 1000, .005, .005, .005/
      DATA TIMEO,TIMEND,OUTPUT       / 0.0, 24., .5  /
C
      DATA BLNK/'  '/
      DATA EXECNS/'STDSTL', 'FWDBCK', 'CNFRDL'/
C
      DATA ARRY12 /'INSIDE', 'OUTSIDE'/
C
C PROMPT USER FOR USER CONSTANTS AND EXECUTION ROUTINES
      CALL CLEARS
101   PRINT 2001
      CALL READIN(NEXE,1,4)
      TRNSNT=.TRUE.
      STDYST=.TRUE.
      IF(NEXE .EQ. 1) TRNSNT=.FALSE.
      IF(NEXE .EQ. 2) STDYST=.FALSE.
      IF(TRNSNT) THEN
        PRINT 2002
  201   PRINT 20021
C   GET FROM USER WHICH UNITS THE TIME VARIABLES ARE TO BE INPUT
C     SECONDS,  MINUTES,  OR  HOURS; THEN CONVERT THEM TO HOURS
        CALL READAL(1,YN)
        IF(YN .EQ. 'H') THEN
          TCNV=1.0
          TUNITS='HRS'
        ELSE
          IF(YN .EQ. 'M') THEN
            TCNV=60.0
            TUNITS='MIN'
          ELSE
            IF(YN .EQ. 'S') THEN
              TCNV=3600.0
              TUNITS='SEC'
            ELSE
              PRINT 3004
              CALL CLEARS
              GO TO 201
            ENDIF
          ENDIF
        ENDIF
        CALL CLEARS
        PRINT 20022, TUNITS
        CALL READRE(TOIN)
        TOHRS=TOIN/TCNV
        PRINT 2003, TUNITS
        CALL READRE(TEIN)
        TEHRS=TEIN/TCNV
        PRINT 2004, TUNITS
        CALL READRE(DTIN)
        DTHRS=DTIN/TCNV
        PRINT 2005, TUNITS,TUNITS
```

```
        CALL READRE(OUTIN)
        OUTHRS=OUTIN/TCNV
        IF(OUTHRS .LE. 0.0) THEN
          OUTHRS=.25
          OUTIN=OUTHRS*TCNV
        ENDIF
      ENDIF
      CALL CLEARS
      PRINT 2006
      CALL READRE(DRLXIN)
      PRINT 2007
      CALL READIN(LOOPIN,1,99990)
C
C  ANY SPECIAL INPUT DATA FOR NTYP =1,2
C  THIS WILL BE KNOWN WHEN THE SUBROUTINES ARE ENTERED INTO THE SYSTEM
C  BASED ON NTYP  AND  NAN
C
      IF(SPLIPT) THEN
CALLSPLINP (471)
        CALL SPLINP(X1,X2,X3,X4)
      ENDIF
C
C         GENERATE  CONSTANTS DATA BLOCK
C    USER CONSTANTS (1,NLAY),(2,NTHETA), (3,NN1), (4,RIN), (5,ROUT)
C
      CALL BL4TTL
      WRITE(MODU,2402) NTHETA, NBETAS, BETA, RIN, TVOL
      IF(SPLIPT) THEN
C  WRITE THE SPECIAL INPUT TO CONSTANTS DATA. USER SUBROUTINE WILL
C  GET THE VALUES FROM THE CONSTANTS BLOCK. K6, K7, K8, K9
        WRITE(MODU,2403) X1, X2, X3, X4
      ENDIF
      WRITE(MODU,2404) MATRLS(9)
      WRITE(MODU,2406) TUNITS, TUNITS, TUNITS, TUNITS,
     1                 TOIN,  TEIN,  DTIN,  OUTIN,
     2                 TOHRS, TEHRS, DTHRS, OUTHRS
      WRITE(MODU,2407) LOOPIN,DRLXIN,DRLXIN
      CALL BLKEND
C
C         GENERATE ARRAY DATA BLOCK
      CALL BL5TTL
C  ARRAY 1 IS ARRAY OF INSIDE TANK SURFACE AREAS, AT RIN.
C  ARRAY 2 IS ARRAY OF OUTSIDE SURFACE AREAS, OUTSIDE SURFACE 1, 2 OR 3
C
      IF(.NOT. REGNS(4)) THEN
        RAD=RIN
        NRAD=-1
        NARAY=1
        NREGN=1
  500   DO 501 J=1,NTHETA
        IF(NTYP .EQ. 1) THEN
          IF(MOD(J,2) .EQ. 0) GO TO 502
          JJJ=J/2
          CALL AREASP(1,JJJ,RAD,0.,SAREA(JJJ+1))
          NJ=NTHETA-J
          IF(NJ .GT. 0) SAREA(NTHETA-JJJ)=SAREA(JJJ+1)
  502     CONTINUE
        ENDIF
        IF(NTYP .EQ. 2) THEN                         AREACYL (472)
 CALL
          CALL AREACYL(1,J,0.0,0,SAREA(J),NRAD)
        ENDIF
  501   CONTINUE
        WRITE(MODU,2501) NARAY,NREGN,RGNNMS(NREGN),ARRY12(NARAY)
        DO 510 I=1,NTHETA,5
        N1=I
        N2=N1+4
        IF(N2 .LE. NTHETA) THEN
          WRITE(MODU,2502) (SAREA(II),II=N1,N2)
        ELSE
```

```
         NN=NTHETA-N1+1
         N2=NTHETA
         IF(NN .EQ. 4) WRITE(MODU,25024) (SAREA(II),II=N1,N2)
         IF(NN .EQ. 3) WRITE(MODU,25023) (SAREA(II),II=N1,N2)
         IF(NN .EQ. 2) WRITE(MODU,25022) (SAREA(II),II=N1,N2)
         IF(NN .EQ. 1) WRITE(MODU,25021) (SAREA(II),II=N1,N2)
        ENDIF
  510   CONTINUE
        WRITE(MODU,2503)
        IF(NARAY .EQ. 1) THEN
C  PUT OUT ARRAY 2; OUTSIDE SURFACE AREAS
         RAD=ROUT(6)
         NRAD=-2
         NARAY=2
         NREGN=1
         IF(REGNS(2)) NREGN=2
         IF(REGNS(3)) NREGN=3
         GO TO 500
        ENDIF
      ENDIF
C
C   CALL SUB PRPTBL TO GET PROPERTIES FROM THE DATABASE FOR EACH
C   MATERIAL, TO PUT THE PROPERTIES INTO DOUBLET ARRAYS, THEN TO
C   OUTPUT THE ARRAYS TO THE ARRAY BLOCK OF THE MODEL.
C   FOR DIFFUSION NODES MAKE ARRAYS FOR K AND  (CP*RHO)
C   IF THE PROPERTY FOR A REGION IS LIQUID, AND, THE ULLAGE .GT. 0
C   THEN GET PROPERTIES AND OUTPUT TABLES FOR BOTH THE LIQUID AND
C   GAS FORMS FOR THAT MATERIAL.
C
      DO 601 LL=1,5
      IF(REGNS(LL)) THEN
CALL                                                   PRPTBL (473)
        CALL PRPTBL(LL)
      ENDIF
  601 CONTINUE
      IF(SPLIPT) CALL PRPTBL(6)
      CALL BLKEND
C
C        GENERATE   EXECUTION BLOCK
C
C   USER MAY HAVE 2 SUBROUTINE CALLS FROM EXECUTION BLOCK
C   GET SUBROUTINE NAMES FROM VECTORS  EXEC1  AND  EXEC2,  IN SUB MENU2
C
      CALL BL6TTL
C  WRITE COMMON STATEMENTS INTO MODEL, EXECUTION BLOCK.
      WRITE(MODU,2602)
      IF(.NOT. REGNS(4)) THEN
        WRITE(MODU,2603)
        WRITE(MODU,2604) NTHETA,NTHETA,NTHETA,NTHETA,NTHETA,NTHETA
      ENDIF
C
C  COMPUTE DIMENSIONS FOR  X  ARRAY AND NDIM, AND OUTPUT TO EXEC. BLOCK
C  THIS IS BASED ON  NO. NODES, NO. CONDS, AND ROUTINES USED, ETC.
C
      NDN=NLAYRS(1)
      NARN=2
      DO 550 I=2,5
      IF(REGNS(I)) THEN
        NDN=NDN+NLAYRS(I)
        NARN=NARN+1
      ENDIF
  550 CONTINUE
      NDN=NDN*NTHETA
      NARN=NARN*NTHETA
      NX=5*(NDN+NARN)
      NX=(NX/100+1)*100
      WRITE(MODU,2605) NX,NX
C
C   OUTPUT FORTRAN CODE TO INITIALIZE THE COMMON BLOCKS
C
```

```
      WRITE(MODU,2610)
      IF(SPLIPT) WRITE(MODU,2611)
      WRITE(MODU,2612)
      IF(.NOT. REGNS(4)) THEN
        WRITE(MODU,2613)
      ENDIF
C  IF REGNS4=F AND REGNS9=T AND VBLBL1=' ' THEN THE USER ASKED FOR
C  TEMPERATURE NODES INSIDE TANK,(NODES 18001),
C  IF PCTFUL=0; THEN CHECK TO SEE IF USER
C  WANTS TO INPUT A CONSTANT H ; THEN CALCULATE G(18000+I)= H*A
C  IF PCTFUL>0; THEN USER INPUT 2 TEMPS,(TL & TV),CHECK TO SEE IF USER
C  WANTS TO INPUT CONSTANT H'S (HL & HV)
C   THEN CALCULATE G(18000+I)= HL*A  AND G=HV*A
C
      IF(.NOT. REGNS(4) .AND. REGNS(9) .AND. VBLBL1 .EQ. ' ') THEN
        IF(PCTFUL .LE. 0.0 .OR. PCTFUL .GE. 100.0) THEN
          PRINT 30021, TEMPS(9), MATNMS(9)
          CALL READAL(1,YN)
          IF(YN .EQ. 'Y') THEN
            PRINT 30031
            CALL READRE(HH)
          ENDIF
          WRITE(MODU,26141) HH
        ELSE
          PRINT 30022, TEMPS(9), MATNMS(9), THICK(9), MATNMS(9)
          CALL READAL(1,YN)
          IF(YN .EQ. 'Y') THEN
            PRINT 30032
            CALL READRE(HL)
            PRINT 30033
            CALL READRE(HV)
          ENDIF
          NLQN=NTHU41-1
          WRITE(MODU,26142) HL,HV,NLQN,NTHU41,NTHETA
        ENDIF
      ENDIF
C   USER SUBROUTINE CALL GOES HERE, 1 OR 2.
C
      IF(XCUT1 .NE. BLNK)WRITE(MODU,6789) XCUT1
      GO TO (610,620,630,640),NEXE
C  610     STEADY STATE ANALYSIS
  610 WRITE(MODU,2630) EXECNS(1)
      GO TO 660
C  620     TRANSIENT ANALYSIS
  620 NEXRT=1
  621 IF(DTIN .GT. 0.) THEN
C  FWDBCK,  NEED -- TO, TEND, OUTPUT AND DTIMEI
        WRITE(MODU,26311)
        WRITE(MODU,26312)
        WRITE(MODU,2630) EXECNS(2)
      ELSE
C  CNFRDL,  NEED -- TO, TEND, OUTPUT
        WRITE(MODU,26311)
        WRITE(MODU,2630) EXECNS(3)
      ENDIF
      GO TO(660,641),NEXRT
C  630    STEADY STATE FOLLOWED BY TRANSIENT
  630 WRITE(MODU,2630) EXECNS(1)
      GO TO 620
C  640    TRANSIENT FOLLOWED BY STEADY STATE
  640 NEXRT=2
      GO TO 621
  641 WRITE(MODU,2632)
      WRITE(MODU,2630) EXECNS(1)
  660 IF(XCUT2 .NE. BLNK)WRITE(MODU,6789) XCUT2
      CALL BLKEND
C
C     GENERATE VARIABLES 1 BLOCK
C
      CALL BL7TTL
```

```
C  WRITE COMMON STATEMENTS INTO MODEL, VBLES1 BLOCK.
      WRITE(MODU,2602)
      IF(.NOT. REGNS(4) .AND. VBLBL1 .NE. BLNK) THEN
        WRITE(MODU,2603)
        WRITE(MODU,2604)NTHETA,NTHETA,NTHETA,NTHETA,NTHETA,NTHETA
        WRITE(MODU,2701)
      ENDIF
      IF(VBLBL1 .NE. BLNK) WRITE(MODU,6789) VBLBL1
      IF(.NOT. REGNS(4) .AND. VBLBL1 .NE. BLNK) THEN
        WRITE(MODU,2702)
      ENDIF
      CALL BLKEND
C
C     GENERATE VARIABLES 2 BLOCK
C
      CALL BL8TTL
      IF(VBLBL2 .NE. BLNK) WRITE(MODU,6789) VBLBL2
      CALL BLKEND
C
C     GENERATE OUTPUT BLOCK
C
      CALL BL9TTL
      IF(OUTBLK .NE. BLNK) THEN
        WRITE(MODU,6789) OUTBLK
      ELSE
        WRITE(MODU,2901)
      ENDIF
C
C  IF THIS IS A SINDA MODEL THAT CALLS SUBROUTINES FROM THE BLOCKS
C  INSERT THESE SUBROUTINES INTO THE MODEL FILE FOLLOWING THE OUTPUT
C  BLOCK. THIS WILL GET THE ROUTINES COMPILED WITH THE PREPROCESSOR
C  OUTPUT.
C
CALL                                                   INSERT (06)
      IF(SINDA .AND. XCUT1 .NE. ' ') CALL INSERT
      CALL BLKEND
C
C     WRITE END OF DATA STATEMENT
C
      CALL ENDDAT
C
C  FORMAT STATEMENTS
C
 2001 FORMAT('   NOW INPUT THE SPECIFIC DATA FOR SINDA'/
     1       '   THIS SINDA ANALYSIS MAY BE:'/
     2       '   1   A STEADY STATE ANALYSIS'/
     3       '   2   A TRANSIENT ANALYSIS'/
     4       '   3   STEADY STATE FOLLOWED BY A TRANSIENT'/
     5       '   4   A TRANSIENT FOLLOWED BY STEADY STATE'/
     6       '     TYPE IN  1,  2,  3,  OR 4')
 2002 FORMAT('   A TRANSIENT ANALYSIS IS TO BE DONE,'/
     1       '   THE EXECUTION SUBROUTINE WILL BE EITHER  FWDBCK ',
     2       ' OR CNFRDL'/
     3       '   THIS WILL BE DETERMINED BY THE VALUE OF THE TIME',
     4       ' STEP, (DELTIME),'/
     5       '   WHICH WILL BE INPUT BELOW.')
20021 FORMAT(/'   THE NEXT 4 INPUT VALUES INVOLVE PROBLEM TIME,'/
     1       '   THESE 4 VALUES MAY BE INPUT IN UNITS OF'/
     2       '              SECONDS,    MINUTES,  OR  HOURS'/
     3       '   NOW TYPE IN     S          M       OR       H ')
20022 FORMAT(//'   NOW TYPE IN THE PROBLEM START TIME (',A3,')')
 2003 FORMAT(/'   NOW TYPE IN THE PROBLEM END TIME (',A3,')')
 2004 FORMAT(/'   TYPE IN THE TIME STEP,(DELTIME),(',A3,') TO BE USED.'/
     1       '   IF DELTIME IS UNKNOWN, OR IF YOU TYPE ZERO ( 0 ), '/
     2       '   THE SINDA FORWARD DIFFERENCE METHOD, (CNFRDL), '/
     3 '   WILL BE USED AND DELTIME WILL BE COMPUTED BY THE PROGRAM')
 2005 FORMAT(/'   TYPE IN THE OUTPUT INTERVAL  DTOUT  (',A3,')',
     1       '   TEMPERATURES WILL BE PRINTED EVERY DT ',A3,'.'/
     2       '   IF INPUT VALUE .LE. 0, >>>  .25 HRS. WILL BE USED')
 2006 FORMAT(//'   TYPE IN THE CONVERGENCE CRITERIA, DELTA TEMPERATURE'/
```

```
     2        '    SUGGESTED VALUE RANGE  .01  TO .001'/                     CRY30100
     3        '    IF INPUT VALUE .LE. 0 >>>  .005 WILL BE USED.')           CRY30110
 2007 FORMAT(//'   TYPE IN NLOOP, THE NUMBER OF ITERATION LOOPS',            CRY30120
     1        '  ALLOWED'/                                                   CRY30130
     2        '   SUGGESTED RANGE OF VALUES  100  TO 1000'/                  CRY30140
     3        '   IF INPUT VALUE  IS .LE. 0 >>>  100 WILL BE USED.'/         CRY30150
     4        '   NOTE: SOME STEADY STATE CASES MAY NEED NLOOP > 1000')      CRY30160
C                                                                            CRY30170
 2402 FORMAT(7X,'REM NTHETA NBETAS       BETA       RIN       TVOL    ',/CRY30180
     1      12X,2H1=,I4,4H, 2=,I4,4H, 3=,F7.3,4H, 4=,F8.3,4H, 5=,F9.3)   CRY30190
 2403 FORMAT(7X,'REM  SPECIAL INPUT VALUES'/                                 CRY30200
     1      12X,2H6=,F9.3,4H, 7=,F9.3,4H, 8=,F9.3, ', 9=',F9.3)             CRY30210
 2404 FORMAT(7X,'REM K10=SINDA TEMP UNITS; K10=1(DEG F); K10=2(DEG R)'/ CRY30220
     1      12X,' 10=',I2)                                                  CRY30230
 2406 FORMAT(7X,'REM   TIMEO(',A3,')',5X, 'TIMEND(', A3,')',5X,              CRY30240
     1          'DTIMEI(', A3,')',5X, 'OUTPUT(',A3,')'/                     CRY30250
     2       7X,'REM ',G11.5,6X,G11.5,6X,G11.5,6X,G11.5/                    CRY30260
     3      11X,'101=',G11.5,', 102=',G11.5,', 103=',G11.5,                  CRY30270
     4          ', 104=',G11.5)                                             CRY30280
 2407 FORMAT(11X,'NLOOP=',I6,', DRLXCA=',F9.6,', ARLXCA=',F9.6)             CRY30290
 2501 FORMAT(11X,I2, 1X,'$REGION',I2,',(',A23,'),',A7,                      CRY30300
     1        ' SURFACE AREAS (IN**2)')                                     CRY30310
 2502 FORMAT(11X, 2X, 4(1PE12.5,','),1PE12.5)                                CRY30320
25024 FORMAT(11X, 2X, 3(1PE12.5,','),1PE12.5)                                CRY30330
25023 FORMAT(11X, 2X, 2(1PE12.5,','),1PE12.5)                                CRY30340
25022 FORMAT(11X, 2X,   1PE12.5,',', 1PE12.5)                                CRY30350
25021 FORMAT(11X, 2X, 1PE12.5)                                               CRY30360
 2503 FORMAT(12X, 'END')                                                     CRY30370
 2504 FORMAT(11X,I2, 20X,'$   TANK OUTSIDE SURFACE AREAS  (IN**2)')          CRY30380
 2602 FORMAT('F     COMMON/USER1/ NTHETA,NBETAS,NTUNIT,BETA,RIN,TVOL')      CRY30390
 2603 FORMAT('F     COMMON/USER2/ PTIME, DELTIM, XC1, XC2, XC3, XC4')       CRY30400
 2604 FORMAT('F     COMMON/INSA /SARIN (',I5,')'/                            CRY30410
     1       'F     COMMON/OUTSA/SAROUT(',I5,')'/                            CRY30420
     2       'F     COMMON/SURFT/TSURF  (',I5,')'/                           CRY30430
     3       'F     COMMON/BNDYT/TBDY   (',I5,')'/                           CRY30440
     4       'F     COMMON/HTRCO/HCOEF  (',I5,')'/                           CRY30450
     5       'F     COMMON/SURFQ/QSURF  (',I5,')')                           CRY30460
 2605 FORMAT('F     DIMENSION X(',I5,')', 46X/                               CRY30470
     1       'F      NDIM= ', I5)                                            CRY30480
 2610 FORMAT('M',6X,'NTHETA= K1'/                                            CRY30490
     1       'M',6X,'NBETAS= K2'/                                            CRY30500
     2       'M',6X,'BETA   =XK3'/                                           CRY30510
     3       'M',6X,'RIN    =XK4'/                                           CRY30520
     4       'M',6X,'TVOL   =XK5')                                           CRY30530
 2611 FORMAT('M',6X,'XC1    =XK6'/                                           CRY30540
     1       'M',6X,'XC2    =XK7'/                                           CRY30550
     2       'M',6X,'XC3    =XK8'/                                           CRY30560
     3       'M',6X,'XC4    =XK9')                                           CRY30570
 2612 FORMAT('M',6X,'NTUNIT= K10')                                           CRY30580
 2613 FORMAT('F',6X,'DO 120 I=1,NTHETA'/                                     CRY30590
     6       'M',6X,'SARIN(I) =A(1+I)'/                                      CRY30600
     7       'M',6X,'SAROUT(I)=A(2+I)'/                                      CRY30610
     8       'F 120 CONTINUE')                                               CRY30620
26141 FORMAT('F',6X,'HH= ', G14.6,'/144.'/                                   CRY30630
     1       'F',6X,'DO 272 I=1,NTHETA'/                                     CRY30640
     2       'F',6X,'IM1=I-1'/                                               CRY30650
     3       'M',6X,'G(18001+IM1)= HH*SARIN(I)'/                             CRY30660
     4       'F 272 CONTINUE')                                               CRY30670
26142 FORMAT('F',6X,'HL= ', G14.6,'/144.'/                                   CRY30680
     1       'F',6X,'HV= ', G14.6,'/144.'/                                   CRY30690
     2       'F',6X,'DO 272 I=1,',I3/                                        CRY30700
     3       'F',6X,'IM1=I-1'/                                               CRY30710
     4       'M',6X,'G(18001+IM1)= HL*SARIN(I)'/                             CRY30720
     5       'F 272 CONTINUE'/                                               CRY30730
     6       'F',6X,'DO 273 I=',I3,',',I3/                                   CRY30740
     7       'F',6X,'IM1=I-1'/                                               CRY30750
     8       'M',6X,'G(18001+IM1)= HV*SARIN(I)'/                             CRY30760
     9       'F 273 CONTINUE')                                               CRY30770
 2630 FORMAT(11X, A6)                                                        CRY30780
26311 FORMAT('M      TIMEO = XK101'/                                         CRY30790
```


3

```
     1        'M       TIMEND= XK102'/                                          CRY30800
     2        'M       OUTPUT= XK104')                                          CRY30810
26312 FORMAT('M       DTIMEI= XK103')                                           CRY30820
 2632 FORMAT('M       TIMEO = 0.0  '/                                           CRY30830
     1        'M       TIMEND= 0.0  '/                                          CRY30840
     2        'M       DTIMEI= 0.0  '/                                          CRY30850
     3        'M       OUTPUT= 0.0  ')                                          CRY30860
 2701 FORMAT('F',6X,'PTIME =TIMEO'/                                             CRY30870
     1        'F',6X,'DELTIM=DTIMEU'/                                           CRY30880
     2        'F',6X,'DO 270 I=1,NTHETA'/                                       CRY30890
     3        'F',6X,'IM1=I-1'/                                                 CRY30900
     4        'M',6X,'TSURF(I)=T(1001+IM1)'/                                    CRY30910
     5        'F 270 CONTINUE')                                                 CRY30920
 2702 FORMAT('F',6X,'DO 271 I=1,NTHETA'/                                        CRY30930
     1        'F',6X,'IM1=I-1'/                                                 CRY30940
     2        'M',6X,'T(18001+IM1)=TBDY (I)'/                                   CRY30950
     3        'M',6X,'Q(1001+IM1)=Q(1001+IM1)+QSURF(I)'/                        CRY30960
     4        'M',6X,'G(18001+IM1)=HCOEF(I)*SARIN(I)'/                          CRY30970
     5        'F 271 CONTINUE')                                                 CRY30980
 2901 FORMAT(11X,'TPRNTF')                                                      CRY30990
 3001 FORMAT('   THE INPUT VALUE FOR TYPE OF ANALYSIS IS OUT OF RANGE'/ CRY31000
     1        '   MUST BE FROM 1 TO 4;   TRY AGAIN.')                           CRY31010
30021 FORMAT(//'  TEMPERATURE INSIDE OF TANK IS DEFINED =',                     CRY31020
     1          F8.2,' DEG ',A1/                                                CRY31030
     2        '  WANT TO INPUT H TO COMPUTE CONVECTION COEFICIENT G=H*A?'CRY31040
     3       //'  TYPE IN    Y   OR   N')                                       CRY31050
30022 FORMAT(//'  TEMPERATURES INSIDE OF TANK ARE DEFINED TL=',                 CRY31060
     1          F8.2,' DEG ',A1,'  AND  TV=',F8.2,' DEG ',A1/                   CRY31070
     2        '  WANT TO INPUT HL AND HV TO COMPUTE CONVECTION',                CRY31080
     3        ' COEFICIENTS G=H*A?'//                                           CRY31090
     4        '  TYPE IN    Y   OR   N')                                        CRY31100
30031 FORMAT(//'  TYPE IN  FILM COEFFICIENT  H    (BTU/HR-FT2-R)')              CRY31110
30032 FORMAT(//'  TYPE IN  FILM COEFFICIENT  HL    (BTU/HR-FT2-R)')             CRY31120
30033 FORMAT(//'  TYPE IN  FILM COEFFICIENT  HV    (BTU/HR-FT2-R)')             CRY31130
 3004 FORMAT(//'    INPUT ERROR ----'/                                          CRY31140
     1        '   THE ONLY CORRECT RESPONSE IS   H,  M, OR  S'/                 CRY31150
     2        '   TRY THIS INPUT AGAIN')                                        CRY31160
 6789 FORMAT('F      CALL ',A6)                                                 CRY31170
      END                                                                       CRY31180
C471SSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSS                  CRY31190
      SUBROUTINE SPLINP(X1,X2,X3,X4)                                            CRY31200
CALLED FROM                                                   SNBLKS(47)        CRY31210
C  SPECIAL INPUT DATA FOR NTYPE=1,(SPHERE) OR NTYP=2,(CYLINDER)                 CRY31220
C  AND  REGNS(4)=.F.                                                            CRY31230
C  THIS SUBROUTINE MAY NEED TO BE CHANGED WHEN NEW FILL PROCEDURES              CRY31240
C  ARE ADDED TO THE SYSTEM IF INPUTS OTHER THAN THE CURRENT ONES                CRY31250
C  ARE REQUIRED.                                                                CRY31260
C  PRESENT INPUTS ARE:                                                          CRY31270
C   NTYP=1  AND  NAN=3----  SPHERE,  THICK WALL FILL                            CRY31280
C                                                                               CRY31290
      COMMON /REGION/ NTHETA,NBETAS,BETA,RIN,TVOL,ROUT(9),                      CRY31300
     1                REGNS(9),NLAYRS(9),TEMPS(9),THICK(9),                     CRY31310
     2                THKLAY(9),MATRLS(9),MATNMS(9),RGNNMS(9)                   CRY31320
      COMMON/GEOMTY/ NTYP,NAN,GEOM(2)                                           CRY31330
C                                                                               CRY31340
      LOGICAL REGNS                                                             CRY31350
C                                                                               CRY31360
      CHARACTER*1   YN                                                          CRY31370
      CHARACTER*8   GEOM                                                        CRY31380
      CHARACTER*16  MATNMS                                                      CRY31390
      CHARACTER*25  RGNNMS                                                      CRY31400
C                                                                               CRY31410
      IF (NTYP .EQ. 1) THEN                                                     CRY31420
        IF(NAN .EQ. 3) THEN                                                     CRY31430
C                                                                               CRY31440
C         A FILL ON A THICK WALL SPHERE     NTYP=1,  NAN=3                      CRY31450
C               LIQUID FLOW RATE (LB/HR)                                        CRY31460
C               LIQUID TEMPERATURE  (DEG F/R)                                   CRY31470
C               VAPOR TEMPERATURE   (DEG F/R)                                   CRY31480
C               FILL THE TANK HOW FULL?   (%)                                   CRY31490
```

```
C              NAME OF LIQUID    (FROM MATERIAL DATA BASE)
         CALL CLEARS
         PRINT 2008
         CALL READRE(FFLOW)
         PRINT 2009,MATNMS(9)
         CALL READRE(TLIQ)
         PRINT 2010,MATNMS(9)
         CALL READRE(TGAS)
         PRINT 2011
         CALL READRE(PCTFIL)
         PRINT 2012
         CALL READAL(1,YN)
         IF(YN .EQ. 'Y') THEN
           CALL MATMNU(6)
         ENDIF
         X1= FFLOW
         X2= TLIQ
         X3= TGAS
         X4= PCTFIL
      ENDIF
        ENDIF
      RETURN
C  FORMATS
 2008 FORMAT('   SPECIAL INPUT FOR TANKFILL PROCEDURES'/
    1       '   TYPE IN FLUID FLOW RATE  (LB/HR)')
 2009 FORMAT('   TYPE IN FLUID TEMPERATURE  (DEG R)'/
    1       '   NOTE:  TEMPERATURE UNITS MUST BE DEG R.')
 2010 FORMAT('   TYPE IN VAPOR TEMPERATURE  (DEG R)')
 2011 FORMAT('   FILL THE TANK HOW FULL?  TYPE IN PERCENT TO FILL')
 2012 FORMAT('   DO YOU NEED MATERIAL PROPERTIES FOR THE LIQUID?'/
    1       '    TYPE   Y   OR  N')
      END
C474SSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSS
      SUBROUTINE INSERT
CALLED FROM                                            SNBLKS(47)
C  SUBROUTINE TO INSERT THE SOURCE CODE OF FLUID SUBROUTINES
C  INTO THE SINDA MODEL.
C        FILEDEF THE PROPER FILE USING DOJCL
C     THE FILENAME WILL BE 'CRYOSUBS "XCUT1"'
C     THIS FILE MUST!!!!! BE LRECL=80, RECFM=F!!!!
C   THEN OPEN FORTRAN UNIT 36 ON THAT FILE
C        READ 36 AND WRITE TO MODU
C
      COMMON/UNITS/ MODU, INPEKO, ISCRCH, SINDA
      COMMON/SUBRTS/ SPLIPT, XCUT1,XCUT2,VBLBL1,VBLBL2,OUTBLK
C
      LOGICAL SPLIPT
      LOGICAL SINDA
C
      CHARACTER*1  L1
      CHARACTER*79 LINE
      CHARACTER*2  EM
      CHARACTER*30 FILD1
      CHARACTER*40 FILDEF
      CHARACTER*6 XCUT1, XCUT2, VBLBL1, VBLBL2, OUTBLK
C
      DATA FILD1/'FILEDEF CRYSUBS DISK CRYOSUBS '/
      DATA EM   /' M'/
C
C  WRITE FORTRAN "END" FOLLOWING LAST LINE OF OUTPUT BLOCK
      WRITE(MODU,2000)
C FILEDEF THE PROPER SOURCE FILE
      FILDEF=FILD1//XCUT1//EM
C     FILDEF=FILD1//XCUT1//' A'
      CALL DOJCL(FILDEF)
      OPEN(UNIT=36,FILE='CRYSUBS')
C
  101 READ(36,1001,END=500) L1,LINE
      IF(L1 .EQ. ' ') THEN
        WRITE(MODU,2001)LINE
```

```
      ELSE                                                              CRY32200
        WRITE(MODU,2002)LINE                                            CRY32210
      ENDIF                                                             CRY32220
      GO TO 101                                                         CRY32230
  500 CLOSE(UNIT=36)                                                    CRY32240
      CALL DOJCL('FILEDEF CRYSUBS CLEAR')                               CRY32250
      RETURN                                                            CRY32260
C  FORMAT STATEMENTS                                                    CRY32270
 1001 FORMAT(A1,A79)                                                    CRY32280
 2000 FORMAT('F       END')                                             CRY32290
 2001 FORMAT('F',A79)                                                   CRY32300
 2002 FORMAT('C',A79)                                                   CRY32310
      END                                                               CRY32320
C48SSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSS       CRY32330
      SUBROUTINE GEOPLT                                                 CRY32340
CALLED FROM                                                 SINTRU(4)   CRY32350
C  PLOT ROUTINES FOR CRYOTRAN                                           CRY32360
C   THE PLOT ROUTINES ARE CALLED FROM SUBROUTINE SINTRU (22)            CRY32370
C   THEY PRODUCE PLOTS OF THE GEOMETRY, SPHERE OR CYLINDER,             CRY32380
C   THAT THE USER HAS DEFINED WITHIN THE CRYOTRAN SYSTEM.               CRY32390
C   THE CURRENT PLOTTING SYSTEM BEING USED ARE:                         CRY32400
C          1. THE DISPLA  SYSTEM TO PLOT SPHERE GEOMETRIES              CRY32410
C          2. THE DISPLA  SYSTEM TO PLOT CYLINDER GEOMETRIES            CRY32420
C   THE PLOTTING SUBROUTINES ARE IN THE FILE  CRYOPLOT FORTRAN.         CRY32430
C                                                                       CRY32440
C   SUBROUTINE TO PLOT THE GEOMETRY                                     CRY32450
C   DISSPLA PLOTTING CALLS.                                             CRY32460
C                                                                       CRY32470
      COMMON/UNITS/ MODU, INPEKO, ISCRCH, SINDA                         CRY32480
      COMMON/GEOMTY/ NTYP,NAN,GEOM(2)                                   CRY32490
C                                                                       CRY32500
      CHARACTER*1 YN, YES                                               CRY32510
      CHARACTER*8   GEOM                                                CRY32520
C                                                                       CRY32530
      LOGICAL PLOTSS                                                    CRY32540
C                                                                       CRY32550
      DATA YES /'Y'/                                                    CRY32560
      DATA PLOTSS /.FALSE./                                             CRY32570
C                                                                       CRY32580
      CALL CLEARS                                                       CRY32590
      PRINT 2001                                                        CRY32600
      READ(5,1001) YN                                                   CRY32610
      WRITE(INPEKO,1001) YN                                             CRY32620
      IF(YN .EQ. YES) THEN                                              CRY32630
        PLOTSS=.TRUE.                                                   CRY32640
CALL                                                    PLTSPH (481)    CRY32650
        IF(NTYP .EQ. 1) CALL PLTSPH                                     CRY32660
CALL                                                    PLTCYL (482)    CRY32670
        IF(NTYP .EQ. 2) CALL PLTCYL                                     CRY32680
      ENDIF                                                             CRY32690
      RETURN                                                            CRY32700
C                                                                       CRY32710
      ENTRY PLTDUN                                                      CRY32720
CALLED FROM MAIN PROGRAM WHEN EXITING CRYOTRAN                          CRY32730
C    TO CALL DONEPL (DISSPLA SUBROUTINE IN PLOT SUBROUTINE)             CRY32740
C    IF PLOTS HAVE PEEN PRODUCED                                        CRY32750
C                                                                       CRY32760
      IF(PLOTSS) CALL DUNPLT                                            CRY32770
      RETURN                                                            CRY32780
C                                                                       CRY32790
 1001 FORMAT(A1)                                                        CRY32800
 2001 FORMAT(//'  IN THE PLOTTING ROUTINE, NTYP=1; 2D SPHERE WEDGE'/    CRY32810
     1       '  DO YOU WANT A PLOT OF THIS GEOMETRY?'/                  CRY32820
     2       '    TYPE  Y  OR  N')                                      CRY32830
      END                                                               CRY32840
C5SSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSS       CRY32850
      SUBROUTINE VMINTR(MAINNM)                                         CRY32860
CALLED FROM                                             MAIN (00)       CRY32870
C   ENTRY TO EXECUTE ANALYSIS ROUTINES ON VM INTERACTIVELY              CRY32880
C   THIS SECTION OF THE CODE MUST BE CHANGED WHENEVER A NEW             CRY32890
```

```
C    INTERACTIVE ANALYSIS PROGRAM IS ADDED TO THE SYSTEM. THE
C    NAMES OF THESE PROGRAMS WILL BE ADDED TO THE ARRAY MAINNM
C    AND THE CORRESPONDING VALUE IN ARRAY NSRUNM WILL BE = 2.
C    FOR THESE PROGRAMS THE OUTPUT WILL GO TO BOTH THE SCREEN
C    AND A DISK FILE NAMED  "PROGRAM OUTPUT". THE FILE  PROGRAM OUTPUT
C    IS FORTRAN UNIT 17 AND MUST BE DEFINED PRIOR TO EXECUTION
C    OF THE PREPROCESSOR PROGRAM. IN THIS INSTANCE THIS FILE IS
C    FILEDEF'ED IN THE VM EXEC THAT STARTS THE EXECUTION. THE EXEC
C    FILE NAME IS  "RUNCRYO EXEC".
C
C  INSERT ENOUGH INPUT INFORMATION TO DETERMINE MATERIAL PROPERTIES
C  NEEDED FOR THE REQUESTED ANALYSIS ROUTINE,
C  THEN CALL MATERIAL SUBROUTINES TO GET THE NECESSARY MATERIAL
C   PROPERTIES FROM THE DATABASE AND INTO THE REQUIRED FORM.
C  THE ANALYSIS ROUTINES MUST BE CHANGED TO CALL PROPERTY ROUTINES
C  WITHIN THE SYSTEM.
C
      COMMON/GEOMTY/ NTYP,NAN,GEOM(2)
C
      CHARACTER*6 MAINNM
      CHARACTER*8   GEOM
C
      CALL CLEARS
      IF(NAN .EQ. 1) CALL NVFILL
      IF(NAN .EQ. 2) CALL CHILL
      IF(NAN .EQ. 3) CALL TARGET
      PRINT 2004,MAINNM
      RETURN
C  FORMAT STATEMENTS
 2004 FORMAT(///'    END OF PROGRAM  ',A6/
     1       '    THE OUTPUT IS IN A FILE NAMED  "PROGRAM OUTPUT".'/
     2       '     RETURNING TO MAIN PROGRAM OF SYSTEM.')
      END
C6SSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSS
      SUBROUTINE NOSIND(NRUNON)
CALLED FROM                                                  MAIN (00)
C    SUBROUTINE TO RUN THERMODYNAMICS PROGRAM WITH NO SINDA ANALYSIS'
C    THIS NEEDS FURTHER WORK.
C    FILE 1     CRAY JCL  TO GET ON AND COMPILE THE MAIN PROGRAM
C    FILE 2     INPUT DATA FOR THE ANALYSIS
C               OR AS AN ALTERNATE INPUT DATA FILE IS STORED ON CRAY
C               AND USER IS PROMPTED FOR THE NAME AND THIS IS INSERTED
C               INTO FILE 1 AS AN ACCESS AND ASSIGN; OR COPY INPUT
C               DATA FILE INTO A COMMON DATA FILE.
C
      COMMON/GEOMTY/ NTYP,NAN,GEOM(2)
      COMMON/UNITS/ MODU, INPEKO, ISCRCH, SINDA
      COMMON/SUBRTS/ SPLIPT, XCUT1,XCUT2,VBLBL1,VBLBL2,OUTBLK
C
      LOGICAL SPLIPT
C
      CHARACTER*6 XCUT1, XCUT2, VBLBL1, VBLBL2, OUTBLK
      CHARACTER*8   GEOM
C
      LOGICAL UNICOS
C
C    RUN AN ANALYSIS WITHOUT A SINDA MODEL GENERATED BY CRYOTRAN.
C    TEST VARIABLE NRUNON,
C       IF  NRUNON = 1  RUN ANALYSIS ON CRAY.
C       IF  NRUNON = 2  RUN ANALYSIS ON VM IN INTERACTIVE MODE.
C                       THE ANALYSIS IS A SUBROUTINE OF THIS SYSTEM,
C                       AND WILL BE CALLED FROM AN ENTRY (VMINTR) IN
C                       SUBROUTINE MENU2. VMINTR IS CALLED FROM MAIN.
C       IF  NRUNON = 3  RUN ANALYSIS ON VM IN BATCH MODE.
C
      IF(NRUNON .EQ. 1) THEN
C       THIS ANALYSIS IS TO GO ON THE CRAY
C       PREPARE A FILE NAMED   CRYOTRAN MODEL  WHICH WILL
C       CONTAIN CRAY JCL AND INPUT DATA TO SUBMIT TO CRAY
C       TO RUN AN ANALYSIS WITH NO SINDA.
```

```
C                                                                      CRY33600
CALL  GET THE CRAYJCL INFO FROM THE USER                GETJCL (41)    CRY33610
        CALL GETJCL(UNICOS)                                            CRY33620
CALL  WRITE FIRST PART OF FILE 1 ON UNIT MODU, CRAJCL FILE. RITJCL(41) CRY33630
          CALL RITJCL                                                  CRY33640
        IF (UNICOS) THEN                                               CRY33650
C  THIS BLOCK FOR UNICOS JCL                                           CRY33660
CALL INDAT1 TO DETERMINE WHERE THE DATA FILE RESIDES                   CRY33670
C  WHEN DATA FILE RESIDENCE IS FOUND, IF NOT STORED ON CRAY            CRY33680
C  INDAT2 WILL DETERMINE LOCATION AND WRITE JCL TO GET IT.             CRY33690
CALL                                                   INDAT1 (61)     CRY33700
          CALL INDAT1(UNICOS)                                          CRY33710
          CALL INDAT2                                                  CRY33720
        ELSE                                                           CRY33730
C   THIS BLOCK FOR COS JCL                                             CRY33740
C    WRITE CRAY COS JCL TO UNIT MODU TO COMPILE MAIN PROGRAM           CRY33750
          WRITE(MODU,3001)                                             CRY33760
          WRITE(MODU,3002)                                             CRY33770
C  NOW GET INPUT DATA FOR THE ANALYSIS PROGRAM          INDAT1 (39A)   CRY33780
          CALL INDAT1(UNICOS)                                          CRY33790
          WRITE(MODU,3003) XCUT1                                       CRY33800
C   WRITE LAST PART OF CRAY COS JCL                                    CRY33810
          CALL RITJC2                                                  CRY33820
C  WRITE A MAIN PROGRAM TO UNIT MODU WHICH CALLS ON THE DESIRED        CRY33830
C  ANALYSIS SUBROUTINE                                                 CRY33840
          WRITE (MODU,3010) XCUT2, XCUT1                               CRY33850
          CALL INDAT2                                                  CRY33860
        ENDIF                                                          CRY33870
      ENDIF                                                            CRY33880
C     IF(NRUNON .EQ. 2) THEN                                           CRY33890
C        THIS ANALYSIS IS RUN ON THE VM SYSTEM IN INTERACTIVE MODE.    CRY33900
C        CALL VMINTR    THIS CALL IS IN THE MAIN PROGRAM.              CRY33910
C     ENDIF                                                            CRY33920
      IF(NRUNON .EQ. 3) THEN                                           CRY33930
C        THIS ANALYSIS IS RUN ON THE VM SYSTEM IN BATCH MODE.          CRY33940
C        THIS FEATURE IS NOT YET IN THE SYSTEM.                        CRY33950
      ENDIF                                                            CRY33960
      RETURN                                                           CRY33970
C                                                                      CRY33980
C   FORMAT STATEMENTS                                                  CRY33990
C   FORMAT STATEMENTS TO PRODUCE  COS  RUNSTREAM                       CRY34000
 3001 FORMAT('CFT77.')                                                 CRY34010
 3002 FORMAT('ACCESS,DN=CRPROC,PDN=CRYOTRANPROCS,ID=CFTO,OWN=CRYOLIB.'/ CRY34020
     1       'LIBRARY,DN=*:CRPROC.')                                   CRY34030
 3003 FORMAT(A6,'.')                                                   CRY34040
 3010 FORMAT('C   MAIN PROGRAM - THIS ANALYSIS IS',A20/                CRY34050
     2          6X,'CALL ',A6/                                         CRY34060
     3          6X,'STOP'/  6X,'END'/   '/EOF.')                       CRY34070
      END                                                              CRY34080
C61SSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSS       CRY34090
      SUBROUTINE INDAT1(UNICOS)                                        CRY34100
CALLED FROM                                             NOSIND (6)     CRY34110
C   SUBROUTINE TO GET THE INPUT DATA FOR AN ANALYSIS PROGRAM.          CRY34120
C   SUBROUTINE HAS 2 ENTRY POINTS  --   INDAT1  AND INDAT2             CRY34130
C   ENTRY INDAT1 INTERROGATES USER AS TO SOURCE OF INPUT DATA          CRY34140
C    IF DATA IS ON CRAY, WRITE ACCESS AND ASSIGN STATEMENTS (CRAY JCL). CRY34150
C   ENTRY INDAT2 USED WHEN DATA IS ON VM OR TYPED IN AT RUN TIME       CRY34160
C     AND WRITES FILE 3 TO UNIT 10                                     CRY34170
C    IF DATA IS ON VM IT MUST!!! BE LRECL=80, AND RECFM=F;             CRY34180
C     THAT IS, FIXED FORMAT AND LINE LENGTH =80.                       CRY34190
C                                                                      CRY34200
      COMMON/UNITS/ MODU, INPEKO, ISCRCH, SINDA                        CRY34210
C                                                                      CRY34220
      CHARACTER*2   NCBCD                                              CRY34230
      CHARACTER*20  FNFTFM                                             CRY34240
      CHARACTER*15  PDN,PID,POWN                                       CRY34250
      CHARACTER*20  FILCOM                                             CRY34260
      CHARACTER*40  FILDEF                                             CRY34270
      CHARACTER*63  FMTOC                                              CRY34280
      CHARACTER*80 DLINE                                               CRY34290
```

```
C
C
      CHARACTER*46  XEDITF
      CHARACTER*6   XEDIT1
      CHARACTER*20  XEDIT2
      DATA  XEDIT1/'XEDIT '/
      DATA  XEDIT2/' (PROF LRECFIX NOMSG'/
C
C
      LOGICAL UNICOS
      LOGICAL EXS,OPN
C
      DATA FMTOC/'(''ACCESS,DN=INPDAT,PDN='',A15,'',ID='',A15,'',OWN='',
     1A15,''.'')'/
      DATA FILCOM/'FILEDEF VMDATA DISK '/
C
      CALL CLEARS
   11 PRINT 2005
      CALL READIN(NINPD,1,4)
      IF(NINPD .EQ. 4) RETURN
C   GET THE INPUT DATA IF NINPD = 1,  DATA STORED ON CRAY
      IF(NINPD .EQ. 1) THEN
C   INPUT DATA STORED ON CRAY, ACCESS FILE, COPY TO UNIT INPUT
        IF(UNICOS) THEN
          PRINT 2007
          CALL READAL(2,PDN)
          CALL RITJC3(6,PDN)
        ELSE
          PRINT 2010
          CALL READAL(2,PDN)
          PRINT 2011
          CALL READAL(2,PID)
          PRINT 2012
          CALL READAL(2,POWN)
          CALL NOCHRS(PDN,'PDN',15,NC,NCBCD)
          FMTOC(27:28)=NCBCD(1:2)
          CALL NOCHRS(PID,'ID', 8, NC,NCBCD)
          FMTOC(38:39)=NCBCD(1:2)
          CALL NOCHRS(POWN,'OWN',15,NC,NCBCD)
          FMTOC(50:51)=NCBCD(1:2)
          WRITE(MODU,FMTOC) PDN, PID, POWN
          WRITE(MODU,3002)
        ENDIF
        CALL RITJC3(NINPD,PDN)
        CALL RITJC4(NINPD)
      ENDIF
      RETURN
C
      ENTRY INDAT2
      IF(NINPD .EQ. 2) THEN
C   INPUT DATA STORED ON VM, ACCESS FILE, READ AND COPY TO UNIT 10
   52 PRINT 2020
      CALL READAL(2,FNFTFM)
C
      FILDEF=FILCOM//FNFTFM
      CALL DOJCL(FILDEF)
C   NOW READ INPUT DATA FROM FILE FNFTFM AND WRITE TO UNIT 10
C       OPEN UNIT 36,FNFTFM
      OPEN (UNIT=36, FILE='VMDATA',IOSTAT=IOS,STATUS='OLD',ERR=65)
C     PRINT *,'  OPEN UNIT 36 VMDATA ,  IOSTAT=',IOS
      INQUIRE(FILE='VMDATA',IOSTAT=IOS,EXIST=EXS,OPENED=OPN,RECL=IRCL)
C     PRINT *, '  INQUIRE ON VMDATA FILE',IOS,EXS,OPN,IRCL
      CALL RITJC3(NINPD,FNFTFM)
   60 READ(36,1003,END=75) DLINE
      WRITE(MODU,1003) DLINE
      GO TO 60
   65 PRINT *,'  ERROR WHEN ATTEMPTING TO  OPEN UNIT 36, IOS=',IOS
      PRINT *,'  FILE (',FNFTFM,')  DOES NOT EXIST'
      CLOSE (UNIT=36)
      CALL DOJCL('FILEDEF VMDATA CLEAR')
```

```
      PRINT *,'  TYPE IN NAME OF DATA FILE ON VM'
      GO TO 52
   75 CONTINUE
      CALL RITJC4(NINPD)
      CLOSE (UNIT=36)
      CALL DOJCL('FILEDEF VMDATA CLEAR')
      ENDIF
      IF(NINPD .EQ. 3) THEN
C   INPUT DATA TO BE TYPED IN AT THIS POINT AND WRITTEN TO UNIT 10
        PRINT 2030
        CALL RITJC3(NINPD,'TERMINAL ')
  101   READ(5,1003) DLINE
        WRITE(INPEKO,1003) DLINE
        IF(DLINE(1:9) .NE. 'ENDOFMYDATA') THEN
          WRITE(MODU,1003) DLINE
          GO TO 101
        ENDIF
        CALL RITJC4(NINPD)
      ENDIF
      PRINT 2040
      RETURN
C  FORMATS
 1003 FORMAT(A80)
 2005 FORMAT('   NOW WE NEED THE INPUT DATA FOR THE ANALYSIS'/
     1       '   THIS INPUT DATA CAN BE:'/
     2       '   1  STORED ON CRAY'/
     3       '   2  STORED ON VM'/
     4       '   3  TYPED IN NOW'/
     5       '   4  NO INPUT DATA FOR THIS ANALYSIS'/
     6       '   TYPE IN  1  2  3  OR  4')
 2007 FORMAT('   ANALYSIS INPUT DATA IS STORED ON CRAY'/
     1       '   IT MUST BE IN YOUR HOME DIRECTORY'/
     2       '   TYPE IN THE FILE NAME OF THE INPUT DATA')
 2010 FORMAT('   ANALYSIS INPUT DATA IS STORED ON CRAY'/
     1       '   TYPE IN  (PDN)  THE PERMANENT DATASET NAME')
 2011 FORMAT('   TYPE IN  (ID)   THE ID OF PDN.')
 2012 FORMAT('   TYPE IN  (OWN)  THE OWNER OF PDN.')
 2020 FORMAT('   ANALYSIS INPUT DATA IS STORED ON VM'/
     1       '   NOW WE NEED  FILE NAME;  FILE TYPE;  FILE MODE'/
     2       '   TYPE IN        FN FT FM')
 2030 FORMAT('   THE ANALYSIS INPUT DATA IS TO BE TYPED IN NOW'/
     1       '   START TYPING IN THE INPUT DATA.'/
     2       '   WHEN ALL THE DATA IS TYPED IN THE NEXT LINE MUST'/
     3       '   BE        ENDOFMYDATA'/
     4       'THIS WILL STOP THE READING AND CONTINUE THE PROGRAM.')
 2040 FORMAT('   THE INPUT DATA IS NOW ALL IN.')
 3002 FORMAT('ASSIGN,DN=INPDAT,A=FT05.')
      END
```

APPENDIX E

CryoTran Program Listings

Part II CRYOSPHR FORTRAN

```
C421SSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSS

      SUBROUTINE SFEERE
CALLED FROM                                                  REGN1 (42)
C  SUBROUTINE TO INPUT SPECIFIC DATA FOR A SPHERE.   (NTYP=1)
C   THIS ROUTINE IS USED FOR REGION 1 ONLY.
C
C    REGION WIDTH, TEMP, MATERIAL, NO. LAYERS THRU
C
      COMMON /REGION/ NTHETA,NBETAS,BETA,RIN,TVOL,ROUT(9),
     1                REGNS(9),NLAYRS(9),TEMPS(9),THICK(9),
     2                THKLAY(9),MATRLS(9),MATNMS(9),RGNNMS(9)
      COMMON/STUFF/ NHTT,PI,CONVY,CONVR,THETA0,DTHETA,NBASOS,ROUTSF,
     1  BNCOEF(2)
      COMMON/GEOMTY/ NTYP,NAN,GOEM(2)
C
      LOGICAL REGNS
C
      CHARACTER*8   GEOM
      CHARACTER*16  MATNMS
      CHARACTER*25  RGNNMS
C
C
C     NOW INPUT THE DATA TO GET SPHERE RADII, VOLUME AND WALL THICKNESS.
      CALL CLEARS
   45 PRINT 2001
   50 PRINT 2002
CALLS  TO                            READIN, READRE, READAL   (02)
      CALL READIN(NN,1,5)
      GO TO (51,52,52,51,53), NN
   51 PRINT 2004
      CALL READRE(RIN)
   55 TVOLIN=4./3.*PI*RIN**3
      TVOL=TVOLIN/1728.
      GO TO 60
   52 PRINT 2005
      CALL READRE(TVOL)
      RIN=((.75*TVOL/PI)**(1./3.))*12.
      TVOLIN=TVOL*1728.
      GO TO 60
   53 PRINT 2006
      CALL READRE(ROUT(1))
   60 GO TO(61,62,61,62,62,65,70),NN
   61 NN=6
      GO TO 53
   62 PRINT 2007
      CALL READRE(WTHICK)
      GO TO(70,63,70,63,64),NN
   63 ROUT(1)=RIN+WTHICK
      GO TO 70
   64 RIN=ROUT(1)-WTHICK
      NN=7
      GO TO 55
   65 WTHICK=ROUT(1)-RIN
   70 CONTINUE
      THICK(1)=WTHICK
      IF(ROUT(1) .LE. RIN .OR. TVOL .LE. 0.0 .OR. WTHICK .LE. 0.0)THEN
        CALL CLEARS
        PRINT 3002
        GO TO 45
      ENDIF
C
C   WE NOW HAVE RIN, ROUT, TNKVOL AND WALLTHICK FOR TANKWALL, (REGION 1)
C
      ROUT(6)=RIN
      ANGLR=2.*PI/BETA
      WDGVIN=TVOLIN/ANGLR
      CALL CLEARS
      PRINT 3001,TVOL,RIN,THICK(1)
C
```

```
C  NOW GET NTHETA, NO. OF NODES ALONG CIRCUMFERENCE, SOUTH POLE TO NORTH
C   SOME OF THIS CODE WILL NEED TO BE CHANGED WHEN WE GO TO A 3D CONFIG.
      PRINT 2008
      CALL READIN(NTHETA,1,200)
      IF(NTHETA .LT. 5) NTHETA=20
      DTHETA=PI/NTHETA
C
        CALL CLEARS
        PRINT 2010
C       CALL READIN(NBETAS,1,8)
C       IF(NBETAS .LE. 0 .OR. NBETAS .GT. 8) NBETAS=6
C       BETA=2.*PI/NBETAS
C       IF(NBETAS .EQ. 1) THEN
C       PRINT 2010
C       ENDIF
C
C  THE REMAINING INPUT FOR REGION 1 IS OBTAINED FROM SUB RGNGNL(42)
C                  (CALLED FROM SUB REGN1   (31)   )
C
      RETURN
 2001 FORMAT(///'      NOW INPUT SPECIFIC DATA FOR THIS SPHERE.'/
     1  '      INPUT DATA TO DEFINE THE SPHERE MAY BE ANY ONE OF:'/
     2  '     1     RIN (IN.)            AND    ROUT (IN.)'/
     3  '     2     TNK VOL.(CU.FT.)     AND    WALL THICKNESS (IN.)'/
     4  '     3     TNK VOL.(CU.FT.)     AND    ROUT (IN.)'/
     5  '     4     RIN (IN.)            AND    WALL THICKNESS (IN.)'/
     6  '     5     ROUT (IN.)           AND    WALL THICKNESS (IN.)')
 2002 FORMAT(/'     ENTER A NUMBER  1  -  5')
 2004 FORMAT(/'     ENTER INSIDE TANK RADIUS,  RIN(IN.).')
 2005 FORMAT(/'     ENTER TANK VOLUME (CU.FT.).')
 2006 FORMAT(/'     ENTER ROUT (IN.).')
 2007 FORMAT(/'     ENTER WALL THICKNESS   (IN.).')
 2008 FORMAT(///'    TYPE IN NUMBER OF NODES ALONG CIRCUMFERENCE',
     1      ' OF THE SPHERE.'/'    SOUTH POLE TO NORTH POLE.'/
     2     '    IF VALUE INPUT IS < 5,  20 WILL BE USED AS A DEFAULT.')
C2009 FORMAT('  THIS IS A 3D CONFIGURATION,'/
C    1         'INPUT NO. OF WEDGES AROUND THE SPHERE, DEFAULT = 6.')
 2010 FORMAT(////'   THIS IS A 2D ANALYSIS, THE WEDGE ANGLE = 1 RAD.')
 3001 FORMAT(////'    THE GEOMETRY FOR THIS ANALYSIS IS A SPHERE WITH'/
     1  '      VOL=',F8.3,' FT**3,   RIN=',F7.3,' IN.,      AND ',
     2  '      WALL THICKNESS=',F7.4,' IN.')
 3002 FORMAT(///'     ERROR IN TYPING DATA TO DEFINE THE SPHERE.'/
     1         '     INCONSISTANT VALUES WERE INPUT, TRY AGAIN.')
      END
C432SSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSS
      SUBROUTINE ULLGET
CALLED FROM                     RGN2T5  (43)      SPHNDS(441)
C
C  IF THERE IS ULLAGE DETERMINE
C                   WHERE THE ULLAGE IS
C                   WHICH NODES ARE ULLAGE
C               AND WHICH NODES ARE LIQUID
C
C  IF PCTFUL < 100%, THEN
C  IF RGNS 4&5 ARE TRUE AND IF PCTFUL < 100% THEN SOME NODES ARE VAPOR
C       COMPUTE WHICH NODES ARE ULLAGE (VAPOR) NODES
C       ULLAGE MAY BE AT THE CENTER OR AT THE TOP.
C  COMPUTE NLUL4, NLUL5 AND NTHU41
C
      COMMON /REGION/ NTHETA,NBETAS,BETA,RIN,TVOL,ROUT(9),
     1                REGNS(9),NLAYRS(9),TEMPS(9),THICK(9),
     2                THKLAY(9),MATRLS(9),MATNMS(9),RGNNMS(9)
      COMMON/STUFF/ NHTT,PI,CONVY,CONVR,THETA0,DTHETA,NBASOS,ROUTSF,
     1 BNCOEF(2)
      COMMON /ULLAGE/ NLUL4,NLUL5,NTHU41,RINMHH,PCTFUL,RADULG,TVULFT,
     1                CT,LG(3),LIQVAP(3)
C
      LOGICAL REGNS
C
      CHARACTER*1   CT,LG
```

```
      CHARACTER*6   LIQVAP
      CHARACTER*16  MATNMS
      CHARACTER*25  RGNNMS
C
      DIMENSION H(3)
C
   10     NLUL4=0
          NLUL5=0
C     PRINT *,'  IN ULLGET, NR, THICK(4)=',NR,THICK(4)
      IF(CT .NE. 'F') THEN
        TVLQFT=TVOL*PCTFUL/100.
        TVULFT=TVOL-TVLQFT
        IF(CT .EQ. '0' .OR. CT .EQ. 'O') THEN
C   TANK IS EMPTY, ALL NODES ARE VAPOR NODES.
          NLUL4= NLAYRS(4)
          NLUL5= NLAYRS(5)
          RETURN
        ENDIF
        IF(CT .EQ. 'C') THEN
C   FOR THE ULLAGE AT THE CENTER, CT=C,  ENTIRE LAYERS WILL BE VAPOR
C   THIS SECTION DETERMINES WHICH LAYERS ARE VAPOR
C
          RADULG=((.75*TVULFT/PI)**(1./3.))*12.
          IF(RADULG .LE. ROUT(5)) THEN
            RATIO=RADULG/THKLAY(5)
            NLUL5=RATIO
            FIXRAT=NLUL5
            IF(RATIO-FIXRAT .GE. 0.5) NLUL5=NLUL5+1
            IF(NLUL5 .GT. NLAYRS(5)) NLUL5=NLAYRS(5)
          ELSE
            IF(RADULG .LE. ROUT(4)) THEN
              RTEMP=RADULG-ROUT(5)
              RATIO=RTEMP/THKLAY(4)
              NLUL4=RATIO
              FIXRAT=NLUL4
              IF(RATIO-FIXRAT .GE. 0.5) NLUL4=NLUL4+1
              IF(NLUL5 .GT. NLAYRS(4)) NLUL4=NLAYRS(4)
              NLUL5=NLAYRS(5)
            ELSE
              PRINT 3001,RADULG,ROUT(4),TVOL,TVLQFT,TVULFT
            ENDIF

          ENDIF
C   END IF BLOCK FOR CT = 'C'
        ELSE
          IF(CT .EQ. 'T') THEN
C   ULLAGE IS AT THE TOP OF THE SPHERE AND THIS IS A 0,(ZERO), G CASE
C   COMPUTE NODES THAT ARE VAPOR. FOR THIS CASE, ULLAGE AT THE TOP,
C   A THIN LAYER OF LIQUID WILL BE AT THE WALL.
C  THIS OPTION IS NOT YET AVAILABLE
            PRINT 3002,CT
CALL                                 ENTRY ULLIN2  IN  ULLINP (431)
            CALL ULLIN2
            GO TO 10
          ELSE
C   END IF BLOCK FOR CT = 'T'
            IF(CT .EQ. '1') THEN
C   CT = 1, 1G CASE,  ULLAGE BUBBLE IS AT TOP AND FLAT.
              NTHU41=0
C  SOLVE THE CUBIC  H**3 + P*H**2 + Q*H + R =0
C         WITH P,Q,R;  P=(-3R),  Q=0,  R=3V/PI
C         FOR H, THE ROOT INSIDE THE SPHERE REPRESENTING THE
C         DISTANCE FROM THE TOP OF THE SPHERE TO THE TOP OF THE ULLAGE.
C
              P=-3.0*RIN
              Q=0.
              ULGVOL=TVULFT*1728.0
              R=3.0*ULGVOL/PI
CALL                                             CUBIC (4321)
              CALL CUBIC(P,Q,R,NROOTS,H)
```

```
C  FIND THE CORRECT ROOT
              RTEST=RIN
              IF(PCTFUL .LE. 50) RTEST=2.*RIN
              DO 50 I=1,3
              IF(H(I) .GT. 0.0 .AND. H(I) .LT. RTEST)GO TO 55
   50         CONTINUE
              PRINT *,'ERROR, ROOT OF CUBIC NOT FOUND'
              STOP
   55         HH=H(I)
              RINMHH=RIN-HH
C  COMPUTE NTHU41, NLUL4 AND NLUL5 FOR THIS ULLAGE
              IF(HH .LT. RIN) THEN
C   %FULL > 50 AND HH < RIN
                RADULG=RINMHH
                PHI=ACOS(RADULG/RIN)
                NTHU41=(PI-PHI)/DTHETA+1.5
                IF(REGNS(5) .AND. RADULG .LE. ROUT(5)) THEN
                  NLUL5=NLAYRS(5)-RADULG/THKLAY(5)
                  NLUL4=NLAYRS(4)
                ELSE
                  RTEMP=RADULG-ROUT(5)
                  NLUL4=(NLAYRS(4)-RTEMP/THKLAY(4))+1
                  IF(NLUL4 .GT. NLAYRS(4))NLUL4=NLAYRS(4)
                  NLUL5=0
                ENDIF
              ELSE
C  %FULL <= 50 AND HH >= RIN BUT < 2*RIN
                RADULG=HH-RIN
                PHI=ACOS(RADULG/RIN)
                NTHU41=PHI/DTHETA+0.5
                IF(REGNS(5) .AND. RADULG .LE. ROUT(5)) THEN
                  NLUL4=NLAYRS(4)
                  TEMP=ROUT(5)-RADULG
                  NLUL5=TEMP/THKLAY(5)
                ELSE
                  RTEMP=ROUT(4)-RADULG
                  NLUL4=RTEMP/THKLAY(4)
                  NLUL5=0
                ENDIF
              ENDIF
              RADULG=PHI
C   END IF BLOCK FOR CT = '1'
            ELSE
C  CT IS NOT 'C',NOR 'T', NOR '1', AND %FULL < 100.
C   SOMETHING IS WRONG,,  INPUT ULLAGE INFO AGAIN.
              PRINT 3003
CALL                                    ENTRY ULLIN2  IN  ULLINP (431)
              CALL ULLIN2
              GO TO 10
            ENDIF
          ENDIF
        ENDIF
      ENDIF
C     PRINT *,'   ULLAGE CALCULATIONS'
C     PRINT *,PCTFUL,TVOL,TVLQFT,TVULFT,RADULG
      RETURN
C  FORMAT STATEMENTS
 3001 FORMAT('  ***  ERROR ***'/
     1        '   RADIUS OF ULLAGE IS GREATER THAN TANK RADIUS'/
     2        '   ULLAGE RADIUS=',F8.2,' IN.;  TANK RADIUS=',F8.2,' IN.'/
     3'  TANK VOL=',F8.2,'  LIQ VOL=',F8.2,'  VAP VOL=',F8.2,' (FT**3)')
 3002 FORMAT('  ***  ERROR ***'/
     1        '   THE TYPE OF ULLAGE REQUESTED, (',A1,') '/
     2        '   LOW-G CASE WITH ULLAGE AT TOP IS NOT YET AVAILABLE.'/
     3        '   RE-INPUT THE ULLAGE INFORMATION'/
     4        '        OR TYPE IN   Q    TO STOP')
 3003 FORMAT('  ***  ERROR ***'/
     1        '   THE POINTER DESIGNATING THE TYPE OF ULLAGE REQUESTED'/
     2        '   IS NOT ONE OF THE ACCEPTABLE VALUES.'/
     3        '   RE-INPUT THE ULLAGE INFORMATION'/
```

```
     4       '        OR TYPE IN   Q    TO STOP')
      END
C4321SSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSS
      SUBROUTINE CUBIC(P,Q,R,NROOTS,X)
CALLED FROM                                            ULLGET (432)
C  SUBROUTINE TO FIND REAL ROOTS OF A CUBIC EQUATION
C         X**3 + P*X**2 + Q*X +R=0
      DIMENSION X(3)
C     TOPIO3=2.*3.14159/3.= 2.094395102
      DATA TOPIO3/2.094395102/
      PO3=P/3.
      PSQ=P*P
      A=(3.*Q-PSQ)/3.
      B=(2.*P*PSQ-9.0*P*Q+27.*R)/27.0
      ACO27=A*A*A/27
      BSO4= B*B/4
      RADD=BSO4+ACO27
      IF(RADD .LT. 0.) THEN
C  RADD < 0, 3 REAL UNEQUAL ROOTS.
        COSPHI=SQRT(BSO4/(-ACO27))
        PHI=ACOS(COSPHI)
        PHIO3=PHI/3.
        XX= SIGN(2.*SQRT(-A/3.),-B)
        X(1)=XX*COS(PHIO3)-PO3
        X(2)=XX*COS(PHIO3+TOPIO3)-PO3
        X(3)=XX*COS(PHIO3+2.*TOPIO3)-PO3
        NROOTS=3
      ELSE
        IF(RADD .GT. 0.0) THEN
C  RADD > 0, 1 REAL, 2 IMAGINARY ROOTS. RETURN ONLY 1 REAL ROOT.
          TANPHI=(0.5*ATAN(1./SQRT(RADD)))**0.3333333
          COT2PH=(1.-TANPHI*TANPHI)/(2.*TANPHI)
          X(1)=SIGN(2.*SQRT(A/3.)*COT2PH,B)
          NROOTS=1
        ELSE
          IF(RADD .EQ. 0.0) THEN
C  RADD = 0, 3 EQUAL ROOTS.
            X(1)=2.*SQRT(-A/3.)
            X(2)=X(1)
            X(3)=X(1)
            NROOTS=3
          ENDIF
        ENDIF
      ENDIF
      RETURN
      END
C441SSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSS
      SUBROUTINE SPHNDS
CALLED FROM                                            NODES (44)
C   SUBROUTINE TO GENERATE NODE DATA ON A SPHERE
C  NTYP=1, NODES ON A SPHERE
C  IF 3D PROBLEM  DO FOLLOWING LOOP NBETAS  TIMES
C
      COMMON /REGION/ NTHETA,NBETAS,BETA,RIN,TVOL,ROUT(9),
     1                REGNS(9),NLAYRS(9),TEMPS(9),THICK(9),
     2                THKLAY(9),MATRLS(9),MATNMS(9),RGNNMS(9)
      COMMON/STUFF/ NHTT,PI,CONVY,CONVR,THETAO,DTHETA,NBASOS,ROUTSF,
     1 BNCOEF(2)
      COMMON /ULLAGE/ NLUL4,NLUL5,NTHU41,RINMHH,PCTFUL,RADULG,TVULFT,
     1                CT,LG(3),LIQVAP(3)
C
      COMMON /UNITS/ MODU, INPEKO, ISCRCH, SINDA
C
      DIMENSION H(3)
C
      LOGICAL REGNS,SINDA
C
      CHARACTER*1    CT,LG,YN
      CHARACTER*6    LIQVAP
      CHARACTER*10   ULTYPE(3),ULWERE(3)
```

```
      CHARACTER*16  MATNMS
      CHARACTER*25  RGNNMS
C
      DATA ULTYPE /' LOW-G',' LOW-G',' 1-G'/
      DATA ULWERE /'CENTER','TOP','TOP & FLAT'/
C
C  IF THERE IS ULLAGE DETERMINE
C                    WHERE THE ULLAGE IS
C                    WHICH NODES ARE ULLAGE
C                AND WHICH NODES ARE LIQUID
C
C  IF PCTFUL < 100%, THEN
C  IF RGNS 4/5 ARE TRUE AND IF PCTFUL < 100% THEN SOME NODES ARE VAPOR
C       COMPUTE WHICH NODES ARE ULLAGE (VAPOR) NODES
C       ULLAGE MAY BE AT THE CENTER OR AT THE TOP.
C
CALL                                                     ULLGET (432)
        IF(REGNS(4)) CALL ULLGET
C
C  GENERATE THE NODES FOR SPHERICAL WEDGE(S); 5 REGIONS /WEDGE;
C   FOR A 2D MODEL NBETAS=1; FOR A 3D MODEL NBETAS>1.
      DO 100 NB=1,NBETAS
      NBM1NT=(NB-1)*NTHETA
C  GENERATE THE NODES AND WRITE THEM TO UNIT 10 FOR ALL REGIONS.
      DO 101 NR=1,5
      IF(REGNS(NR)) THEN
C  COMPUTE NODEBASE FOR CURRENT REGION.
        NODBAS=2000*NR+ NBM1NT
        TMPTR=TEMPS(NR)
C   SURFACE (ARITHMETIC) NODES, REGION 1, INSIDE TANKWALL.
        NM1=NODBAS-1000
        IF(NR .EQ. 1)THEN
          WRITE(MODU,2001)
CALL                                                     SETUPA (4411)
          CALL SETUPA(NR,4,NM1)
        ENDIF
        IF(NR .EQ. 5)THEN
C  SURFACE (ARITHMETIC) NODES BETWEEN REGION 4 AND REGION 5.
          WRITE(MODU,2002)NR,RGNNMS(NR)
CALL                                                     SETUPA (4411)
          CALL SETUPA(NR,NR,NM1)
        ENDIF
CALL  DIFFUSION NODES, REGIONS 1 TO 5                    SPHDIF (4412)
        WRITE(MODU,2003)NR,RGNNMS(NR)
        NLG=MATRLS(NR)/100
        IF(NR .EQ. 4 .AND. NLG .EQ. 1) THEN
          NGT=1
          IF(CT .EQ. 'T') NGT=2
          IF(CT .EQ. '1') NGT=3
          WRITE(MODU,2004) PCTFUL,ULTYPE(NGT),ULWERE(NGT)
       IF(CT .EQ. 'C') WRITE(MODU,2005) NLUL5,NLAYRS(5),NLUL4,NLAYRS(4)
          IF(CT .EQ. '1') WRITE(MODU,2006) NTHU41
        ENDIF
        CALL SPHDIF(NR,NODBAS)
C   SURFACE (ARITHMETIC) NODES, REGIONS 1, 2 OR 3, OUTSIDE SURFACE.
        IF(NR .LT. 4)THEN
          WRITE(MODU,2002)NR,RGNNMS(NR)
          NP1=NODBAS+1000
C                                                        SETUPA (4411)
          CALL SETUPA(NR,NR,NP1)
        ENDIF
      ENDIF
  101 CONTINUE
  100 CONTINUE
      RETURN
 2001 FORMAT(7X,'REM  SURFACE NODES, INSIDE TANK WALL')
 2002 FORMAT(7X,'REM  SURFACE NODES, OUTSIDE SURFACE, REGION ',I2,
     1       ', ',A25)
 2003 FORMAT(7X,'REM  DIFFUSION NODES, REGION ',I2,', ',A25)
 2004 FORMAT(7X,'REM  THIS MODEL; TANK IS ',F4.0,'% FULL, A',
```

```
     1          A6,' CASE, ULLAGE AT ',A10)                                CRY04200
 2005 FORMAT(7X,'REM  NO. OF LAYERS THAT ARE ULLAGE IN REGION 5 = ',I3,   CRY04210
     1          '  OF ',I3,' LAYERS.'/                                     CRY04220
     2        7X,'REM                              IN REGION 4 = ',I3,   CRY04230
     3          '  OF ',I3,' LAYERS.')                                     CRY04240
 2006 FORMAT(7X,'REM  ULLAGE STARTS AT TANK WALL AT THETA POSITION',       CRY04250
     1          ' NO. ',I3/                                                CRY04260
     2        7X,'REM   (COUNTING FROM SOUTH POLE)')                       CRY04270
      END                                                                  CRY04280
C4411SSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSS       CRY04290
      SUBROUTINE SETUPA(I,NR,NBASE)                                        CRY04300
CALLED FROM                                            SPHNDS(441)         CRY04310
C   CHECK FOR HEAT EXCHANGERS, THEN PUT OUT ARITHMETIC NODES               CRY04320
C                                                                          CRY04330
      COMMON /REGION/ NTHETA,NBETAS,BETA,RIN,TVOL,ROUT(9),                 CRY04340
     1                REGNS(9),NLAYRS(9),TEMPS(9),THICK(9),                CRY04350
     2                THKLAY(9),MATRLS(9),MATNMS(9),RGNNMS(9)              CRY04360
      COMMON /HTXGRS/ NHX,HXTEMP(10),NRHX(10),NLHX(10),                    CRY04370
     1                NTHHX(10),LNGTHX(10)                                 CRY04380
      COMMON /UNITS/ MODU, INPEKO, ISCRCH, SINDA                           CRY04390
C                                                                          CRY04400
      LOGICAL REGNS,SINDA                                                  CRY04410
C                                                                          CRY04420
      DIMENSION NCHX(10),NNODES(10),NODENO(10),NODTYP(10),NOHX(10)         CRY04430
C                                                                          CRY04440
      CHARACTER*16 LABEL1,LABEL2,LABL                                      CRY04450
C                                                                          CRY04460
      DATA LABEL1/'SURFACE NODES'/, LABEL2/'HEAT EXCHANGER'/               CRY04470
C                                                                          CRY04480
      NSECT=1                                                              CRY04490
      NODENO(1)=1                                                          CRY04500
      NNODES(1)=NTHETA                                                     CRY04510
      NODTYP(1)=2                                                          CRY04520
      TMPTR=TEMPS(I)                                                       CRY04530
      IF(NHX .GT. 0) THEN                                                  CRY04540
C    THERE ARE HX'(S) IN THIS GEOMETRY.                                    CRY04550
C                                                                          CRY04560
        NC=0                                                               CRY04570
C                                                                          CRY04580
C     CHECK FOR HX'S IN LAYER 1 OF THIS REGION (NR)                        CRY04590
C     IF ANY, GET HOW MANY HX'S IN THIS LAYER,                             CRY04600
C     THEN PUT THE HX NO. INTO ARRAY NCHX                                  CRY04610
C                                                                          CRY04620
        DO 100 K=1,NHX                                                     CRY04630
        IF(NRHX(K) .EQ. NR) THEN                                           CRY04640
          IF(NLHX(K) .EQ. 1) THEN                                          CRY04650
            NC=NC+1                                                        CRY04660
            NCHX(NC)=K                                                     CRY04670
          ENDIF                                                            CRY04680
        ENDIF                                                              CRY04690
  100   CONTINUE                                                           CRY04700
        NPOS =1                                                            CRY04710
        IF(NC .GT. 0) THEN                                                 CRY04720
C                                                                          CRY04730
C   THERE ARE NC HX'S IN LAYER 1 OF REGION NR.                             CRY04740
C   SORT THE HX'S INTO ASCENDING ORDER BY NTHHX                            CRY04750
          IF(NC .GE. 2) THEN                                               CRY04760
            NCM1=NC-1                                                      CRY04770
            DO 152 KK=1,NCM1                                               CRY04780
            DO 151 K=2,NC                                                  CRY04790
            K1=NCHX(K-1)                                                   CRY04800
            K2=NCHX(K)                                                     CRY04810
            IF(NTHHX(K2) .LT. NTHHX(K1)) THEN                              CRY04820
              NSAV=NCHX(K1)                                                CRY04830
              NCHX(K1)=NCHX(K2)                                            CRY04840
              NCHX(K2)=NSAV                                                CRY04850
            ENDIF                                                          CRY04860
  151       CONTINUE                                                       CRY04870
  152       CONTINUE                                                       CRY04880
          ENDIF                                                            CRY04890
```

```
C     FIND POSITIONS IN THE LAYER, AND PUT OUT THE ARITHMETIC NODES
C     SURROUNDING THE HX'S.
            DO 200 K=1,NC
C           HEAT EXCHANGER NO.
            NUMHX=NCHX(K)
C           GET START THETA AND LENGTH OF THIS HX
            NTHO =NTHHX (NUMHX)
            LNGTH=LNGTHX(NUMHX)
            IF(NTHO .EQ. NPOS) THEN
              NODENO(NSECT)= NPOS
              NNODES(NSECT)= LNGTH
              NOHX(NSECT)  = NUMHX
              NODTYP(NSECT)= 7
              NPOS         = NPOS+NNODES(NSECT)
            ELSE
              NNODES(NSECT)= NTHO-1
              NPOS         = NPOS+NNODES(NSECT)
              NSECT=NSECT+1
              NODENO(NSECT)= NTHO
              NNODES(NSECT)= LNGTH
              NOHX(NSECT)  = NUMHX
              NODTYP(NSECT)= 7
              NPOS         = NPOS+NNODES(NSECT)
            ENDIF
            IF(NPOS .LE. NTHETA) THEN
              NSECT=NSECT+1
              NODENO(NSECT)= NPOS
              NNODES(NSECT)= NTHETA-NPOS+1
              NODTYP(NSECT)= 2
            ELSE
C          NEW POS > NTHETA; LAST HX ENDED AT NTHETA; STOP AND PRINT
              GO TO 250
            ENDIF
  200       CONTINUE
          ENDIF
        ENDIF
C
  250 DO 300 J=1,NSECT
        NNO=NBASE+NODENO(J)
        NNOPN=NNO+NNODES(J)-1
        IF(NODTYP(J) .EQ. 7) THEN
          WRITE(MODU,2001) NOHX(J),NNO,NNOPN
        ELSE
          CALL RITNDS(NNODES(J),NODTYP(J),NNO,1,1,TMPTR,1.0,LABEL1)
        ENDIF
  300 CONTINUE
        RETURN
 2001 FORMAT(7X,'REM HEAT EXCHANGER NO. ',I2,', REPLACES NODES',
     1       I5,' THRU ',I5)
        END
C4412SSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSS
        SUBROUTINE SPHDIF(NR,NODBAS)
CALLED FROM                                                 SPHNDS (441)
C  COMPUTE DIFFUSION NODES FOR ALL NLAY LAYERS OF A SPHERICAL WEDGE.
C  IF A 2D PROBLEM DO ONCE, -- IF 3D PROBLEM DO MORE WEDGES.
C INPUT TO THIS SUBROUTINE
C  NTHETA - NO. OF ANGLES, SOUTH POLE TO NORTH POLE ALONG CIRCUMFERENCE
C  NODBAS - BEGINNING NODE NO.
C  RI     - RADIUS FROM CENTER OF WEDGE TO OUTSIDE SURFACE OF REGION
C  SIGN   - MULTIPLIER TO CHANGE RADIUS FROM LAYER TO LAYER,  (+1 OR -1)
C  THICK  - THICKNESS OF REGION
C  NLAY   - NO. OF LAYERS THRU THE REGION
C  TEMP   - INITIAL TEMPERATURE OF THE REGION
C  BETA   - ANGLE OF THE WEDGE (RAD). FOR 2D MODEL BETA IS USUALLY -1.
C  MATN   - MATERIAL NO. FOR THIS REGION
C  MATNAM - NAME OF MATERIAL
C
C    TH      -  THICKNESS OF THE LAYER
C    THETA1, THETA2 - ANGLES FROM HORIZONTAL TO FARTHEST SIDE OF LAYER
C                                  AND  TO NEAREST SIDE RESPECTIVLY
```

```
C                                               THETA1 IS .GT. THETA2
C     R  - RADIUS FROM CENTER OF SPHERE TO OUTSIDE SURFACE OF LAYER.
C
C  NARY  - NMAT+1000, SINDA ARRAY NO. FOR CP*RHO TABLE
C                NMAT - 1XX FOR LIQUID MATERIAL NUMBER.
C                NMAT - 2XX FOR SOLID MATERIAL NUMBER.
C                NMAT - 3XX FOR VAPOR MATERIAL NUMBER.
C                      FOR VAPOR CORRESPONDING TO THE LIQUID ABOVE.
C
C
      COMMON /REGION/ NTHETA,NBETAS,BETA,RIN,TVOL,ROUT(9),
     1                REGNS(9),NLAYRS(9),TEMPS(9),THICK(9),
     2                THKLAY(9),MATRLS(9),MATNMS(9),RGNNMS(9)
      COMMON/STUFF/ NHTT,PI,CONVY,CONVR,THETA0,DTHETA,NBASOS,ROUTSF,
     1  BNCOEF(2)
      COMMON /ULLAGE/ NLUL4,NLUL5,NTHU41,RINMHH,PCTFUL,RADULG,TVULFT,
     1                CT,LG(3),LIQVAP(3)
      COMMON /UNITS/ MODU, INPEKO, ISCRCH, SINDA
C
      CHARACTER*1   CT,LG
      CHARACTER*1   DASH
      CHARACTER*6   LIQVAP
      CHARACTER*16  MATNMS
      CHARACTER*16  NAME
      CHARACTER*25  RGNNMS
C
      LOGICAL REGNS, SINDA
C
C     DIMENSION VOLLAY(2,20)
C
C
C     DATA VOLSUM/0.0/,  SUMVLI/0.0/
      DATA DASH/'-'/
C
      NSECT=-1
      NLAY=NLAYRS(NR)
      TH=THKLAY(NR)
      IL=NR-3
C     NSUML=0
C  SET NXX FOR ARRAY NO. - MATERIAL NUMBER
      NXX=MATRLS(NR)
      NLGR=NXX/100
      IF(NLGR .LE. 0 .OR. NLGR .GT. 3) NLGR=2
C     PRINT 9898,NR,NXX,NL,CT,MATRLS,MATNMS
C9898 FORMAT('     IN SPHDIF, NR,NXX,MATRLS=',2I5,I6,2X,A4/9I5/(5A15))
C   SET NNNM =1000 FOR  PROPERTY   CP*RHO
      NNNM=1000
      DO 125 NL=1,NLAY
C  SET NLVG=0, MATERIAL IS THE SAME FOR ENTIRE LAYER
      WRITE(MODU,2002)NR,NL
      NVLG=0
      NLG=NLGR
      IF(NR .GE. 4) THEN
        IF(NR .EQ. 4) THEN
          IF(NLAY .EQ. 1 .AND. .NOT. REGNS(5) .AND.
     1        CONVR .NE. 0.0 .AND. CONVY .EQ. 0.0) THEN
            CALL CLEARS
            PRINT 2001,LIQVAP(NLGR)
            CALL READIN(NCON,1,2)
            IF(NCON .EQ. 1) THEN
C   SINGLE NODES IN REGION 4 ARE CONSTANT BOUNDARY NODES
              NNODE=NODBAS+1
              IF(NLG .EQ. 2) THEN
               NAME=MATNMS(NR)
              ELSE
               NAME=LG(NLG)//DASH//MATNMS(NR)
              ENDIF
CALL                                                RITNDS (443)
              CALL RITNDS(NTHETA,3,NNODE,1,1,TEMPS(NR),1,NAME)
              RETURN
```

```
          ENDIF
        ENDIF
C  END IF BLOCKS(COL 11);R5=.F.,CONVR>0,GEN BDY NODES IN RGN 4, RETURN.
      ENDIF
      CALL ULLCHK(NR,NL,NLVG,NYYL)
      IF(NLVG .EQ. 0) THEN
        IF(NLGR .EQ. 1 .AND. NYYL .EQ. 200) THEN
          NYY=NYYL
          NLG=3
        ENDIF
      ELSE
        NTHU=NYYL
      ENDIF
    ENDIF
C  END IF BLOCK(COL 7);NR>= 4, GENS BDY NODES IN RGN 4  OR CALLS ULLCHK
    NSECT=NSECT+1
    IF(NR .LT. 4) EL=NLAY-NL+1
    IF(NR .GE. 4) EL=NL
    R= ROUT(NR)-TH*(EL-.5)
    NNODE=NODBAS+NTHETA*(NSECT)
C   IF(NR .GE. 4)VOLLAY(IL,NL)=0.
C  BEGIN 130 LOOP, WRITE OUT THE NODES FOR THE LAYER NL(125 LOOP)
    DO 130 J=1,NTHETA,2
    NNODE=NNODE+1
    JJJ=J/2
C  SET NARY FOR ARRAY NO.
CALL                                                   AREASP (451)
    CALL AREASP(1,JJJ,R,1.,AREA)
    VOL=AREA*TH
    NMANY=2
    NJ=NTHETA-J
    IF( NJ .LE. 0) NMANY=1
    IF(NLVG .EQ. 0) THEN
C    NLVG=0; NODES ARE SAME MATERIAL FOR ENTIRE LAYER.
C      IF(NR .GE. 4) SMRGNI=SMRGNI+NMANY*VOL
C      IF(NR .GE. 4) VOLLAY(IL,NL)=VOLLAY(IL,NL)+NMANY*VOL
C      VOLSUM=SUM ALL NODES(IN3); VOLLAY=SUM EACH LAYER(IN3)
      NARY=NNNM+NXX+NYY
      IF(NLG .EQ. 2) THEN
        NAME=MATNMS(NR)
      ELSE
        NAME=LG(NLG)//DASH//MATNMS(NR)
      ENDIF
CALL                                                   RITNDS (443)
      CALL RITNDS(NMANY,1,NNODE,NJ,NARY,TEMPS(NR),VOL,NAME)
    ELSE
C  TO HERE IF NLVG=1, MATERIALS NOT SAME OVER ENTIRE LAYER
C  THIS STILL PUTS OUT 2 NODES IF NMANY=2, BUT PUTS THEM OUT
C  ONE AT A TIME. BECAUSE THE 2 NODES MAY BE OF DIFFERENT
C  MATERIALS,  NARY AND NAME MAY BE DIFFERENT FOR THE 2 CALLS
C  TO RITNDS. TEMPS AND VOL WILL BE THE SAME.
      NMNY=1
      NNJ=0
      IF(CT .EQ. '1') THEN
        NYY=0
        NLG1=NLGR
        NLG2=NLGR
        IF(JJJ+1 .GE. NTHU .AND. NLGR .EQ. 1) THEN
          NYY=200
          NLG1=3
        ENDIF
      ENDIF
      NARY=NNNM+NXX+NYY
      IF(NLG1 .EQ. 2) THEN
        NAME=MATNMS(NR)
      ELSE
        NAME=LG(NLG1)//DASH//MATNMS(NR)
      ENDIF
C     PRINT *,'NLG1',NR,JJJ,NTHU,NLGR,NLG1,LG(NLG1),MATNMS(NR),NAME
CALL                                                   RITNDS (443)
```

```
        CALL RITNDS(NMNY,1,NNODE,NNJ,NARY,TEMPS(NR),VOL,NAME)
        IF(NMANY .EQ. 2) THEN
          NODE2=NNODE+NJ
          IF(CT .EQ. '1') THEN
            NYY=0
            IF(JJJ+NJ+1 .GE. NTHU .AND. NLGR .EQ. 1) THEN
              NYY=200
              NLG2=3
            ENDIF
          ENDIF
          NARY=NNNM+NXX+NYY
          IF(NLG2 .EQ. 2) THEN
            NAME=MATNMS(NR)
          ELSE
            NAME=LG(NLG2)//DASH//MATNMS(NR)
          ENDIF
C       PRINT *,'NLG2',NR,JJJ,NTHU,NLGR,NLG2,LG(NLG2),MATNMS(NR),NAME
          CALL RITNDS(NMNY,1,NODE2,NNJ,NARY,TEMPS(NR),VOL,NAME)
        ENDIF
      ENDIF
  130 CONTINUE
C     IF(NR .GE. 4) THEN
C     SUMVLI=SUMVLI+VOLLAY(IL,NL)
C     NSUML=NSUML+1
C     ENDIF
  125 CONTINUE
C     IF(NR .GE. 4) THEN
C     SMRGNF=SMRGNI/1728.
C     VOLSUM=VOLSUM+SMRGNI
C     VOLSFT=VOLSUM/1728.
C     WDGVFT=WDGVIN/1728.
C     PRINT 9999,NR,TVOL,WDGVFT,WDGVIN,WVLQIN,WVULIN,RADULG,NULL
C    1SMRGNI,SMRGNF,VOLSUM,VOLSFT
C     PRINT 9997,NR,(VOLLAY(IL,LL),LL=1,NLAY)
C     SUMVLF=SUMVLI/1728.
C     PRINT 9998,NSUML,SUMVLI,SUMVLF
C     ENDIF
      RETURN
C  FORMATS
 2001 FORMAT(///'   THIS MODEL HAS ONLY 1 ',A6,' NODE AT EACH THETA',
     1       ' IN REG 4,'/
     2       '      AND THE HEAT TRANSFER TO THE TANK WALL IS'/
     3       '      CONVECTION. ARE THE NODES IN REGION 4 TO BE'/
     4       '         1. CONSTANT VALUE BNDY NODES?'/
     5       '    OR  2. DIFFUSION NODES THAT VARY?'/
     6       '     TYPE  IN 1  OR  2')
 2002 FORMAT(7X,'REM   REGION ',I2,',  LAYER NO. ',I3)
C9997 FORMAT('  REGION ',I2,'  VOL OF EACH LAYER'/
C    1       (5F15.4))
C9999 FORMAT(' IN SUB SPHNDS, REGION ',I2/
C    1     '      TVOL(FT3)=      ',F10.4,
C    2     '      WEDGE VOL(FT3)=',F10.4,
C    2     '      WEDGE VOL(IN3)=',F10.4/
C    2     '     LIQUID VOL(IN3)=',F10.4,
C    2     '     ULLAGE VOL(IN3)=',F10.4/
C    3     ' COMP RGN VOL(IN3)=',F10.4,' COMP RGN VOL(FT3)=',F10.4/
C    4     ' COMP WDG VOL(IN3)=',F10.4,' COMP WDG VOL(FT3)=',F10.4)
C9998 FORMAT('NSUM=',I4,'  VSUMLAYERS=',F10.4,';  VSUM FT3=',F10.4)
      END
C44121SSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSS
      SUBROUTINE ULLCHK(NR,LN,NLVG,NYY)
CALLED FROM    SPHDIF (4412)     RADCON (4611)      CIRCON (4612)
C   THIS SUBROUTINE CHECKS THE TYPE OF ULLAGE FOR REGION NR.
C   AND COMPUTES WHERE IT STARTS; IE
C    WHEN CT = '1', AT WHICH THETA ANGLE, COUNTING FROM SOUTH POLE,
C   DOES THE ULLAGE START FOR THE CURRENT LAYER  LN.
C    OR WHEN CT = 'C', IS THE CURRENT LAYER ULLAGE OR NOT.
C   ULLCHK IS CALLED  WHEN:  NR (REGION NO.)  >= 4
C             NR    = REGION NO.
C             LN    = CURRENT LAYER NO.
```

```
C     NLVG AND NYY ARE RETURNED TO THE CALLING PROGRAM.
C          NLAY - NO OF LAYERS IN REGION NR
C
      COMMON /REGION/ NTHETA,NBETAS,BETA,RIN,TVOL,ROUT(9),
     1                REGNS(9),NLAYRS(9),TEMPS(9),THICK(9),
     2                THKLAY(9),MATRLS(9),MATNMS(9),RGNNMS(9)
      COMMON /ULLAGE/ NLUL4,NLUL5,NTHU41,RINMHH,PCTFUL,RADULG,TVULFT,
     1                CT,LG(3),LIQVAP(3)
      COMMON/STUFF/ NHTT,PI,CONVY,CONVR,THETA0,DTHETA,NBASOS,ROUTSF,
     1  BNCOEF(2)
C
      LOGICAL REGNS
C
      CHARACTER*1   CT,LG
      CHARACTER*16  MATNMS
      CHARACTER*16  LABLE
      CHARACTER*25  RGNNMS
      CHARACTER*6   LIQVAP
C
      NYY=0
      NLVG=0
      IF(LN .LE. 0) RETURN
      NLAY=NLAYRS(NR)
C
      IF(CT .EQ. 'F') RETURN
      IF(CT .EQ. '0' .OR. CT .EQ. 'O') THEN
C  CT=0, TANK EMPTY, ALL NODES ARE VAPOR
        NYY=200
        RETURN
      ENDIF
C  END OF IF BLOCK FOR EMPTY TANK
      IF(CT .EQ. 'C') THEN
C   CT =C, I.E. ULLAGE IS AT CENTER OF SPHERE
        IF(NR .EQ. 4) THEN
          IF(NLUL4 .GT. 0) THEN
            IF(NLAY-LN-NLUL4 .LT. 0) THEN
              NYY=200
            ENDIF
          ENDIF
        ELSE
          IF(NLUL5 .GT. 0) THEN
            IF(NLAY-LN-NLUL5 .LT. 0) THEN
              NYY=200
            ENDIF
          ENDIF
        ENDIF
        RETURN
      ENDIF
C  END OF IF BLOCK FOR CT = 'C'
      IF(CT .EQ. '1') THEN
C  CT=1;  1-G ANALYSIS, ULLAGE ON TOP AND FLAT
C   FOR THIS CONDITION NODES. IN A LAYER MAY BE DIFFERENT MATERIALS
C   THE ANGLE PHI IS THE ANGLE FROM THE VERTICAL HEMISPHERE TO THE
C   RADIUS DEFINING NTHU41, THE THETA WHERE THE ULLAGE STARTS IN
C   LAYER 1 OF REGION 4.
C   PHI IS IN THE COMMON VARIABLE RADULG WHEN CT=1 AND NLVG = 1.
C    SET NLVG=1, MATERIALS NOT SAME FOR ENTIRE LAYER
C  COMPUTE NTHU FOR THIS LAYER.
C    NTHU = NO. OF THETA WHERE MATERIAL CHANGES FROM LIQUID TO VAPOR
C
        NLVG=1
        IF(NTHU41 .GT. 0) THEN
          IF(NR .EQ. 4 .AND. LN .EQ. 1) THEN
            NTHU=NTHU41
          ELSE
C   NR = 4 AND LN > 1; OR  NR=5 FOR ALL LN
            PHI=RADULG
            IF(RINMHH .EQ. 0.) THEN
              NTHU = NTHETA/2
            ELSE
```

```
              IF(RINMHH .GT. 0) THEN                                    CRY08400
C    %FUL > 50% AND RIN-HH >0;  RADIUS OF ULG  FROM CENTER UP. (COL 13 IFCRY08410
                YULL=RINMHH                                             CRY08420
                ISIGN=1                                                 CRY08430
                NDO=NTHETA                                              CRY08440
                INC=1                                                   CRY08450
              ELSE                                                      CRY08460
C    %FUL < 50% AND RIN-HH <0;  RADIUS OF ULG  FROM CENTER DOWN.        CRY08470
                YULL=-RINMHH                                            CRY08480
                ISIGN=-1                                                CRY08490
                NDO=1                                                   CRY08500
                INC=-1                                                  CRY08510
              ENDIF                                                     CRY08520
            ENDIF                                                       CRY08530
            IF(NR .EQ. 4) R=RIN-(LN-1)*THKLAY(4)                        CRY08540
            IF(NR .EQ. 5) R=ROUT(5)-(LN-1)*THKLAY(5)                    CRY08550
            IF(R .LT. YULL) THEN                                        CRY08560
              NTHU=0                                                    CRY08570
            ELSE                                                        CRY08580
              UANG=PI/2.-PHI+DTHETA/2.                                  CRY08590
              DO 100 I=NTHU41,NDO,INC                                   CRY08600
              NCOUNT=I-NTHU41                                           CRY08610
              Y=R*SIN(UANG)                                             CRY08620
              IF(Y .GE. YULL) THEN                                      CRY08630
                NTHU=NTHU41+ISIGN*NCOUNT                                CRY08640
                GO TO 101                                               CRY08650
              ELSE                                                      CRY08660
                UANG=UANG+DTHETA                                        CRY08670
              ENDIF                                                     CRY08680
  100         CONTINUE                                                  CRY08690
              NTHU=NTHETA+1                                             CRY08700
  101         CONTINUE                                                  CRY08710
            ENDIF                                                       CRY08720
          ENDIF                                                         CRY08730
        ENDIF                                                           CRY08740
        NYY=NTHU                                                        CRY08750
C       PRINT *,'ULLCHK',CT,NR,LN,NTHU41,ISIGN,NDO,INC,RINMHH,          CRY08760
C    1         YULL,R,Y,UANG,NCOUNT,NTHU,NYY,NLVG                       CRY08770
        RETURN                                                          CRY08780
      ENDIF                                                             CRY08790
C  END OF IF BLOCK FOR  CT = '1'                                        CRY08800
      IF(CT .EQ. 'T') THEN                                              CRY08810
C  CT= T;  ULLAGE IS AT THE TOP OF THE SPHERE                           CRY08820
C    THIS OPTION IS NOT YET AVAILABLE.                                  CRY08830
C                                                                       CRY08840
      ENDIF                                                             CRY08850
C  END OF IF BLOCK FOR  CT = 'T'                                        CRY08860
      RETURN                                                            CRY08870
      END                                                               CRY08880
C461SSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSS CRY08890
      SUBROUTINE SPHCDS                                                 CRY08900
CALLED FROM                                            CONDRS  (46)     CRY08910
C  SUBROUTINE TO GENERATE CONDUCTOR DATA FOR SPHERE WEDGE.              CRY08920
C                                                                       CRY08930
C  NARY = 6000 + NXX, SINDA ARRAY NO. FOR K, (THERMAL CONDUCTIVITY).    CRY08940
C                 WHERE  NXX = MATERIAL NO. AS INPUT BY USER.           CRY08950
C                        NXX = 1XX,  LIQUID MATERIAL NO.                CRY08960
C                        NXX = 2XX,  SOLID  MATERIAL NO.                CRY08970
C                        NXX = 3XX,  VAPOR  MATERIAL NO.                CRY08980
C                                                                       CRY08990
      COMMON /REGION/ NTHETA,NBETAS,BETA,RIN,TVOL,ROUT(9),              CRY09000
     1                REGNS(9),NLAYRS(9),TEMPS(9),THICK(9),             CRY09010
     2                THKLAY(9),MATRLS(9),MATNMS(9),RGNNMS(9)           CRY09020
      COMMON /HTXGRS/ NHX,HXTEMP(10),NRHX(10),NLHX(10),                 CRY09030
     1                NTHHX(10),LNGTHX(10)                              CRY09040
      COMMON/STUFF/ NHTT,PI,CONVY,CONVR,THETAO,DTHETA,NBASOS,ROUTSF,    CRY09050
     1  BNCOEF(2)                                                       CRY09060
      COMMON /ULLAGE/ NLUL4,NLUL5,NTHU41,RINMHH,PCTFUL,RADULG,TVULFT,   CRY09070
     1                CT,LG(3),LIQVAP(3)                                CRY09080
      COMMON /UNITS/ MODU, INPEKO, ISCRCH, SINDA                        CRY09090
```

```
C
      DIMENSION NHXADL(10)
C
      LOGICAL REGNS, SINDA
C
      CHARACTER*1   CT,LG
      CHARACTER*6   LIQVAP
      CHARACTER*10  ATOSL(2)
      CHARACTER*16  MATNMS
      CHARACTER*16  LABLE
      CHARACTER*25  RGNNMS
C
      DATA ATOSL / 'CONVECTION',  'RADIATION'/
C
C   IF NHTT =1  CONDUCTION ONLY           IN REGIONS 4 AND 5
C   IF NHTT =2  CONVECTION ONLY           IN REGIONS 4 AND 5
C   IF NHTT =3  CONDUCTION AND CONVECTION IN REGIONS 4 AND 5
C
      NG=0
      NS=1
C
C   GENERATE RADIAL CONDUCTORS, (CONDUCTION)
C   DO REGIONS IN ORDER, 1, 2, 3 FROM RIN TO OUT
C                        4, 5    FROM RIN INWARD
C
      NG=1
      DO 100 NR=1,5
C  RADIAL AND CIRCUMFERENTIAL CONDUCTORS, (CONDUCTION), ALL REGIONS
      IF(REGNS(NR)) THEN
        IF(NR .GE. 4 .AND. NHTT .EQ. 2) GO TO 110
        WRITE(MODU,2001)
CALL                                                   RADCON (4611)
        CALL RADCON(NR,1,NG)
        WRITE(MODU,2002)
CALL                                                   CIRCON (4612)
        CALL CIRCON(NR,1,NG)
  110   CONTINUE
      ENDIF
  100 CONTINUE
C  END OF IF BLOCKS FOR  CONDUCTION CONDUCTORS IN ALL REGIONS.
C   NOW GENERATE CONVECTION CONDUCTORS IN REGIONS 4,5 IF NHTT >= 2.
      IF(NHTT .GE. 2) THEN
        IF(CONVR .NE. 0.0) THEN
C  RADIAL CONDUCTORS, (CONVECTION)
          WRITE(MODU,2003)
          DO 330 NR=4,5
          IF(REGNS(NR)) THEN
CALL                                                   RADCON (4611)
            CALL RADCON(NR,2,NG)
          ENDIF
  330     CONTINUE
        ENDIF
C
        IF(CONVY .NE. 0.0) THEN
C  CIRCUMFERENTIAL CONDUCTORS, (CONVECTION)
          WRITE(MODU,2004)
          DO 340 NR=4,5
          IF(REGNS(NR)) THEN
CALL                                                   CIRCON (4612)
            CALL CIRCON(NR,2,NG)
          ENDIF
  340     CONTINUE
        ENDIF
      ENDIF
C END OF IF BLOCKS FOR CONVECTION CONDUCTORS IN REGIONS 4,5.
C
C   CONDUCTORS FROM OUTSIDE 'ATMOSPHERE' NODE (20301) TO SPHERE
C   OUTER SURFACE, IF ANY.  IF(TEMPS(8) .NE. -9999.9) THEN THERE
C   IS A NODE OUTSIDE, GENERATE THE CONDUCTORS.
C
```

```
      IG =1
      IA =0
      IB =1
      NAA  =1
      NTP = 3
      NR=1
      IF(REGNS(2)) NR=2
      IF(REGNS(3)) NR=3
      RAD=ROUT(NR)
      NODBAS=2000*NR+1000
      DO 401 II=1,2
      IF(BNCOEF(II) .NE. 0.0) THEN
        NCR=NLAYRS(7+II)
        LABLE=ATOSL(NCR)
        WRITE(MODU,2007) LABLE
        NA=20300+II
        NB=NODBAS
        DO 410 J=1,NTHETA,2
        JJJ=J/2
        CALL AREASP(1,JJJ,RAD,TH,AREA)
        FA = BNCOEF(II)*AREA
        NG=NG+NS
        NS=2
        NJ =NTHETA-J
        IF(NJ .LE. 0) NS=1
        NB=NB+1
CALL                                                    RITCND (4613)
        CALL RITCND(NTP,NG,NS,IG,NA,IA,NB,NJ,NAA,NAB,FA,FB,LABLE)
  410   CONTINUE
      ENDIF
  401 CONTINUE
      RETURN
C   FORMATS
 2001 FORMAT(7X,'REM  RADIAL CONDUCTORS,  CONDUCTION')
 2002 FORMAT(7X,'REM  CIRCUMFERENTIAL CONDUCTORS; Y- DIRECTION,',
     1        '  CONDUCTION')
 2003 FORMAT(7X,'REM  RADIAL CONDUCTORS,  CONVECTION')
 2004 FORMAT(7X,'REM  CIRCUMFERENTIAL CONDUCTORS; Y- DIRECTION,',
     1        '  CONVECTION')
 2007 FORMAT(7X,'REM  ',A10,' CONDUCTORS; ATMOSPHERE TO OUTER SURFACE')
      END
C4611SSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSS
      SUBROUTINE RADCON(NR,NCC,NG)
CALLED FROM                                                SPHCDS (461)
C  SUBROUTINE TO GENERATE RADIAL CONDUCTOR DATA FOR SPHERE WEDGE.
C
C  COMPUTE RADIAL CONDUCTORS FOR REGION NR.
C  IF NCC =1, COMPUTE CONDUCTION CONDUCTORS IN REGIONS 4 AND 5.
C  IF NCC =2, COMPUTE CONVECTION CONDUCTORS IN REGIONS 4 AND 5.
C
C  NARY = 6000 + NXX, SINDA ARRAY NO. FOR K,(THERMAL CONDUCTIVITY).
C                WHERE  NXX = MATERIAL NO. AS INPUT BY USER.
C                       NXX = 1XX,  LIQUID MATERIAL NO.
C                       NXX = 2XX,  SOLID  MATERIAL NO.
C                       NXX = 3XX,  VAPOR  MATERIAL NO.
C
      COMMON /REGION/ NTHETA,NBETAS,BETA,RIN,TVOL,ROUT(9),
     1                REGNS(9),NLAYRS(9),TEMPS(9),THICK(9),
     2                THKLAY(9),MATRLS(9),MATNMS(9),RGNNMS(9)
      COMMON /HTXGRS/ NHX,HXTEMP(10),NRHX(10),NLHX(10),
     1                NTHHX(10),LNGTHX(10)
      COMMON/STUFF/ NHTT,PI,CONVY,CONVR,THETAO,DTHETA,NBASOS,ROUTSF,
     1 BNCOEF(2)
      COMMON /ULLAGE/ NLUL4,NLUL5,NTHU41,RINMHH,PCTFUL,RADULG,TVULFT,
     1                CT,LG(3),LIQVAP(3)
      COMMON /CONDUL/ MA,MB,NC,NARAY,NLVGA,NLVGB,NYYA,NYYB
      COMMON /UNITS/ MODU, INPEKO, ISCRCH, SINDA
C
      DIMENSION NHXADL(10)
C
```

```
      LOGICAL REGNS,SINDA
C
      CHARACTER*1   CT,LG
      CHARACTER*6   LIQVAP
      CHARACTER*16  MATNMS
      CHARACTER*16  LABLE
      CHARACTER*25  RGNNMS
C
C   GENERATE RADIAL CONDUCTORS.
C   DO REGIONS IN ORDER, 1, 2, 3 FROM RIN TO OUT
C                        4, 5    FROM RIN INWARD
C
      SIGN=1.0
      IF(NR .GE. 4) SIGN=-1.0
      NLAY=NLAYRS(NR)
      NLP1=NLAY+1
      TH=THKLAY(NR)
      EL=TH/2.
C   RAD - INSIDE RADIUS OF REGION  NR.
      RAD=RIN
      IF(NR .EQ. 2) RAD=RIN+THICK(1)
      IF(NR .EQ. 3) RAD=RIN+THICK(1)+THICK(2)
      IF(NR .EQ. 5) RAD=RIN-THICK(4)
      NODBAS=2000*NR
C   SET  ARRAY NOS. FOR K,  MATERIAL NO. + 6000.  PROPERTY NMAT.
      NARAY=MATRLS(NR)+6000
      NLGR=MATRLS(NR)/100
      DO 110 L=1,NLP1
      IF(NR .EQ. 5 .AND. L .EQ. NLP1) GO TO 110
      IF(NR .EQ. 4 .AND. L .EQ. NLP1 .AND. .NOT. REGNS(5)) GO TO 110
      IF(L .EQ. 1)THEN
C  CONDUCTORS LAYER 1  TO REGION BOUNDARY; NA=BOUNDARY, NB=INTERIOR.
C  TEST FOR HEAT EXCHANGERS ON TOP OF LAYER CORRESPONDING TO
C  NODES NA, (NODBAS-1000).  IF THERE ARE ANY GET NO. OF HX'S ON THIS
C  LAYER, AND WHICH HX'S THEY ARE.
C  GET REGION NO. WHICH CONTAINS THE HX  ADJACENT TO THIS LAYER (1).
C NR=1, ADJR=4; NR=2, ADJR=1; NR=3, ADJR=2; NR=4,ADJR=4; NR=5,ADJR=5.
        NCT=1
        NLTEST=1
        NADJR=NR/4+NR-1
        IF(NADJR .LE. 0) NADJR=4
        NTP=5
        NA=NODBAS-1000
        IF(NR .EQ. 4) NA=1000
        NB=NODBAS
        RADA=RAD+SIGN*TH/4.
        RADB=RADA
        RADAB=RADA
        LTOUCA=1
        LTOUCB=1
        NEXT=NADJR
        IF(NR .EQ. 4) NEXT=1
        IF(NR .EQ. 5) NEXT=4
        WRITE(MODU,2002) NR,L,NR,NEXT
       ELSE
        IF(L .EQ. NLP1) THEN
C  CONDUCTORS LAYER  NLAY TO REGION BOUNDARY
C   TEST FOR HEAT EXCHANGERS ON TOP OF LAYER CORRESPONDING TO
C   NODES NB, (NODBAS+1000).  IF THERE ARE ANY GET NO. OF HX'S ON THIS
C   LAYER, AND WHICH HX'S THEY ARE.
C  GET REGION NO. WHICH CONTAINS THE HX  ADJACENT TO THIS LAYER (NLP1).
C NR=1, ADJR=1; NR=2, ADJR=2; NR=3, ADJR=3; NR=4,ADJR=5; NR=5,ADJR=0.
          NCT=3
          NTP=5
          NLTEST=1
          NADJR=MOD(NR,5)
          IF(NR .EQ. 4) NADJR=5
          IF(NR .LT. 5) THEN
            NA=NODBAS+(NLAY-1)*NTHETA
            NB=NODBAS+1000
```

```
            RADA=RAD+SIGN*(THICK(NR)- TH/4.)
            RADB=RADA
            RADAB=RADA
          ENDIF
          LTOUCA=NLAY
          LTOUCB=NLAY
          NEXT=NADJR
          IF(NR .LT. 4) NEXT=NADJR+1
          WRITE(MODU,2002) NR,NLAY,NR,NEXT
        ELSE
C  CONDUCTORS  LAYER TO LAYER INSIDE OF REGION.
          NCT=2
          NTP=7
          NADJR=NR
          IF(NR .LE. 3) THEN
            NLTEST=NLAY-L+2
          ELSE
            NLTEST=L
          ENDIF
          LM1=L-1
          ELM1=LM1
          ELM2=ELM1-1.
          NA=NTHETA*ELM2+NODBAS
          NB=NA+NTHETA
          RADAB=RAD+SIGN*TH*ELM1
          RADA=RAD+SIGN*(TH*ELM1-TH/4.)
          RADB=RAD+SIGN*(TH*ELM1+TH/4.)
          LTOUCA=L-1
          LTOUCB=L
          WRITE(MODU,2003) NR,LM1,L
        ENDIF
      ENDIF
C   TEST FOR HX(S) ON THE BOUNDARY OF THE LAYER TO LAYER CONDS.
C   OR FOR HX(S) ON THE BOUNDARY OF THE LAYER TO REGION BOUNDARY CONDS.
C   GET HOW MANY AND WHICH ONES THEY ARE.
      NHXS=0
      DO 120 K=1,NHX
      IF(NRHX(K) .EQ. NADJR) THEN
C   TEST FOR HX IN APPROPRIATE LAYER OF ADJACENT REGION.
        IF(NLHX(K) .EQ. NLTEST) THEN
          NHXS=NHXS+1
          NHXADL(NHXS)=K
        ENDIF
      ENDIF
  120 CONTINUE
C     PRINT *,NR,L,NADJR,NLTEST,NCT,NHX,NHXS,(NHXADL(K),K=1,NHXS),
C    1  NA,NB
C  IF LL = 1,2 OR 3 THE MATERIALS IN MATRLS(NR) WILL BE 2XX.
C  IF LL = 4 OR 5 THE MATERIALS MAY BE; 1XX (LIQUID)
C                                       2XX  (SOLID)
C                                    OR 3XX  (VAPOR)
C      IF MATRL = 1XX; THE PROPERTY IS LIQ., ULLAGE IS VAPOR.
C      IF MATRL = 2XX; THE PROPERTY IS A SOLID. IF NR >= 4,
C                     THEN CT MUST BE = 'F'. IF NOT USE AS SUCH.
C      IF MATRL = 3XX; THE PROPERTY IS VAPOR, USE ALL NODES AS SUCH.
C
      NYYA=0
      NYYB=0
      NLVGA=0
      NLVGB=0
      IF(NR .GE. 4) THEN
CALL                                                  ULLCHK (44121)
        CALL ULLCHK(NR,LTOUCA,NLVGA,NYYA)
        CALL ULLCHK(NR,LTOUCB,NLVGB,NYYB)
      ENDIF
C
C  GENERATE THE CONDUCTORS FOR THE CURRENT VALUE OF L. (LOOP 110)
C L=1,          LAYER 1 TO BOUNDARY
C L=2 TO NLAY,  LAYER (L-1) TO LAYER L
C L=NLAY+1,     LAYER L TO BOUNDARY
```

```
      DO 130 J=1,NTHETA,2
      JJJ=J/2
      NA=NA+1
      NB=NB+1
      NMANY=2
      NJ=NTHETA-J
      IF(NJ .LE. 0) THEN
        NMANY=1
        NL=0
      ENDIF
      IA=NJ
      IB=IA
      IG=1
      MA=NA
      MB=NB
      NC=NMANY
      NT=NTP
        NNJ=0
      IF(NC .EQ. 1) NT=NTP-1
C
      IF(NCC .EQ. 1) THEN
C  NCC=1, CONDUCTION CONDUCTORS
        CALL AREASP(1,JJJ,RADA,TH,AREA)
        FA = AREA/EL
        CALL AREASP(1,JJJ,RADB,TH,AREA)
        FB = AREA/EL
      ELSE
C   NCC=2, CONVECTION CONDUCTORS
        CALL AREASP(1,JJJ,RADAB,TH,AREA)
        XAA=AREA
        XAB=CONVR
        IF(NC .EQ. 2) THEN
C  2 CONDUCTORS TO BE PUT OUT, USE GEN
          NTP=3
        ELSE
C  1 CONDUCTOR TO BE PUT OUT, USE CAL
          NTP=2
        ENDIF
      ENDIF
C
C  TEST IF THERE ANY HEAT EXCHANGERS ON THIS LAYER.
      IF(NHXS .GT. 0) THEN
C   THERE ARE HEAT EXCHANGERS ON THIS BOUNDARY
C    SET CONTROLS TO PUT OUT 1 CONDUCTOR AT A TIME FOR THETA1 AND
C    THETA2(MIRROR THETA)
        NC=1
        IF(NCC .EQ. 1) THEN
          NT=4
        ELSE
          NT=2
        ENDIF
C  TEST FOR THIS THETA IN A RANGE OF AN HX ON THIS BOUNDARY
        NTKK=1
        NTEST=(J+1)/2
  145   CONTINUE
        DO 140 KK=1,NHXS
        NKK=NHXADL(KK)
        NLO=NTHHX(NKK)
        NHI=NLO+LNGTHX(NKK)-1
        IF(NTEST .GE. NLO .AND. NTEST .LE. NHI) THEN
          IF(NCT .EQ. 3) THEN
            MB=20000+NKK
          ELSE
            MA=20000+NKK
            FA=FB
          ENDIF
C   THIS THETA IS WITHIN THE RANGE OF THE HX
        ENDIF
C  END OF IF BLOCK TO TEST FOR THETA WITHIN THE RANGE OF THE HX
  140   CONTINUE
```

```
        IF(NCC .EQ. 1) THEN
          CALL SETARY(NR,JJJ,NNJ,NAA,NAB)
          CALL RITCND(NT,NG,NC,IG,MA,IA,MB,IB,NAA,NAB,FA,FB,LABLE)
        ELSE
          CALL RITCND(NT,NG,NC,IG,MA,IA,MB,IB,XAA,XAB,1.,1.,LABLE)
        ENDIF
        NG=NG+NC
C       IF(NC .EQ. 1) THEN
          IF(NCT .EQ. 2) THEN
            MB=MA
            MA=NA
            IF(NCC .EQ. 1) THEN
CALL                                                   SETARY(46111)
          CALL SETARY(NR,JJJ,NNJ,NAA,NAB)
          CALL RITCND(NT,NG,NC,IG,MA,IA,MB,IB,NAA,NAB,FA,FB,LABLE)
            ELSE
          CALL RITCND(NT,NG,NC,IG,MA,IA,MB,IB,XAA,XAB,1.,1.,MATNMS(NR))
            ENDIF
            NG=NG+NC
          ENDIF
C       ENDIF
C  CHECK FOR A COND IN THE MIRROR POSITION. IF THERE IS A MIRROR
C  POSITION THETA2 AT THETA1+NJ, SET UP NA AND NB AND REPEAT THE
C  2 CONDUCTOR OUTPUT FOR THIS CONNECTION.
        IF(NTKK .EQ. 1 .AND. NMANY .EQ. 2)THEN
          NTKK=2
          MA=NA+IA
          MB=NB+IB
          NTEST=NTEST+NJ
          NNJ=NJ
          GO TO 145
        ENDIF
C   END OF 1ST HALF OF IF BLOCK  ON NHX > 0.
      ELSE
C  NO HEAT EXCHANGERS ON THIS BOUNDARY
        IF(NCC .EQ. 1) THEN
C       NCC = 1, CONDUCTION CONDUCTORS
C       IF NLVGA+NLVGB>0, MATERIALS NOT SAME OVER ENTIRE LAYER
C       THIS STILL PUTS OUT 2 CONDS IF NS=2, BUT PUTS THEM OUT
C       ONE AT A TIME. BECAUSE THE 2 NODES MAY BE OF DIFFERENT
C       MATERIALS,  NARY AND NAME MAY BE DIFFERENT FOR THE 2 CALLS
C       TO RITNDS. TEMPS AND VOL WILL BE THE SAME.
C
          CALL SETARY(NR,JJJ,NNJ,NAA,NAB)
C       PRINT *,'RADCON1',CT,NR,J,JJJ,NNJ,NG,NC,NAA,NAB,MA,MB
CALL                                                      RITCND   (77)
          CALL RITCND(NTP,NG,NC,IG,MA,IA,MB,IB,NAA,NAB,FA,FB,MATNMS(NR))
          NG=NG+NC
          IF(NMANY .EQ. 2 .AND. NC .EQ. 1) THEN
            MA=MA+NJ
            MB=MB+NJ
            NNJ=NJ
CALL                                                SETARY (46111)
          CALL SETARY(NR,JJJ,NNJ,NAA,NAB)
C       PRINT *,'RADCON2',CT,NR,J,JJJ,NNJ,NC,NG,NAA,NAB,MA,MB
            CALL RITCND(NTP,NG,NC,IG,MA,IA,MB,IB,NAA,NAB,FA,FB,LABLE)
            NG=NG+NC
          ENDIF
        ELSE
C   NCC = 2,  CONVECTION CONDUCTORS
          CALL RITCND(NTP,NG,NC,IG,MA,IA,MB,IB,XAA,XAB,1.,1.,LABLE)
          NG=NG+NC
        ENDIF
C  END OF IF BLOCK (COL 9) IS  NCC = 1?
      ENDIF
C
  130 CONTINUE
  110 CONTINUE
      RETURN
C   FORMAT STATEMENTS
```

```
 2002 FORMAT(7X,'REM  RADIAL CONDUCTORS REGION',I2,
     1          ', LAYER ',I2,' TO BOUNDARY  ',I2,'-',I2)
 2003 FORMAT(7X,'REM  RADIAL CONDUCTORS REGION',I2,
     1          ', LAYER ',I2,' TO LAYER ',I2)
      END
C46111SSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSS
      SUBROUTINE SETARY(NR,JJJ,NNJ,NAA,NAB)
CALLED FROM                                          RADCON (4611)
C   THIS SUBROUTINE CHECKS FOR VAPOR NODES IN CONDUCTOR DATA.
C   AND SETS NYA AND NYB = 0 OR 200 TO CHANGE THE PROPERTY TABLES
C   FOR A NODE. THIS IS ONLY DONE WHEN NR >= 4 AND NLGR=1.
C
      COMMON /REGION/ NTHETA,NBETAS,BETA,RIN,TVOL,ROUT(9),
     1                REGNS(9),NLAYRS(9),TEMPS(9),THICK(9),
     2                THKLAY(9),MATRLS(9),MATNMS(9),RGNNMS(9)
      COMMON /ULLAGE/ NLUL4,NLUL5,NTHU41,RINMHH,PCTFUL,RADULG,TVULFT,
     1                CT,LG(3),LIQVAP(3)
      COMMON /CONDUL/ MA,MB,NC,NARAY,NLVGA,NLVGB,NYYA,NYYB
C
C
      CHARACTER*1   CT,LG
      CHARACTER*16  LABLE
      LOGICAL REGNS
      CHARACTER*16  MATNMS
      CHARACTER*25  RGNNMS
C
      NAA=NARAY
      NAB=NARAY
      IF(NR .LE. 3) RETURN
      IF(NLVGA+NLVGB .EQ. 0) THEN
C  NLVG = 0, ALL NODES IN BOTH LAYERS SAME MATERIAL.
        NAA=NARAY+NYYA
        NAB=NARAY+NYYB
        NC=2
        LABLE=LG(NLG)//MATNMS(NR)
      ELSE
C  NLVG > 0, SOME NODES IN ONE OF THE LAYERS MAY BE DIFFERENT MATERIALS
        IF(CT .EQ. '1') THEN
C  CT = '1', 1-G CASE AND ULLAGE ON TOP AND FLAT
          NC=1
          NYA=0
          NYB=0
          NTHUA=NYYA
          NTHUB=NYYB
          IF(NTHUA .GT. 0 .AND. MA .LT. 20000) THEN
            IF(JJJ+NNJ+1 .GE. NTHUA) THEN
              NYA=200
              NLG=3
            ENDIF
          ENDIF
          IF(NTHUB .GT. 0 .AND. MB .LT. 20000) THEN
            IF(JJJ+NNJ+1 .GE. NTHUB) THEN
              NYB=200
              NLG=3
            ENDIF
          ENDIF
        ENDIF
      NAA=NARAY+NYA
      NAB=NARAY+NYB
      LABLE=LG(NLG)//MATNMS(NR)
      ENDIF
C     PRINT *,'SETARY',NR,CT,JJJ,NNJ,NYYA,NYYB,NLVGA,NLVGB,
C    1        NARAY,NTHUA,NTHUB,MA,MB,NYA,NYB,NAA,NAB,NC
      RETURN
      END
C4612SSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSS
      SUBROUTINE CIRCON(NR,NCC,NG)
CALLED FROM                                          SPHCDS (461)
C  SUBROUTINE TO GENERATE CIRCUMFERENTIAL CONDUCTOR DATA
C                            (Y DIRECTION)
```

```
C
C  IF NCC =1, COMPUTE CONDUCTION CONDUCTORS IN REGIONS 4 AND 5.
C  IF NCC =2, COMPUTE CONVECTION CONDUCTORS IN REGIONS 4 AND 5.
C
C  NARY = 6000 + NXX, SINDA ARRAY NO. FOR K, (THERMAL CONDUCTIVITY).
C                WHERE  NXX = MATERIAL NO. AS INPUT BY USER.
C                       NXX = 1XX,  LIQUID MATERIAL NO.
C                       NXX = 2XX,  SOLID  MATERIAL NO.
C                       NXX = 3XX,  VAPOR  MATERIAL NO.
C
      COMMON /REGION/ NTHETA,NBETAS,BETA,RIN,TVOL,ROUT(9),
     1                REGNS(9),NLAYRS(9),TEMPS(9),THICK(9),
     2                THKLAY(9),MATRLS(9),MATNMS(9),RGNNMS(9)
      COMMON /HTXGRS/ NHX,HXTEMP(10),NRHX(10),NLHX(10),
     1                NTHHX(10),LNGTHX(10)
      COMMON/STUFF/ NHTT,PI,CONVY,CONVR,THETA0,DTHETA,NBASOS,ROUTSF,
     1  BNCOEF(2)
      COMMON /ULLAGE/ NLUL4,NLUL5,NTHU41,RINMHH,PCTFUL,RADULG,TVULFT,
     1                CT,LG(3),LIQVAP(3)
      COMMON /UNITS/ MODU, INPEKO, ISCRCH, SINDA
C
      DIMENSION NHXADL(10)
C
      LOGICAL REGNS,SINDA
C
      CHARACTER*1   CT,LG
      CHARACTER*6   LIQVAP
      CHARACTER*16  MATNMS
      CHARACTER*25  RGNNMS
C
C   GENERATE CONDUCTORS ALONG CIRCUMFERENCE (Y DIRECTION)
      NTM1=NTHETA-1
      SIGN=1.0
      IF(NR .GE. 4) SIGN=-1.0
      NLAY=NLAYRS(NR)
      TH=THKLAY(NR)
      RAD=RIN
      IF(NR .EQ. 2) RAD=RIN+THICK(1)
      IF(NR .EQ. 3) RAD=RIN+THICK(1)+THICK(2)
      IF(NR .EQ. 5) RAD=RIN-THICK(4)
      RAD=RAD-SIGN*TH/2.
      NODBAS=2000*NR
      NARAY=MATRLS(NR)+6000
      NLGR=MATRLS(NR)/100
      DO 325 L=1,NLAY
      NYY=0
      NLVG=0
      NLG=NLGR
      IF(NR .GE. 4) THEN
        IF(NLGR .EQ. 1) THEN
CALL                                               ULLCHK (44121)
          CALL ULLCHK(NR,L,NLVG,NYY)
        ENDIF
      ENDIF
      WRITE(MODU,2005)NR,L
      RAD=RAD+SIGN*TH
      EL =RAD*DTHETA/2.
      NA=NTHETA*(L-1)+NODBAS
      DO 330 J=1,NTM1,2
      JJJ=J/2
      NA=NA+1
      NB=NA+1
      NMANY=2
      MA=NA
      MB=NB
      NC=NMANY
      NJ=NTHETA-J-1
      NTP =7
CALL                                                  AREASP (451)
      CALL AREASP(2,JJJ,RAD,TH,AREA)
```

```
      XAA=AREA
      FA = AREA/EL
      IF(NJ .EQ. 0) THEN
        NC=1
        NTP =6
      ELSE
        CALL AREASP(2,JJJ+1,RAD,TH,AREA)
        FB = AREA/EL
      ENDIF
      IA=NJ
      IB=IA
      IC=1
      IF(NCC .EQ. 1) THEN
        IF(NLVG .EQ. 0) THEN
C   NLVG=0,  SAME MATERIAL FOR THIS LAYER.
          NAA=NARAY+NYY
          NAB=NAA
                                                   RITCND (4613)
CALL
        CALL RITCND(NTP,NG,NC,IG,MA,IA,MB,IB,NAA,NAB,FA,FB,MATNMS(NR))
          NG=NG+NC
        ELSE
C   NLVG > 0, MATERIAL MAY BE DIFFERENT FOR SOME NODES IN THIS LAYER
          NTHU=NYY
          NTP=6
          IGO=0
          NAA=NARAY
          NAB=NAA
          IF(CT .EQ. '1') THEN
            IF(JJJ .GE. NTHU) THEN
              NAA=NARAY+200
              NC=1
            ENDIF
            IF(JJJ+1 .GE. NTHU) THEN
              NAB=NARAY+200
              NC=1
              NLG=3
            ENDIF
        CALL RITCND(NTP,NG,NC,IG,MA,IA,NB,IB,NAA,NAB,FA,FB,MATNMS(NR))
            NG=NG+NC
            IF(NMANY .EQ. 2 .AND. NC .EQ. 1) THEN
              MA=MA+NJ
              MB=MB+NJ
              IF(CT .EQ. '1') THEN
                IF(JJJ+NJ+1 .GE. NTHU) NAA=NARAY+200
                IF(JJJ+NJ   .GE. NTHU) NAB=NARAY+200
              ENDIF
C             LABLE=LG(NLG)//MATNMS(NR)
        CALL RITCND(NTP,NG,NC,IG,MA,IA,MB,IB,NAA,NAB,FA,FB,MATNMS(NR))
              NG=NG+NC
            ENDIF
          ENDIF
        ENDIF
      ELSE
        XAB=CONVY
        NTP=NTP-4
        CALL RITCND(NTP,NG,NC,IG,MA,IA,MB,IB,XAA,XAB,1.,1.,MATNMS(NR))
        NG=NG+NC
      ENDIF
  330 CONTINUE
  325 CONTINUE
      RETURN
C   FORMAT STATEMENTS
 2005 FORMAT(7X,'REM  CIRCUMFERENTIAL CONDUCTORS REGION', I2,
     1         ', LAYER NUMBER ',I2)
      END
```

APPENDIX E

CryoTran Program Listings

Part III CRYOCYL FORTRAN

```
      SUBROUTINE CYLNDR (NAN)
      COMMON/REGION/NTHETA,NBETAS,BETA,RIN,TVOL,
     *            ROUT(9),REGNS(9),NLAYRS(9),TEMPS(9),THICK(9),
     *            THKLAY(9),MATRLS(9),MATNMS(9),RGNNMS(9)
      COMMON/TOPBOT/NTOP,NBOT,NFTLAY,NSTLAY,NETLAY,NFBLAY,NSBLAY,
     *                    NEBLAY,ETRAT,EBRAT,FTTHK,FBTHK
      COMMON/ULLAGE/ NLUL4,NLUL5,NTHU41,RINMHH,PCTFUL,RADULG,TVULFT,
     *            CT,LG(3),LIQVAP(3)
      COMMON/CYDATA/CYLHGT,NCYLAY
      COMMON/HTXGRS/NHX,HXTEMP(10),NRHX(10),NLHX(10),NTHHX(10),
     *            LNGTHX(10)
      COMMON/UNITS/MODU,SINDA
      LOGICAL REGNS
      CHARACTER*16 RGNNMS,MNAME,MATNMS
      CHARACTER*1 CT,LG,YORN
      CHARACTER*6 LIQVAP
      CALL CLEARS
      WRITE (6,44)
      WRITE (6,*) 'NOW ENTER YOUR CHOICE OF HOW THE CYLINDERICAL'
      WRITE (6,*) 'SECTION OF THE TANK IS GOING TO BE DEFINED:'
      WRITE (6,*)
      WRITE (6,*) '1. HEIGHT ; WALL THICKNESS ; INSIDE RADIUS (INCH).'
      WRITE (6,*) '2. HEIGHT ; OUTSIDE RADIUS ; INSIDE RADIUS (INCH).'
      WRITE (6,*) '3. HEIGHT ; OUTSIDE RADIUS ; WALL THICKNESS(INCH).'
      CALL READIN (NMENU,1,3)
      IF (NMENU.EQ.1) THEN
         CALL CLEARS
         WRITE (6,44)
         WRITE (6,*) 'ENTER CYLINDERICAL HEIGHT (INCHES).'
         CALL READRE(CYLHGT)
         CALL CLEARS
         WRITE (6,44)
         WRITE (6,*) 'ENTER THE THICKNESS OF THE WALL (INCHES).'
         CALL READRE (THICK(1))
         CALL CLEARS
         WRITE (6,44)
         WRITE (6,*) 'ENTER THE INSIDE RADIUS OF THE TANK (INCHES).'
         CALL READRE (RIN)
         CALL CLEAR
         ROUT(1)=RIN+THICK(1)
      ENDIF
      IF (NMENU.EQ.2) THEN
         CALL CLEARS
         WRITE (6,44)
         WRITE (6,*) 'ENTER CYLINDERICAL HEIGHT (INCHES).'
         CALL READRE(CYLHGT)
         CALL CLEARS
         WRITE (6,44)
         WRITE (6,*) 'ENTER THE OUTSIDE RADIUS OF THE TANK (INCHES).'
         CALL READRE (RADIUS)
         CALL CLEARS
         WRITE (6,44)
         WRITE (6,*) 'ENTER THE INSIDE RADIUS OF THE TANK (INCHES).'
         CALL READRE (RIN)
         CALL CLEAR
         THICK(1)=RADIUS-RIN
         ROUT(1)=RIN+THICK(1)
      ENDIF
      IF (NMENU.EQ.3) THEN
         CALL CLEARS
         WRITE (6,44)
         WRITE (6,*) 'ENTER CYLINDERICAL HEIGHT (INCHES).'
         CALL READRE(CYLHGT)
         CALL CLEARS
         WRITE (6,44)
         WRITE (6,*) 'ENTER THE OUTSIDE RADIUS OF THE TANK (INCHES).'
         CALL READRE (RADIUS)
         CALL CLEARS
         WRITE (6,44)
         WRITE (6,*) 'ENTER THE WALL THICKNESS (INCHES).'
```

```
         CALL READRE (THICK(1))
         CALL CLEAR
         RIN=RADIUS-THICK(1)
         ROUT(1)=RIN+THICK(1)
      ENDIF
      CALL CLEARS
      WRITE (6,44)
      WRITE (6,*) 'ENTER NUMBER OF LAYERS TO DIVIDE THE HEIGHT INTO '
      CALL READIN (NCYLAY,0,9999)
      CALL CLEAR
      WRITE (6,44)
      WRITE (6,*) 'ENTER THE NUMBER CORRESPONDING TO THE TOP SHAPE: '
      WRITE (6,*) '(1=NO TOP, 2=FLAT TOP, 3=SPHERICAL TOP, 4=ELIPTICAL T
     *OP)'
      CALL READIN (NTOP,1,4)
      CALL CLEARS
      WRITE (6,44)
      WRITE (6,*) 'ENTER THE NUMBER CORRESPONDING TO THE BOTTOM SHAPE'
      WRITE (6,*) '(1=NO BOTTOM, 2=FLAT BOTTOM, 3=SPHERICAL BOTTOM, 4=EL
     *IPTICAL BOTTOM)'
      CALL READIN (NBOT,1,4)
      CALL CLEARS
      IF (NTOP.EQ.1) GOTO 7
      WRITE (6,44)
      WRITE (6,*) 'ENTER THE LAYERS TO DIVIDE THE TOP INTO'
      IF (NTOP.EQ.2) THEN
         CALL READIN (NFTLAY,0,9999)
         CALL CLEARS
         WRITE (6,44)
         WRITE (6,*) 'ENTER THE THICKNESS OF THE FLAT TOP (INCHES).'
         CALL READRE (FTTHK)
      ENDIF
      IF (NTOP.EQ.3) CALL READIN(NSTLAY,0,9999)
      IF (NTOP.EQ.4) THEN
         CALL READIN (NETLAY,0,9999)
         CALL CLEARS
         WRITE (6,44)
         WRITE (6,*) 'DO YOU WANT A SQRT(2.) ELIPSE  I.E. A:B=SQRT(2.)?'
         CALL READAL(1,YORN)
         IF (YORN.EQ.'Y') ETRAT=1./SQRT(2.)
         IF (YORN.EQ.'N') THEN
            WRITE (6,*) 'ENTER THE RATIO OF A (MAJOR AXIS) TO B '
            WRITE (6,*) '(MINOR AXIS) I.E. A/B FOR THE TOP'
            CALL READRE(ETRAT)
            ETRAT=1/ETRAT
            CALL CLEARS
         ENDIF
      ENDIF
7     IF (NBOT.EQ.1) GOTO 99
      CALL CLEARS
      WRITE (6,44)
      WRITE (6,*) 'ENTER THE LAYERS TO DIVIDE THE BOTTOM INTO'
      IF (NBOT.EQ.2) THEN
         CALL READIN (NFBLAY,0,9999)
         CALL CLEARS
         WRITE (6,44)
         WRITE (6,*) 'ENTER THICKNESS FOR FLAT BOTTOM SHAPE (INCHES).'
         CALL READRE(FBTHK)
      ENDIF
      IF (NBOT.EQ.3) CALL READIN (NSBLAY,0,9999)
      IF (NBOT.EQ.4) THEN
         CALL READIN (NEBLAY,0,9999)
         CALL CLEARS
         WRITE (6,44)
         WRITE (6,*) 'DO YOU WANT A SQRT(2.) ELIPSE  I.E. A:B=SQRT(2.)?'
         CALL READAL(1,YORN)
         IF (YORN.EQ.'Y') EBRAT=1./SQRT(2.)
         IF (YORN.EQ.'N') THEN
            WRITE (6,*) 'ENTER THE RATIO OF A (MAJOR AXIS) TO B '
            WRITE (6,*) '(MINOR AXIS). I.E. A/B FOR THE BOTTOM'
```

```
         CALL READRE(EBRAT)
         EBRAT=1/EBRAT
         CALL CLEARS
      ENDIF
   ENDIF
99 NTHETA=NCYLAY+NFTLAY+NETLAY+NSTLAY+NFBLAY+NEBLAY+NSBLAY
44 FORMAT(///)
   RETURN
   END

   SUBROUTINE MATMNU (IREG)
   COMMON/REGION/NTHETA,NBETAS,BETA,RIN,TVOL,
  *              ROUT(9),REGNS(9),NLAYRS(9),TEMPS(9),THICK(9),
  *              THKLAY(9),MATRLS(9),MATNMS(9),RGNNMS(9)
   COMMON/UNITS/MODU,SINDA
   DIMENSION P(100)
   LOGICAL REGNS
   CHARACTER*16 MNAME,MATNMS,RGNNMS
   CALL CLEARS
12 REWIND 4
   WRITE (6,1)
30 READ (4,2) MNUM,MNAME
   IF (MNUM.EQ.0) GOTO 10
   IF (MNUM.GE.100.AND.MNUM.LT.200) WRITE (6,133) MNUM,MNAME
   IF (MNUM.GE.200.AND.MNUM.LT.300) WRITE (6,3) MNUM,MNAME
   IF (MNUM.GE.300) WRITE (6,134) MNUM,MNAME
   READ (4,*) SPRES,EPRES,NINC
   GOTO 30
10 MNUM=999
   MNAME='USER DEFINED    '
   WRITE (6,3) MNUM,MNAME
   CALL READIN (MATRLS(IREG),100,1000)
   NTEST=0
   REWIND 4
20 READ (4,2) MNUM,MNAME
   IF (MNUM.EQ.0) GOTO 11
   READ (4,*) SPRES,EPRES,NINC
   IF (MATRLS(IREG).EQ.MNUM.OR.MATRLS(IREG).EQ.999) NTEST=1
   IF (MATRLS(IREG).EQ.MNUM) MATNMS(IREG)=MNAME
   GOTO 20
11 IF (NTEST.EQ.0) THEN
      CALL CLEARS
      WRITE (6,*) 'MATERIAL NUMBER DOES NOT EXIST'
      WRITE (6,*) 'PLEASE ENTER A MATERIAL NUMBER FROM THE'
      WRITE (6,*) 'MENU BELOW OR ENTER 999 TO ENTER YOUR'
      WRITE (6,*) 'OWN PROPERTY DATA.'
      GOTO 12
   ENDIF
   IF (MATRLS(IREG).EQ.999) THEN
      CALL CLEARS
      WRITE (6,7) IREG
      CALL READLC (MATNMS(IREG))
   ENDIF
   REWIND 4
 1 FORMAT (//,' ENTER MATERIAL NUMBER FOR REGION ',I1,':')
 2 FORMAT (I3,A16)
 3 FORMAT (1X,I3,5X,A16)
133 FORMAT (1X,I3,5X,'LIQUID ',A16)
134 FORMAT (1X,I3,5X,'GAS ',A16)
 7 FORMAT (//,' ENTER MATERIAL NAME FOR REGION ',I1,':')
   RETURN
   END

   SUBROUTINE PRPTBL(IREG)
   COMMON/REGION/NTHETA,NBETA,BETA,RIN,TVOL,
  *              ROUT(9),REGNS(9),NLAYRS(9),TEMPS(9),THICK(9),
  *              THKLAY(9),MATRLS(9),MATNMS(9),RGNNMS(9)
   COMMON/UNITS/MODU,SINDA
   LOGICAL REGNS
   CHARACTER*16 MNAME,MATNMS,RGNNMS
```

```
      CHARACTER*15 TABUNT(10)
      CHARACTER*1 TB
      CHARACTER*20 PRPUNT(10)
      CHARACTER*13 PROP
      DIMENSION P(100),T(10,700),NAMTAB(10),PRTOUT(1000),CONFAC(10)
      NRPT=0
      DO 581 I=1,IREG
         IF (I.NE.IREG) THEN
            IF (MATRLS(I).EQ.MATRLS(IREG)) NRPT=1
         ENDIF
581   CONTINUE
      IF (NRPT.EQ.1) GOTO 100
      IF (MATRLS(IREG).EQ.999) THEN
         CALL MATUSR(IREG)
         GOTO 100
      ENDIF
      CALL CLEARS
      IF (MATRLS(IREG).GE.200.AND.MATRLS(IREG).LE.299) THEN
         MNUM=1
         REWIND 4
         PRES=0.0
         GOTO 35
      ENDIF
 12   REWIND 4
      WRITE (6,2)
      WRITE (6,3) MATNMS(IREG),IREG
      NTEST=0
 10   READ (4,4) MNUM,MNAME
      IF (MNUM.EQ.0) GOTO 11
      READ (4,*) SPRES,EPRES,PINC
      IK=1
      IF (MATRLS(IREG).EQ.MNUM) THEN
          WRITE (6,56) SPRES,EPRES,PINC
          NTEST=1
          P(IK)=SPRES
 1        IK=IK+1
          P(IK)=P(IK-1)+PINC
          IF (P(IK).LT.EPRES) GOTO 1
          NP=IK
          GOTO 11
      ENDIF
      IF (NTEST.EQ.1)GOTO 11
      GOTO 10
 11   CALL READRE (PRES)
      NTEST=0
      DO 5 IK=1,NP
         IF (ABS(PRES-P(IK)).LE.0.01) NTEST=1
  5   CONTINUE
      IF (NTEST.EQ.0) THEN
         CALL CLEARS
         WRITE (6,*) ' THIS PRESSURE IS NOT IN THE DATA BASE.'
         GOTO 12
      ENDIF
 35   KTEMP=0
 36   IF (MNUM.EQ.0) GOTO 51
      READ (4,4) MNUM,MNAME
      IF (MNUM.NE.0) READ(4,*)SPRES,EPRES,PINC
      GOTO 36
 51   READ (4,6,END=9) MNUM,MNAME,NTABLE,NTSETS,NPSIA
      DO 71 IK=1,NTABLE+2
         READ (4,74) NAMTAB(IK),TABUNT(IK),CONFAC(IK),PRPUNT(IK)
 71   CONTINUE
      DO 72 IK=1,NTSETS*NPSIA
        READ (4,*) (T(J,IK),J=1,NTABLE+2)
        DO 197 J=1,NTABLE+2
           T(J,IK)=T(J,IK)*CONFAC(J)
197   CONTINUE
 72   CONTINUE
      IF (MATRLS(IREG).NE.MNUM) GOTO 51
  9   DO 73 IK=3,NTABLE+2
```

```
      IF (NAMTAB(IK).EQ.2) PROP='SPECIFIC HEAT'
      IF (NAMTAB(IK).EQ.3) PROP='DENSITY'
      IF (NAMTAB(IK).EQ.4) PROP='VISCOSITY'
      IF (NAMTAB(IK).EQ.5) PROP='ENTHALPHY'
      IF (NAMTAB(IK).EQ.6) PROP='CONDUCTIVITY'
      IF (MNUM.GE.200.AND.MNUM.LE.299) THEN
         WRITE (MODU,29) PROP,PRPUNT(IK),MNAME
      ELSE
         WRITE (MODU,19) PROP,PRPUNT(IK),MNAME,PRES,TABUNT(2)
      ENDIF
      JJ=0
      DO 75 IJ=1,NTSETS*NPSIA
         IF (ABS(T(1,IJ)-PRES).LE.0.01) THEN
            JJ=JJ+1
            PRTOUT(JJ)=T(2,IJ)
            TB=TABUNT(1)
            IF (TB.EQ.'R'.AND.MATNMS(9).EQ.'F')
     *           PRTOUT(JJ)=PRTOUT(JJ)-459.69
            IF (TB.EQ.'F'.AND.MATNMS(9).EQ.'R')
     *         PRTOUT(JJ)=PRTOUT(JJ)+459.69
            IF (TB.EQ.'C'.AND.MATNMS(9).EQ.'F')
     *         PRTOUT(JJ)=(1.8*PRTOUT(JJ))+32
            IF (TB.EQ.'C'.AND.MATNMS(9).EQ.'R')
     *         PRTOUT(JJ)=((PRTOUT(JJ)-32)/1.8)+459.69
            IF (TB.EQ.'K'.AND.MATNMS(9).EQ.'F')
     *         PRTOUT(JJ)=(1.8*(PRTOUT(JJ)-273.16))+32
            IF (TB.EQ.'K'.AND.MATNMS(9).EQ.'R')
     *         PRTOUT(JJ)=((1.8*(PRTOUT(JJ)-273.16))+32)+459.69
            JJ=JJ+1
            PRTOUT(JJ)=T(IK,IJ)
         ENDIF
75    CONTINUE
      LINES=JJ/6
      IF (JJ.EQ.2) WRITE (MODU,92) NAMTAB(IK),MATRLS(IREG),
     *                 PRTOUT(1),PRTOUT(2)
      IF (JJ.EQ.4) WRITE (MODU,93) NAMTAB(IK),MATRLS(IREG),
     *                 PRTOUT(1),PRTOUT(2),PRTOUT(3),PRTOUT(4)
      IF (JJ.EQ.6) WRITE (MODU,94) NAMTAB(IK),MATRLS(IREG),
     *                 PRTOUT(1),PRTOUT(2),PRTOUT(3),PRTOUT(4),
     *                 PRTOUT(5),PRTOUT(6)
      IF (JJ.GT.6) WRITE (MODU,95) NAMTAB(IK),MATRLS(IREG),
     *                 PRTOUT(1),PRTOUT(2),PRTOUT(3),PRTOUT(4),
     *                 PRTOUT(5),PRTOUT(6)
   M=MOD(JJ,6)
   DO 76 II=2,LINES
      L=LINES
      IJ=((II-1)*6)+1
   IF (M.EQ.0.AND.II.NE.L)WRITE (MODU,91) (PRTOUT(KK),KK=IJ,IJ+5)
   IF (M.NE.0.AND.II.EQ.L)WRITE (MODU,91) (PRTOUT(KK),KK=IJ,IJ+5)
   IF (M.NE.0.AND.II.NE.L)WRITE (MODU,91) (PRTOUT(KK),KK=IJ,IJ+5)
   IF (M.EQ.0.AND.II.EQ.L) WRITE (MODU,98) PRTOUT(IJ),PRTOUT(IJ+1),
  *             PRTOUT(IJ+2),PRTOUT(IJ+3),PRTOUT(IJ+4),PRTOUT(IJ+5)
76 CONTINUE
   IJ=((LINES)*6)+1
   IF (NTSETS.EQ.1) GOTO 73
   IF (M.EQ.2) WRITE (MODU,96) PRTOUT(IJ),PRTOUT(IJ+1)
   IF (M.EQ.4) WRITE (MODU,97) PRTOUT(IJ),PRTOUT(IJ+1),PRTOUT(IJ+2),
  *                            PRTOUT(IJ+3)
73 CONTINUE
      IF (MNUM.GE.200.AND.MNUM.LE.299) THEN
         WRITE (MODU,84) MNAME
      ELSE
         WRITE (MODU,85) MNAME,PRES,TABUNT(2)
      ENDIF
   DO 81 IK=3,NTABLE+2
      IF (NAMTAB(IK).EQ.2) NSP=IK
      IF (NAMTAB(IK).EQ.3) NCND=IK
81 CONTINUE
   JJ=0
   DO 82 IJ=1,NTSETS*NPSIA
```

```
         IF (ABS(T(1,IJ)-PRES).LE.0.01) THEN
            JJ=JJ+1
            PRTOUT(JJ)=T(2,IJ)
               TB=TABUNT(1)
               IF (TB.EQ.'R'.AND.MATNMS(9).EQ.'F')
     *              PRTOUT(JJ)=PRTOUT(JJ)-459.69
               IF (TB.EQ.'F'.AND.MATNMS(9).EQ.'R')
     *             PRTOUT(JJ)=PRTOUT(JJ)+459.69
               IF (TB.EQ.'C'.AND.MATNMS(9).EQ.'F')
     *             PRTOUT(JJ)=(1.8*PRTOUT(JJ))+32
               IF (TB.EQ.'C'.AND.MATNMS(9).EQ.'R')
     *             PRTOUT(JJ)=((PRTOUT(JJ)-32)/1.8)+459.69
               IF (TB.EQ.'K'.AND.MATNMS(9).EQ.'F')
     *             PRTOUT(JJ)=(1.8*(PRTOUT(JJ)-273.16))+32
               IF (TB.EQ.'K'.AND.MATNMS(9).EQ.'R')
     *             PRTOUT(JJ)=((1.8*(PRTOUT(JJ)-273.16))+32)+459.69
            JJ=JJ+1
            PRTOUT(JJ)=T(NSP,IJ)*T(NCND,IJ)
         ENDIF
82    CONTINUE
      LINES=JJ/6
      K=1
         IF (JJ.EQ.2) WRITE (MODU,92) K,MATRLS(IREG),
     *                 PRTOUT(1),PRTOUT(2)
         IF (JJ.EQ.4) WRITE (MODU,93) K,MATRLS(IREG),
     *                 PRTOUT(1),PRTOUT(2),PRTOUT(3),PRTOUT(4)
         IF (JJ.EQ.6) WRITE (MODU,94) K,MATRLS(IREG),
     *                 PRTOUT(1),PRTOUT(2),PRTOUT(3),PRTOUT(4),
     *                 PRTOUT(5),PRTOUT(6)
         IF (JJ.GT.6) WRITE (MODU,95) K,MATRLS(IREG),
     *                 PRTOUT(1),PRTOUT(2),PRTOUT(3),PRTOUT(4),
     *                 PRTOUT(5),PRTOUT(6)
      M=MOD(JJ,6)
      DO 86 II=2,LINES
      L=LINES
      IJ=((II-1)*6)+1
      IF (M.EQ.0.AND.II.NE.L)WRITE (MODU,91) (PRTOUT(KK),KK=IJ,IJ+5)
      IF (M.NE.0.AND.II.EQ.L)WRITE (MODU,91) (PRTOUT(KK),KK=IJ,IJ+5)
      IF (M.NE.0.AND.II.NE.L)WRITE (MODU,91) (PRTOUT(KK),KK=IJ,IJ+5)
      IF (M.EQ.0.AND.II.EQ.L) WRITE (MODU,98) PRTOUT(IJ),PRTOUT(IJ+1),
     *             PRTOUT(IJ+2),PRTOUT(IJ+3),PRTOUT(IJ+4),PRTOUT(IJ+5)
86    CONTINUE
      M=MOD(JJ,6)
      IJ=((LINES)*6)+1
      IF (NTSETS.EQ.1) GOTO 739
      IF (M.EQ.2) WRITE (MODU,96) PRTOUT(IJ),PRTOUT(IJ+1)
      IF (M.EQ.4) WRITE (MODU,97) PRTOUT(IJ),PRTOUT(IJ+1),PRTOUT(IJ+2),
     *                            PRTOUT(IJ+3)
739   IF(MATRLS(IREG).GE.100.AND.MATRLS(IREG).LT.200.AND.KTEMP.EQ.0)THEN
        KTEMP=1
        MATRLS(IREG)=MATRLS(IREG)+200
        REWIND 4
        GOTO 36
      ENDIF
      IF (MATRLS(IREG).GE.300.AND.KTEMP.EQ.1) THEN
         MATRLS(IREG)=MATRLS(IREG)-200
      ENDIF
      IF (MATRLS(IREG).GE.300.AND.KTEMP.EQ.0) THEN
         MATRLS(IREG)=MATRLS(IREG)-200
         REWIND 4
         KTEMP=1
         GOTO 36
      ENDIF
      IF(MATRLS(IREG).GE.100.AND.MATRLS(IREG).LT.200.AND.KTEMP.EQ.0)THEN
          MATRLS(IREG)=MATRLS(IREG)+200
      ENDIF
831   FORMAT (1X,A1)
  2   FORMAT (/,' THE FOLLOWING IS THE RANGE OF PRESSURES IN THE')
  3   FORMAT (' MATERIAL DBASE FOR ',A16,' IN REGION #',I1,': '//)
  4   FORMAT (I3,A16)
```

```
    6 FORMAT (2X,I4,5X,A16,5X,I2,5X,I4,7X,I2)
   19 FORMAT (7X,'REM ',A13,A17,' FOR ',A16,' AT P=',F7.1,' ',A4)
   29 FORMAT (7X,'REM ',A13,A17,' FOR ',A16)
   56 FORMAT (/,' STARTING PRESSURE = ',F10.2,//,
     *          ' ENDING PRESSURE   = ',F10.2,//,
     *          ' INCREMENT         = ',F10.2,////,
     *          ' ENTER THE DESIRED PRESSURE FOR THAT REGION '/)
   74 FORMAT (I3,A15,F9.7,1X,A20)
   84 FORMAT (7X,'REM CP * RHO FOR ',A16)
   85 FORMAT (7X,'REM CP * RHO FOR ',A16,' AT P=',F7.1,' ',A10)
   91 FORMAT (12X,2(F6.0,',',E12.5,','),F6.0,',',E12.5)
   92 FORMAT (12X,I1,I3,',',F6.0,',',E12.5,',END')
   93 FORMAT (12X,I1,I3,',',2(F6.0,',',E12.5,','),'END')
   94 FORMAT (12X,I1,I3,',',3(F6.0,',',E12.5,','),'END')
   95 FORMAT (12X,I1,I3/12X,2(F6.0,',',E12.5,','),F6.0,',',E12.5)
   96 FORMAT (12X,F6.0,',',E12.5,',END')
   97 FORMAT (12X,2(F6.0,',',E12.5,','),'END')
   98 FORMAT (12X,3(F6.0,',',E12.5,','),'END')
  198 FORMAT (12X,A19)
  100 RETURN
      END

      SUBROUTINE MATUSR(IREG)
      COMMON/REGION/NTHETA,NBETA,BETA,RIN,TVOL,
     *              ROUT(9),REGNS(9),NLAYRS(9),TEMPS(9),THICK(9),
     *              THKLAY(9),MATRLS(9),MATNMS(9),RGNNMS(9)
      COMMON/UNITS/MODU,SINDA
      LOGICAL REGNS
      CHARACTER*16 MNAME,MATNMS,RGNNMS
      CHARACTER*15 TABUNT(10)
      CHARACTER*1 TB
      CHARACTER*13 PROP
      DIMENSION P(100),T(10,700),NAMTAB(10),PRTOUT(1000)
      CALL CLEARS
      WRITE (6,*) ' PLEASE ENTER THE NUMBER CORRESPONDING TO THE STATE'
      WRITE (6,*) ' OF THE MATERIAL TO CREATE:'
      WRITE (6,*) ' 1 = LIQUID          2 = SOLID              3 = GAS'
      CALL READIN (LSG,1,3)
      LSG=LSG*100
      MAX=0
      DO 1 I=1,5
         IF (I.NE.IREG) THEN
            IF (MATRLS(I)-LSG.LT.100.AND.MATRLS(I)-LSG.GT.MAX)
     *         MAX=MATRLS(I)-LSG
         ENDIF
    1 CONTINUE
      MATRLS(IREG)=LSG+MAX+1
      MNUM=MATRLS(IREG)
      IF (LSG.NE.200) THEN
         CALL CLEARS
         WRITE (6,*) ' ENTER THE PRESSURE FOR REGION # ',IREG,' (PSIA)'
         CALL READRE(PRESS)
         TABUNT(2)='PSIA'
      ENDIF
      CALL CLEARS
      WRITE (6,*) ' ENTER NUMBER OF TABLES YOU WISH TO INPUT (MIN = 2)'
      WRITE (6,*) ' NOTE: SPECIFIC HEAT AND CONDUCTIVITY MUST BE GIVEN'
      CALL READIN (NTABLE,2,999)
      WRITE (6,*) ' ENTER THE NUMBER OF TEMPERATURES YOU WISH TO INPUT '
      CALL READIN (NTEMP,1,999)
      NAMTAB(3)=2
      NAMTAB(4)=6
      DO 2 I=3,NTABLE
         CALL CLEARS
         WRITE (6,*) ' ENTER THE NUMBER CORRESPONDING TO TABLE #',I
         WRITE (6,*) ' 1. VISCOSITY'
         WRITE (6,*) ' 2. ENTHALPY'
         WRITE (6,*) ' 3. DENSITY'
         CALL READIN(NTYPE,1,3)
         IF (NTYPE.EQ.1) NAMTAB(I+2)=4
```

```
         IF (NTYPE.EQ.2) NAMTAB(I+2)=5                                   CRY04910
         IF (NTYPE.EQ.3) NAMTAB(I+2)=3                                   CRY04920
 2    CONTINUE                                                           CRY04930
      DO 3 I=1,NTEMP                                                     CRY04940
         CALL CLEARS                                                     CRY04950
         WRITE (6,*) 'ENTER THE NEW TEMPERATURE (R)'                     CRY04960
         CALL READRE (TEMP)                                              CRY04970
         DO 4 J=1,NTABLE                                                 CRY04980
            CALL CLEARS                                                  CRY04990
            T(2,I)=TEMP                                                  CRY05000
            T(1,I)=PRESS                                                 CRY05010
            IF (NAMTAB(J+2).EQ.2) PROP='SPECFIC HEAT'                    CRY05020
            IF (NAMTAB(J+2).EQ.3) PROP='DENSITY'                         CRY05030
            IF (NAMTAB(J+2).EQ.4) PROP='VISCOSITY'                       CRY05040
            IF (NAMTAB(J+2).EQ.5) PROP='ENTHALPY'                        CRY05050
            IF (NAMTAB(J+2).EQ.6) PROP='CONDUCTIVITY'                    CRY05060
            IF (LSG.NE.200) WRITE (6,7) PROP,T(2,I),T(1,I)               CRY05070
            IF (LSG.EQ.200) WRITE (6,8) PROP,T(2,I)                      CRY05080
            CALL READRE (T(J+2,I))                                       CRY05090
 4       CONTINUE                                                        CRY05100
 3    CONTINUE                                                           CRY05110
 9    DO 73 IK=3,NTABLE+2                                                CRY05120
         IF (NAMTAB(IK).EQ.2) PROP='SPECIFIC HEAT'                       CRY05130
         IF (NAMTAB(IK).EQ.3) PROP='DENSITY'                             CRY05140
         IF (NAMTAB(IK).EQ.4) PROP='VISCOSITY'                           CRY05150
         IF (NAMTAB(IK).EQ.5) PROP='ENTHALPHY'                           CRY05160
         IF (NAMTAB(IK).EQ.6) PROP='CONDUCTIVITY'                        CRY05170
         IF (MNUM.GE.200.AND.MNUM.LE.299) THEN                           CRY05180
            WRITE (MODU,29) PROP,MATNMS(IREG)                            CRY05190
         ELSE                                                            CRY05200
            WRITE (MODU,19) PROP,MATNMS(IREG),PRESS,TABUNT(2)            CRY05210
         ENDIF                                                           CRY05220
         JJ=0                                                            CRY05230
         DO 75 IJ=1,NTEMP                                                CRY05240
            IF (ABS(T(1,IJ)-PRESS).LE.0.01) THEN                         CRY05250
               JJ=JJ+1                                                   CRY05260
               PRTOUT(JJ)=T(2,IJ)                                        CRY05270
               TB=TABUNT(1)                                              CRY05280
               IF (TB.EQ.'R'.AND.MATNMS(9).EQ.'F')                       CRY05290
     *               PRTOUT(JJ)=PRTOUT(JJ)-459.69                        CRY05300
               IF (TB.EQ.'F'.AND.MATNMS(9).EQ.'R')                       CRY05310
     *            PRTOUT(JJ)=PRTOUT(JJ)+459.69                           CRY05320
               IF (TB.EQ.'C'.AND.MATNMS(9).EQ.'F')                       CRY05330
     *            PRTOUT(JJ)=(1.8*PRTOUT(JJ))+32                         CRY05340
               IF (TB.EQ.'C'.AND.MATNMS(9).EQ.'R')                       CRY05350
     *            PRTOUT(JJ)=((PRTOUT(JJ)-32)/1.8)+459.69                CRY05360
               IF (TB.EQ.'K'.AND.MATNMS(9).EQ.'F')                       CRY05370
     *            PRTOUT(JJ)=(1.8*(PRTOUT(JJ)-273.16))+32                CRY05380
               IF (TB.EQ.'K'.AND.MATNMS(9).EQ.'R')                       CRY05390
     *            PRTOUT(JJ)=((1.8*(PRTOUT(JJ)-273.16))+32)+459.69       CRY05400
               JJ=JJ+1                                                   CRY05410
               PRTOUT(JJ)=T(IK,IJ)                                       CRY05420
            ENDIF                                                        CRY05430
75       CONTINUE                                                        CRY05440
         LINES=JJ/6                                                      CRY05450
         IF (JJ.EQ.2) WRITE (MODU,92) NAMTAB(IK),MATRLS(IREG),           CRY05460
     *                  PRTOUT(1),PRTOUT(2)                              CRY05470
         IF (JJ.EQ.4) WRITE (MODU,93) NAMTAB(IK),MATRLS(IREG),           CRY05480
     *                  PRTOUT(1),PRTOUT(2),PRTOUT(3),PRTOUT(4)          CRY05490
         IF (JJ.EQ.6) WRITE (MODU,94) NAMTAB(IK),MATRLS(IREG),           CRY05500
     *                  PRTOUT(1),PRTOUT(2),PRTOUT(3),PRTOUT(4),         CRY05510
     *                  PRTOUT(5),PRTOUT(6)                              CRY05520
         IF (JJ.GT.6) WRITE (MODU,95) NAMTAB(IK),MATRLS(IREG),           CRY05530
     *                  PRTOUT(1),PRTOUT(2),PRTOUT(3),PRTOUT(4),         CRY05540
     *                  PRTOUT(5),PRTOUT(6)                              CRY05550
      M=MOD(JJ,6)                                                        CRY05560
      DO 76 II=2,LINES                                                   CRY05570
         L=LINES                                                         CRY05580
         IJ=((II-1)*6)+1                                                 CRY05590
      IF (M.EQ.0.AND.II.NE.L)WRITE (MODU,91) (PRTOUT(KK),KK=IJ,IJ+5)     CRY05600
```

```
      IF (M.NE.0.AND.II.EQ.L)WRITE (MODU,91) (PRTOUT(KK),KK=IJ,IJ+5)
      IF (M.NE.0.AND.II.NE.L)WRITE (MODU,91) (PRTOUT(KK),KK=IJ,IJ+5)
      IF (M.EQ.0.AND.II.EQ.L) WRITE (MODU,98) PRTOUT(IJ),PRTOUT(IJ+1),
     *            PRTOUT(IJ+2),PRTOUT(IJ+3),PRTOUT(IJ+4),PRTOUT(IJ+5)
   76 CONTINUE
      IJ=((LINES)*6)+1
      IF (NTEMP.EQ.1) GOTO 73
      IF (M.EQ.2) WRITE (MODU,96) PRTOUT(IJ),PRTOUT(IJ+1)
      IF (M.EQ.4) WRITE (MODU,97) PRTOUT(IJ),PRTOUT(IJ+1),PRTOUT(IJ+2),
     *                            PRTOUT(IJ+3)
   73 CONTINUE
         IF (MNUM.GE.200.AND.MNUM.LE.299) THEN
            WRITE (MODU,84) MATNMS(IREG)
         ELSE
            WRITE (MODU,85) MATNMS(IREG),PRESS,TABUNT(2)
         ENDIF
      DO 81 IK=3,NTABLE+2
         IF (NAMTAB(IK).EQ.2) NSP=IK
         IF (NAMTAB(IK).EQ.6) NCND=IK
   81 CONTINUE
      JJ=0
      DO 82 IJ=1,NTEMP
         IF (ABS(T(1,IJ)-PRESS).LE.0.01) THEN
            JJ=JJ+1
            PRTOUT(JJ)=T(2,IJ)
               TB=TABUNT(1)
               IF (TB.EQ.'R'.AND.MATNMS(9).EQ.'F')
     *              PRTOUT(JJ)=PRTOUT(JJ)-459.69
               IF (TB.EQ.'F'.AND.MATNMS(9).EQ.'R')
     *           PRTOUT(JJ)=PRTOUT(JJ)+459.69
               IF (TB.EQ.'C'.AND.MATNMS(9).EQ.'F')
     *           PRTOUT(JJ)=(1.8*PRTOUT(JJ))+32
               IF (TB.EQ.'C'.AND.MATNMS(9).EQ.'R')
     *           PRTOUT(JJ)=((PRTOUT(JJ)-32)/1.8)+459.69
               IF (TB.EQ.'K'.AND.MATNMS(9).EQ.'F')
     *           PRTOUT(JJ)=(1.8*(PRTOUT(JJ)-273.16))+32
               IF (TB.EQ.'K'.AND.MATNMS(9).EQ.'R')
     *           PRTOUT(JJ)=((1.8*(PRTOUT(JJ)-273.16))+32)+459.69
            JJ=JJ+1
            PRTOUT(JJ)=T(NSP,IJ)*T(NCND,IJ)
         ENDIF
   82 CONTINUE
      LINES=JJ/6
      K=1
         IF (JJ.EQ.2) WRITE (MODU,92) K,MATRLS(IREG),
     *                PRTOUT(1),PRTOUT(2)
         IF (JJ.EQ.4) WRITE (MODU,93) K,MATRLS(IREG),
     *                PRTOUT(1),PRTOUT(2),PRTOUT(3),PRTOUT(4)
         IF (JJ.EQ.6) WRITE (MODU,94) K,MATRLS(IREG),
     *                PRTOUT(1),PRTOUT(2),PRTOUT(3),PRTOUT(4),
     *                PRTOUT(5),PRTOUT(6)
         IF (JJ.GT.6) WRITE (MODU,95) K,MATRLS(IREG),
     *                PRTOUT(1),PRTOUT(2),PRTOUT(3),PRTOUT(4),
     *                PRTOUT(5),PRTOUT(6)
      M=MOD(JJ,6)
      DO 86 II=2,LINES
      L=LINES
      IJ=((II-1)*6)+1
      IF (M.EQ.0.AND.II.NE.L)WRITE (MODU,91) (PRTOUT(KK),KK=IJ,IJ+5)
      IF (M.NE.0.AND.II.EQ.L)WRITE (MODU,91) (PRTOUT(KK),KK=IJ,IJ+5)
      IF (M.NE.0.AND.II.NE.L)WRITE (MODU,91) (PRTOUT(KK),KK=IJ,IJ+5)
      IF (M.EQ.0.AND.II.EQ.L) WRITE (MODU,98) PRTOUT(IJ),PRTOUT(IJ+1),
     *            PRTOUT(IJ+2),PRTOUT(IJ+3),PRTOUT(IJ+4),PRTOUT(IJ+5)
   86 CONTINUE
      M=MOD(JJ,6)
      IJ=((LINES)*6)+1
      IF (NTEMP.GT.1) THEN
      IF (M.EQ.2) WRITE (MODU,96) PRTOUT(IJ),PRTOUT(IJ+1)
      IF (M.EQ.4) WRITE (MODU,97) PRTOUT(IJ),PRTOUT(IJ+1),PRTOUT(IJ+2),
     *                            PRTOUT(IJ+3)
```

```
      ENDIF                                                             CRY06310
    6 FORMAT (2X,I4,5X,A16,5X,I2,5X,I4,7X,I2)                          CRY06320
    7 FORMAT (1X,'ENTER THE ',A16,' VALUE AT ',                          CRY06330
     *        F7.1,' (R) AND ',F7.1,' (PSIA).')                          CRY06340
    8 FORMAT (1X,'ENTER THE ',A16,' VALUE AT ',F7.1,' (R).')             CRY06350
   19 FORMAT (7X,'REM ',A13,' FOR ',A16,' AT P=',F7.1,' ',A10)           CRY06360
   29 FORMAT (7X,'REM ',A13,' FOR ',A16)                                 CRY06370
   74 FORMAT (I3,A10)                                                    CRY06380
   84 FORMAT (7X,'REM CP * K FOR ',A16)                                  CRY06390
   85 FORMAT (7X,'REM Cp * k FOR ',A16,' AT P=',F7.1,' ',A10)            CRY06400
   91 FORMAT (12X,2(F6.0,',',E12.5,','),F6.0,',',E12.5)                  CRY06410
   92 FORMAT (7X,I1,I3,',',F6.0,',',E12.5,',END')                        CRY06420
   93 FORMAT (7X,I1,I3,',',2(F6.0,',',E12.5,','),'END')                  CRY06430
   94 FORMAT (7X,I1,I3,',',3(F6.0,',',E12.5,','),'END')                  CRY06440
   95 FORMAT (7X,I1,I3,',',2(F6.0,',',E12.5,','),F6.0,',',E12.5)         CRY06450
   96 FORMAT (12X,F6.0,',',E12.5,',END')                                 CRY06460
   97 FORMAT (12X,2(F6.0,',',E12.5,','),'END')                           CRY06470
   98 FORMAT (12X,3(F6.0,',',E12.5,','),'END')                           CRY06480
  100 RETURN                                                             CRY06490
      END                                                                CRY06500
                                                                         CRY06510
      SUBROUTINE CYLNDS                                                  CRY06520
      COMMON/REGION/NTHETA,NBETAS,BETA,RIN,TVOL,                         CRY06530
     *              ROUT(9),REGNS(9),NLAYRS(9),TEMPS(9),                 CRY06540
     *              THICK(9),THKLAY(9),MATRLS(9),MATNMS(9),RGNNMS(9)     CRY06550
      COMMON/TOPBOT/NTOP,NBOT,NFTLAY,NSTLAY,NETLAY,NFBLAY,NSBLAY,NEBLAY,CRY06560
     *                          ETRAT,EBRAT,FTTHK,FBTHK                  CRY06570
      COMMON/REGINP/MATT,DIST,THK,NLAY,MATN,RGNAM                        CRY06580
      COMMON/CYDATA/CYLHGT,NCYLAY                                        CRY06590
      COMMON/HTXGRS/ NHX,HXTEMP(10),NRHX(10),NLHX(10),NTHHX(10),         CRY06600
     *              LNGTHX(10)                                           CRY06610
      COMMON/UNITS/MODU,SINDA                                            CRY06620
      COMMON/ULLAGE/ NLUL4,NLUL5,NTHU41,RINMHH,PCTFUL,RADULG,TVULFT,     CRY06630
     *              CT,LG(3),LIQVAP(3)                                   CRY06640
      COMMON/VOLUME/VOLLIQ,ACCLIQ                                        CRY06650
      COMMON/NODDAT/NODNUM(10000),VOL(10000),NLGS(10000)                 CRY06660
      LOGICAL REGNS                                                      CRY06670
      CHARACTER*16 MLABL                                                 CRY06680
      CHARACTER*16 RGNNMS,MNAME,MATNMS,RGNAM,MATN                        CRY06690
      CHARACTER*10 TYPE1,TYPE2                                           CRY06700
      CHARACTER*1 CT,LG                                                  CRY06710
      CHARACTER*6 LIQVAP                                                 CRY06720
      IF (NTOP.EQ.2) TYPE1='FLAT'                                        CRY06730
      IF (NTOP.EQ.3) TYPE1='SPHERICAL'                                   CRY06740
      IF (NTOP.EQ.4) TYPE1='ELLIPTICAL'                                  CRY06750
      IF (NBOT.EQ.2) TYPE2='FLAT'                                        CRY06760
      IF (NBOT.EQ.3) TYPE2='SPHERICAL'                                   CRY06770
      IF (NBOT.EQ.4) TYPE2='ELLIPTICAL'                                  CRY06780
      DO 4 I=1,5                                                         CRY06790
         IF (I.EQ.1) NUMNOD=2001                                         CRY06800
         IF (I.EQ.2) NUMNOD=4001                                         CRY06810
         IF (I.EQ.3) NUMNOD=6001                                         CRY06820
         IF (I.EQ.4) NUMNOD=8001                                         CRY06830
         IF (I.EQ.5) NUMNOD=9001                                         CRY06840
         IF (REGNS(I)) THEN                                              CRY06850
            NLAY=NLAYRS(I)                                               CRY06860
            TMP=TEMPS(I)                                                 CRY06870
            THK=THICK(I)                                                 CRY06880
            DIST=ROUT(I)                                                 CRY06890
            MATT=MATRLS(I)                                               CRY06900
            MATN=MATNMS(I)                                               CRY06910
            RGNAM=RGNNMS(I)                                              CRY06920
         ELSE                                                            CRY06930
            GOTO 4                                                       CRY06940
         ENDIF                                                           CRY06950
         IF (NBOT.EQ.1) GOTO 160                                         CRY06960
         IF (NBOT.EQ.2) CALL FEND(I,NUMNOD,FBTHK,NFBLAY,2)               CRY06970
         IF (NBOT.EQ.3) CALL SEND(I,NUMNOD,NSBLAY,2)                     CRY06980
         IF (NBOT.EQ.4) CALL EEND(I,NUMNOD,EBRAT,2)                      CRY06990
                                                                         CRY07000
```

```
160      CALL CYLSEC (I,NUMNOD)

         IF (NTOP.EQ.1) GOTO 4
         IF (NTOP.EQ.2) CALL FEND(I,NUMNOD,FTTHK,NFTLAY,1)
         IF (NTOP.EQ.3) CALL SEND(I,NUMNOD,NSTLAY,2)
         IF (NTOP.EQ.4) CALL EEND(I,NUMNOD,ETRAT,1)

    4 CONTINUE

      IF (PCTFUL.GT.0.001.AND.CT.EQ.'1') CALL ULL1G
      IF (PCTFUL.LE.0.001) THEN
         DO 91 I=8001,10000
            IF (NLGS(I).GT.100.AND.NLGS(I).LE.199)NLGS(I)=NLGS(I)+200
91       CONTINUE
      ENDIF
      IF (PCTFUL.GT.0.001.AND.CT.EQ.'0') CALL ULL0G

      WRITE (MODU,170)
      CALL RITNDS(NTHETA,2,1001,1,0,TEMPS(1),0.0,MATNMS(1))
      WRITE (MODU,171)
      NN=1
      WRITE (MODU,172) '1'
      DO 46 I=2001,3000
         IF (NODNUM(I).EQ.0) GOTO 46
         IF (VOL(I).NE.VOL(I+1).OR.NLGS(I).NE.NLGS(I+1)) THEN
            NUMNOD=I-NN+1
            NARY=NLGS(NUMNOD)
            CALL RITNDS(NN,1,NUMNOD,1,NARY,TEMPS(1),VOL(I),MATNMS(1))
            NN=1
         ENDIF
         IF (VOL(I).EQ.VOL(I+1).AND.NLGS(I).EQ.NLGS(I+1)) NN=NN+1
   46 CONTINUE
      WRITE (MODU,173) '1'
      WRITE (MODU,170)
      CALL RITNDS(NTHETA,2,3001,1,0,TEMPS(1),0.0,MATNMS(1))
      WRITE (MODU,171)
      NN=1
      IF (REGNS(2)) THEN
         WRITE (MODU,172) '2'
         DO 47 I=4001,5000
         IF (NODNUM(I).EQ.0) GOTO 47
         IF (VOL(I).NE.VOL(I+1).OR.NLGS(I).NE.NLGS(I+1)) THEN
            NUMNOD=I-NN+1
            NARY=NLGS(NUMNOD)
            CALL RITNDS(NN,1,NUMNOD,1,NARY,TEMPS(2),VOL(I),MATNMS(2))
            NN=1
         ENDIF
         IF (VOL(I).EQ.VOL(I+1).AND.NLGS(I).EQ.NLGS(I+1)) NN=NN+1
   47    CONTINUE
         WRITE (MODU,173) '2'
         WRITE (MODU,170)
         CALL RITNDS(NTHETA,2,5001,1,0,TEMPS(2),0.0,MATNMS(2))
         WRITE (MODU,171)
      ENDIF
      NN=1
      IF (REGNS(3)) THEN
      WRITE (MODU,172) '3'
      DO 48 I=6001,7000
         IF (NODNUM(I).EQ.0) GOTO 48
         IF (VOL(I).NE.VOL(I+1).OR.NLGS(I).NE.NLGS(I+1)) THEN
            NUMNOD=I-NN+1
            NARY=NLGS(NUMNOD)
            CALL RITNDS(NN,1,NUMNOD,1,NARY,TEMPS(3),VOL(I),MATNMS(3))
            NN=1
         ENDIF
         IF (VOL(I).EQ.VOL(I+1).AND.NLGS(I).EQ.NLGS(I+1)) NN=NN+1
   48 CONTINUE
         WRITE (MODU,173) '3'
         WRITE (MODU,170)
         CALL RITNDS(NTHETA,2,7001,1,0,TEMPS(3),0.0,MATNMS(3))
```

```
         WRITE (MODU,171)
      ENDIF
      NN=1
      IF (REGNS(4)) WRITE (MODU,172) '4'
      DO 49 I=8001,9000
         IF (NODNUM(I).EQ.0) GOTO 49
         IF (VOL(I).NE.VOL(I+1).OR.NLGS(I).NE.NLGS(I+1)) THEN
            NUMNOD=I-NN+1
            NARY=NLGS(NUMNOD)
            CALL RITNDS(NN,1,NUMNOD,1,NARY,TEMPS(4),VOL(I),MATNMS(4))
            NN=1
         ENDIF
         IF (VOL(I).EQ.VOL(I+1).AND.NLGS(I).EQ.NLGS(I+1)) NN=NN+1
 49   CONTINUE
      IF (REGNS(4)) WRITE (MODU,173) '4'
      NN=1
      IF (REGNS(5)) THEN
         WRITE (MODU,170)
         CALL RITNDS (NTHETA,2,9001,1,0,TEMPS(5),0.00,MATNMS(I))
         WRITE (MODU,171)
         WRITE (MODU,172) '5'
         DO 50 I=9001,10000
         IF (NODNUM(I).EQ.0) GOTO 50
         IF (VOL(I).NE.VOL(I+1).OR.NLGS(I).NE.NLGS(I+1)) THEN
            NUMNOD=I-NN+1001
            NARY=NLGS(NUMNOD)
            CALL RITNDS(NN,1,NUMNOD,1,NARY,TEMPS(5),VOL(I),MATNMS(5))
            NN=1
         ENDIF
         IF (VOL(I).EQ.VOL(I+1).AND.NLGS(I).EQ.NLGS(I+1)) NN=NN+1
 50   CONTINUE
      WRITE (MODU,173) '5'
      ENDIF
      IF (NHX.GT.0) WRITE (MODU,178)

170   FORMAT (7X,'REM START OF SURFACE NODES')
171   FORMAT (7X,'REM END OF SURFACE NODES')
172   FORMAT (7X,'REM START OF NODES FOR REGION #',A1)
173   FORMAT (7X,'REM END OF NODES FOR REGION #',A1)
178   FORMAT (7X,'REM THE REMAINNING NODES ARE HEAT EXCHANGERS')

      RETURN
      END

      SUBROUTINE CYLSEC (I,NUMNOD)

      COMMON/REGION/NTHETA,NBETAS,BETA,RIN,TVOL,
     *              ROUT(9),REGNS(9),NLAYRS(9),TEMPS(9),
     *              THICK(9),THKLAY(9),MATRLS(9),MATNMS(9),RGNNMS(9)
      COMMON/TOPBOT/NTOP,NBOT,NFTLAY,NSTLAY,NETLAY,NFBLAY,NSBLAY,NEBLAY,
     *                        ETRAT,EBRAT,FTTHK,FBTHK
      COMMON/REGINP/MATT,DIST,THK,NLAY,MATN,RGNAM
      COMMON/NODDAT/NODNUM(10000),VOL(10000),NLGS(10000)
      COMMON/CYDATA/CYLHGT,NCYLAY

      LOGICAL REGNS
      CHARACTER*16 RGNNMS,MNAME,MATNMS,RGNAM,MATN

      HGT=CYLHGT/NCYLAY
      DIN=ROUT(I)-THICK(I)
      NDIV=NLAYRS(I)
      WIDTH=THICK(I)/NDIV
      DOUT=DIN+WIDTH
      ANG=BETA

      NARY=1000+MATRLS(I)
      DO 1 J=1,NDIV
         RAD1=ANG*DOUT
         RAD2=ANG*DIN
         VOLU=WIDTH*HGT*((RAD1+RAD2)/2.)
```

```
         IF (J.LT.NDIV) NL=NCYLAY+NUMNOD
         IF (J.EQ.NDIV) NL=NCYLAY+NUMNOD-1
         DO 3 IJ=NUMNOD,NL
            NODNUM(IJ)=IJ
            VOL(IJ)=VOLU
            NLGS(IJ)=NARY
    3    CONTINUE
C        CALL RITNDS(NCYLAY,1,NUMNOD,1,NARY,TEMPS(I),VOLU,MATNMS(I))
         NUMNOD=NUMNOD+NCYLAY
         DIN=DIN+WIDTH
         DOUT=DOUT+WIDTH
    1 CONTINUE

      RETURN
      END

      SUBROUTINE FEND(I,NUMNOD,FTHK,NFLAY,NWHICH)

      COMMON/REGION/NTHETA,NBETAS,BETA,RIN,TVOL,
     *              ROUT(9),REGNS(9),NLAYRS(9),TEMPS(9),
     *              THICK(9),THKLAY(9),MATRLS(9),MATNMS(9),RGNNMS(9)
      COMMON/TOPBOT/NTOP,NBOT,NFTLAY,NSTLAY,NETLAY,NFBLAY,NSBLAY,NEBLAY,
     *                       ETRAT,EBRAT,FTTHK,FBTHK
      COMMON/REGINP/MATT,DIST,THK,NLAY,MATN,RGNAM
      COMMON/NODDAT/NODNUM(10000),VOL(10000),NLGS(10000)
      COMMON/CYDATA/CYLHGT,NCYLAY
      COMMON/VOLUME/VOLLIQ,ACCLIQ
      LOGICAL REGNS
      CHARACTER*16 RGNNMS,MNAME,MATNMS,RGNAM,MATN

      HGT=FTHK/NFLAY
      DIN=ROUT(I)-THICK(I)
      NDIV=NLAYRS(I)
      ANG=BETA
      WIDTH=THICK(I)/NDIV
      DOUT=DIN+WIDTH

      NARY=1000 + MATRLS(I)
      DO 1 J=1,NDIV
         RAD1=ANG*DOUT
         RAD2=ANG*DIN
         VOLU=WIDTH*HGT*((RAD1+RAD2)/2.)
         DO 3 IJ=NUMNOD,NUMNOD+NFLAY
         NODNUM(IJ)=IJ
         VOL(IJ)=VOLU
         NLGS(IJ)=NARY
    3    CONTINUE
C        CALL RITNDS (NFLAY,1,NUMNOD,1,NARY,TEMPS(I),VOLU,MATNMS(I))
         NUMNOD=NUMNOD+NFLAY
         DOUT=DOUT+WIDTH
         DIN=DIN+WIDTH
    1 CONTINUE

      RETURN
      END

      SUBROUTINE SEND(I,NUMNOD,NRGLAY,NWHICH)

      COMMON/REGION/NTHETA,NBETAS,BETA,RIN,TVOL,
     *              ROUT(9),REGNS(9),NLAYRS(9),TEMPS(9),
     *              THICK(9),THKLAY(9),MATRLS(9),MATNMS(9),RGNNMS(9)
      COMMON/TOPBOT/NTOP,NBOT,NFTLAY,NSTLAY,NETLAY,NFBLAY,NSBLAY,NEBLAY,
     *                       ETRAT,EBRAT,FTTHK,FBTHK
      COMMON/REGINP/MATT,DIST,THK,NLAY,MATN,RGNAM
      COMMON/NODDAT/NODNUM(10000),VOL(10000),NLGS(10000)
      COMMON/CYDATA/CYLHGT,NCYLAY
      COMMON/UNITS/MODU,SINDA
      COMMON/VOLUME/VOLLIQ,ACCLIQ
      COMMON/STUFF/ NHTT,PI,CONVY,CONVR,THETA0,DTHETA,NBASOS,ROUTSF,
     *  BNCOEF(2)
```

```
      LOGICAL REGNS
      CHARACTER*16 RGNNMS,MNAME,MATNMS,RGNAM,MATN


C THIS SECTION CALCULATES THE NODE AREA FOR A NODE IN EITHER THE TOP
C OR BOTTOM SPHERE.

      TH = THKLAY(I)
      NARY = 1000 +  MATRLS(I)
      IF (NWHICH.EQ.1) THEN
          NSLAY=NSTLAY
          THETA0=0
      ELSE
          NSLAY=NSBLAY
          THETA0=PI/2.
      ENDIF
      DTHETA=PI/2./NSLAY

      DO 1 M=1,NLAYRS(I)
      IF (I.EQ.4) EL=M
      IF (I.EQ.3) EL=NLAYRS(I)-M+1
      R=ROUT(I)-TH*(EL-0.5)
      DO 2 JPOS=0,NRGLAY-1
      IF (NWHICH.EQ.1) POS=-1*(JPOS+1)
      IF (NWHICH.EQ.2) POS=JPOS
      THETA1=THETA0-POS*DTHETA
      THETA2=THETA1-DTHETA
      AREA=BETA*R*R*(COS(THETA1)+COS(THETA2))*DTHETA/2.
      NODNUM(NUMNOD)=NUMNOD
      VOL(NUMNOD)=AREA*TH
      NLGS(NUMNOD)=NARY
      NUMNOD = NUMNOD + 1
 2    CONTINUE
 1    CONTINUE

      RETURN
      END



      SUBROUTINE EEND(I,NUMNOD,ERAT,NWHICH)

      COMMON/REGION/NTHETA,NBETAS,BETA,RIN,TVOL,
     *             ROUT(9),REGNS(9),NLAYRS(9),TEMPS(9),
     *             THICK(9),THKLAY(9),MATRLS(9),MATNMS(9),RGNNMS(9)
      COMMON/TOPBOT/NTOP,NBOT,NFTLAY,NSTLAY,NETLAY,NFBLAY,NSBLAY,NEBLAY,
     *                       ETRAT,EBRAT,FTTHK,FBTHK
      COMMON/REGINP/MATT,DIST,THK,NLAY,MATN,RGNAM
      COMMON/NODDAT/NODNUM(10000),VOL(10000),NLGS(10000)
      COMMON/CYDATA/CYLHGT,NCYLAY
      COMMON/UNITS/MODU,SINDA
      COMMON/VOLUME/VOLLIQ,ACCLIQ
      COMMON/STUFF/ NHTT,PI,CONVY,CONVR,THETA0,DTHETA,NBASOS,ROUTSF,
     *  BNCOEF(2)

      LOGICAL REGNS
      CHARACTER*16 RGNNMS,MNAME,MATNMS,RGNAM,MATN


C THIS SECTION CALCULATES THE NODE AREA FOR A NODE IN EITHER THE TOP
C OR BOTTOM ELIPSE.

      TH = THKLAY(I)
C     BETA = 1.0
      NARY = 1000 +  MATRLS(I)
      IF (NWHICH.EQ.1) THEN
          NELAY=NETLAY
          THETA0=0
      ELSE
          NELAY=NEBLAY
```

```
          THETAO=PI/2.
       ENDIF
       DTHETA=PI/2./NELAY
       DO 1 M=1,NLAYRS(I)
       IF (I.GE.4) EL=M-1
       IF (I.LE.3) EL=NLAYRS(I)-M+1
       AI=ROUT(I)-TH*(EL)
       AO=AI+TH
       BI=AI*ERAT
       BO=BI+TH
C      PRINT *,' EEND,I,NW,RO,THO,DTH',I,NWHICH,ROUT(I),THETAO,DTHETA
C      PRINT *,'M,AI,AO,BI,BO',M,AI,AO,BI,BO
       DO 2 JPOS=0,NELAY-1
       IF (NWHICH.EQ.1) POS=-1*(JPOS+1)
       IF (NWHICH.EQ.2) POS=JPOS
       THETA2=THETAO-POS*DTHETA
       THETA1=THETA2-DTHETA
       NODNUM(NUMNOD)=NUMNOD
       AAVG=(AO+AI)/2.
       BAVG=(BO+BI)/2.
       THAVG=(THETA1+THETA2)/2.
       COSAVG=COS(THAVG)
       SINAVG=SIN(THAVG)
C      PRINT *,'NN,TH1,TH2,A,B,THAV,CTHA,STHA',
C     1 NUMNOD,THETA1,THETA2,AAVG,BAVG,THAVG,COSAVG,SINAVG
       FRST=((BETA*COSAVG)/2.)*((AAVG*BAVG)/SQRT((BAVG*BAVG*
      1 COSAVG*COSAVG)+(AAVG*AAVG*SINAVG*SINAVG)))
       SND=AO*BO*(ATAN((AO/BO)*TAN(THETA2))-ATAN((AO/BO)*TAN(THETA1)))
       THR=AI*BI*(ATAN((AI/BI)*TAN(THETA2))-ATAN((AI/BI)*TAN(THETA1)))
       VOL(NUMNOD)=FRST*(SND-THR)
C      WRITE (6,*) 'FIRST,SND,THR,VOL',FRST, SND, THR, VOL(NUMNOD)
       NLGS(NUMNOD)=NARY
       NUMNOD = NUMNOD + 1
    2  CONTINUE
    1  CONTINUE
       RETURN
       END

       SUBROUTINE HXARR

       COMMON/REGION/NTHETA,NBETAS,BETA,RIN,TVOL,
      *              ROUT(9),REGNS(9),NLAYRS(9),TEMPS(9),THICK(9),
      *              THKLAY(9),MATRLS(9),MATNMS(9),RGNNMS(9)
       COMMON/TOPBOT/NTOP,NBOT,NFTLAY,NSTLAY,NETLAY,NFBLAY,NSBLAY,
      *                    NEBLAY,ETRAT,EBRAT,FTTHK,FBTHK
       COMMON/CYDATA/CYLHGT,NCYLAY
       COMMON/VOLUME/VOLLIQ,ACCLIQ
       COMMON/HTXGRS/ NHX,HXTEMP(10),NRHX(10),NLHX(10),NTHHX(10),
      *              LNGTHX(10)
       COMMON/HX/NDS(1000),NCND(1000),INDEX
       COMMON/UNITS/MODU,SINDA

       LOGICAL REGNS
       CHARACTER*16 MLABL
       CHARACTER*16 RGNNMS,MNAME,MATNMS,RGNAM,MATN

       NUMCND=1
       INDEX=0
       NUMBER=-20001
       NTLAY=NFTLAY+NETLAY+NSTLAY
       NBLAY=NFBLAY+NEBLAY+NSBLAY
       DO 1 I=1,NHX
       IF (NRHX(I).EQ.1) NSTART=2001
       IF (NRHX(I).EQ.2) NSTART=4001
       IF (NRHX(I).EQ.3) NSTART=6001
       IF (NRHX(I).EQ.4) NSTART=8001
       IF (NRHX(I).EQ.5) NSTART=9001
       IF (NRHX(I).EQ.1.AND.NLHX(I).EQ.1) NSTART=1001
       IF (NRHX(I).EQ.2.AND.NLHX(I).EQ.1) NSTART=3001
       IF (NRHX(I).EQ.3.AND.NLHX(I).EQ.1) NSTART=5001
```

```
      IF (NRHX(I).EQ.4.AND.NLHX(I).EQ.1) NSTART=1001
      IF (NRHX(I).EQ.5.AND.NLHX(I).EQ.1) NSTART=8001+
     *   (NCYLAY*NLAYRS(4))+(NTLAY*NLAYRS(4))+(NBLAY*NLAYRS(4))
      LEVEL=NTHHX(I)
      LEVEL2=0
      LEVEL3=0
      DO 2 K=1,LNGTHX(I)
      IF (LEVEL.LE.NBLAY) NUM=NSTART+(NBLAY*(NLHX(I)-1))+(LEVEL-1)
      IF (LEVEL.GT.NBLAY.AND.NBLAY.GT.0.AND.LEVEL.LE.NBLAY+NCYLAY) THEN
         LEVEL2=LEVEL2+1
         NUM=NSTART+(NBLAY*NLAYRS(NRHX(I)))+(NCYLAY*(NLHX(I)-1))+
     *   LEVEL2
      ENDIF
      IF (NBLAY.EQ.0.AND.LEVEL.LE.NCYLAY)
     *   NUM=NSTART+(NBLAY*NLAYRS(NRHX(I)))+(NCYLAY*(NLHX(I)-1))+
     *   (LEVEL-1)
      IF (LEVEL.GT.NBLAY+NCYLAY) THEN
         LEVEL3=LEVEL3+1
         NUM=NSTART+(NBLAY*NLAYRS(NRHX(I)))+(NCYLAY*NLAYRS(NRHX(I)))+
     *   (NTLAY*(NLHX(I)-1))+LEVEL3
      ENDIF
      INDEX=INDEX+1
      LEVEL=LEVEL+1
      NDS(INDEX)=NUM
      NCND(INDEX)=NUMBER
2     CONTINUE
      NUMBER=NUMBER-1
1     CONTINUE

      RETURN
      END

      SUBROUTINE CYLCDS

      COMMON/REGION/NTHETA,NBETAS,BETA,RIN,TVOL,
     *              ROUT(9),REGNS(9),NLAYRS(9),TEMPS(9),THICK(9),
     *              THKLAY(9),MATRLS(9),MATNMS(9),RGNNMS(9)
      COMMON/TOPBOT/NTOP,NBOT,NFTLAY,NSTLAY,NETLAY,NFBLAY,NSBLAY,
     *                       NEBLAY,ETRAT,EBRAT,FTTHK,FBTHK
      COMMON/CYDATA/CYLHGT,NCYLAY
      COMMON/HTXGRS/ NHX,HXTEMP(10),NRHX(10),NLHX(10),NTHHX(10),
     *              LNGTHX(10)
      COMMON/UNITS/MODU,SINDA
      COMMON/NANB/NA1(5,3),NB1(5,3)
      COMMON/HX/NDS(1000),NCND(1000),INDEX
      COMMON/NODDAT/NODNUM(10000),VOL(10000),NLGS(10000)
      COMMON/STUFF/ NHTT,PI,CONVY,CONVR,THETAO,DTHETA,NBASOS,ROUTSF,
     * BNCOEF(2)
      LOGICAL REGNS
      CHARACTER*16 MATNMS
      CALL HXARR
      NCON=1
      DO 1 I=1,5
         IF (.NOT.REGNS(I)) GOTO 1
         NB=2000*I+1
         NA=NB-1000
         IF (I.EQ.4) NA=1001
         IF (NBOT.NE.1) THEN
            NA1(I,1)=NA
            NB1(I,1)=NB
            NA1(I,2)=NA1(I,1)+NFBLAY+NSBLAY+NEBLAY
            NB1(I,2)=NB1(I,1)+((NFBLAY+NSBLAY+NEBLAY)*NLAYRS(I))
         ENDIF
         IF (NBOT.EQ.1) THEN
            NA1(I,1)=0
            NB1(I,1)=0
            NA1(I,2)=NA
            NB1(I,2)=NB
         ENDIF
         NA1(I,3)=NA1(I,2)+NCYLAY
```

```
      NB1(I,3)=NB1(I,2)+(NCYLAY*NLAYRS(I))

      IF (NBOT.EQ.2)
     *   CALL FCND (I,NA1(I,1),NB1(I,1),NCON,NFBLAY,FBTHK,1)
      IF (NBOT.EQ.3)
     *   CALL SCND (I,NA1(I,1),NB1(I,1),NCON,NSBLAY,1)
      IF (NBOT.EQ.4)
     *   CALL ECND (I,NA1(I,1),NB1(I,1),NCON,NEBLAY,EBRAT,1)

      CALL CYLALL (I,NA1(I,2),NB1(I,2),NCON)

      IF (NTOP.EQ.2)
     *   CALL FCND (I,NA1(I,3),NB1(I,3),NCON,NFTLAY,FTTHK,2)
      IF (NTOP.EQ.3)
     *   CALL SCND (I,NA1(I,3),NB1(I,3),NCON,NSTLAY,2)
      IF (NTOP.EQ.4)
     *   CALL ECND (I,NA1(I,3),NB1(I,3),NCON,NETLAY,ETRAT,2)
1     CONTINUE

      RETURN
      END

      SUBROUTINE CYLALL (I,NA,NB,NCON)

      COMMON/REGION/NTHETA,NBETAS,BETA,RIN,TVOL,
     *              ROUT(9),REGNS(9),NLAYRS(9),TEMPS(9),THICK(9),
     *              THKLAY(9),MATRLS(9),MATNMS(9),RGNNMS(9)
      COMMON/TOPBOT/NTOP,NBOT,NFTLAY,NSTLAY,NETLAY,NFBLAY,NSBLAY,
     *                        NEBLAY,ETRAT,EBRAT,FTTHK,FBTHK
      COMMON/CYDATA/CYLHGT,NCYLAY
      COMMON/HTXGRS/ NHX,HXTEMP(10),NRHX(10),NLHX(10),NTHHX(10),
     *              LNGTHX(10)
      COMMON/UNITS/MODU,SINDA
      COMMON/HX/NDS(1000),NCND(1000),INDEX
      COMMON/NODDAT/NODNUM(10000),VOL(10000),NLGS(10000)
      COMMON/STUFF/ NHTT,PI,CONVY,CONVR,THETA0,DTHETA,NBASOS,ROUTSF,
     * BNCOEF(2)

      LOGICAL REGNS
      CHARACTER*16 MLABL
      CHARACTER*16 RGNNMS,MNAME,MATNMS,RGNAM,MATN

      WRITE (MODU,171) I

      NARY=6000 + MATRLS(I)
      NDIV=NLAYRS(I)
      IF (NDIV.EQ.1) NTEMP=1
      IF (NDIV.GT.1) NTEMP=NDIV-1
      DO 1 J=1,NTEMP
         IF (J.EQ.1) THEN
            DIN=BETA*(ROUT(I)-THICK(I))
            DOUT=DIN + (BETA*((THICK(I)/NDIV)/2.))
            F=(((DIN+DOUT)/2.)*(CYLHGT/NCYLAY))/((THICK(I)/NDIV)/2.)
            NTSTHX=0
            DO 71 K=1,INDEX
               IF (NDS(K).GE.NA.AND.NDS(K).LE.NA+NCYLAY) THEN
                  NUM=0
                  NPART=0
                  DO 52 IK=K,INDEX
                     IF (NCND(IK).EQ.NCND(IK-1).AND.IK.EQ.K) NPART=1
                     IF (NDS(IK+1).EQ.(NDS(IK)+1).AND.
     *                   NCND(IK+1).EQ.NCND(IK)) NUM=NUM+1
                     IF (NDS(IK+1).NE.(NDS(IK)+1)) GOTO 62
52                CONTINUE
62                NTSTHX=1
                  NAHX=NDS(K)
                  NBHX=NCND(K)
                  N=ABS(20000+NCND(K))
                  NTH=NTHHX(N)-(NFBLAY+NEBLAY+NSBLAY)
                  NCOV1=NTH-1
```

```
            NCOV2=NUM+1
            NCOV3=NCYLAY-NCOV1-NCOV2
            IF (NPART.EQ.1) THEN
               NCOV1=0
               NCOV2=NUM+1
               NCOV3=NCYLAY-NCOV1-NCOV2
            ENDIF
            GOTO 72
         ENDIF
71    CONTINUE
72    N=NCOV1
      IF (NTSTHX.EQ.1) THEN
      WRITE (MODU,123) I
      IF (N.EQ.0) GOTO 91
      CALL RITCND(5,NCON,N,1,NA,1,NB,1,NARY,0,F,0,MATNMS(I))
91    NP=NA+N
      NCON=NCON+N
      N=NCOV2
      NH=NBHX
      CALL RITCND(5,NCON,N,1,NH,1,NP,1,NARY,0,F,0,MATNMS(I))
      NCON=NCON+N
      NH=NB+NCOV1
      CALL RITCND(5,NCON,N,1,NP,1,NH,1,NARY,0,F,0,MATNMS(I))
      NCON=NCON+N
      IF (NCOV3.EQ.0) GOTO 321
      N=NCOV3
      NP=NA+NCOV1+NCOV2
      NH=NB+NCOV1+NCOV2
      CALL RITCND(5,NCON,N,1,NP,1,NH,1,NARY,0,F,0,MATNMS(I))
      NCON=NCON+NCOV3
321   WRITE (MODU,124) I
      ENDIF
      IF (NTSTHX.EQ.0) THEN
      CALL RITCND(5,NCON,NCYLAY,1,NA,1,NB,1,NARY,0,F,0,MATNMS(I))
      NCON=NCON+NCYLAY
      ENDIF
      IF (NDIV.EQ.1.AND.I.EQ.5) GOTO 776
      DIN=DOUT
      DOUT=DIN + (BETA * ((THICK(I)/NDIV)/2.))
      F=(((DIN+DOUT)/2.)*(CYLHGT/NCYLAY))/((THICK(I)/NDIV)/2.)
      NA=NB
      NB=NB+NCYLAY
      IF (NDIV.EQ.1) THEN
         IF (I.EQ.1) NB=3001+(NFBLAY+NSBLAY+NEBLAY)
         IF (I.EQ.2) NB=5001+(NFBLAY+NSBLAY+NEBLAY)
         IF (I.EQ.3) NB=7001+(NFBLAY+NSBLAY+NEBLAY)
      ENDIF
      NTSTHX=0
      DO 21 K=1,INDEX
         IF (NDS(K).GE.NA.AND.NDS(K).LE.NA+NCYLAY) THEN
            NUM=0
            NPART=0
            DO 51 IK=K,INDEX
               IF (NCND(IK).EQ.NCND(IK-1).AND.IK.EQ.K) NPART=1
               IF (NDS(IK+1).EQ.(NDS(IK)+1).AND.
     *             NCND(IK+1).EQ.NCND(IK)) NUM=NUM+1
               IF (NDS(IK+1).NE.(NDS(IK)+1)) GOTO 32
51          CONTINUE
32          NTSTHX=1
            NAHX=NDS(K)
            NBHX=NCND(K)
            N=ABS(20000+NCND(K))
            NTH=NTHHX(N)-(NFBLAY+NEBLAY+NSBLAY)
            NCOV1=NTH-1
            NCOV2=NUM+1
            NCOV3=NCYLAY-NCOV1-NCOV2
            IF (NPART.EQ.1) THEN
               NCOV1=0
               NCOV2=NUM+1
               NCOV3=NCYLAY-NCOV1-NCOV2
```

```
                  ENDIF                                                      CRY12610
                  GOTO 22                                                    CRY12620
                ENDIF                                                        CRY12630
 21           CONTINUE                                                       CRY12640
 22           N=NCOV1                                                        CRY12650
              IF (NTSTHX.EQ.1) THEN                                          CRY12660
              WRITE (MODU,123) I                                             CRY12670
              IF (N.EQ.0) GOTO 92                                            CRY12680
              CALL RITCND(5,NCON,N,1,NA,1,NB,1,NARY,0,F,0,MATNMS(I))         CRY12690
 92           NP=NA+N                                                        CRY12700
              NCON=NCON+N                                                    CRY12710
              N=NCOV2                                                        CRY12720
              NH=NBHX                                                        CRY12730
              CALL RITCND(5,NCON,N,1,NH,1,NP,1,NARY,0,F,0,MATNMS(I))         CRY12740
              NCON=NCON+N                                                    CRY12750
              NH=NB+NCOV1                                                    CRY12760
              CALL RITCND(5,NCON,N,1,NP,1,NH,1,NARY,0,F,0,MATNMS(I))         CRY12770
              NCON=NCON+N                                                    CRY12780
              IF (NCOV3.EQ.0) GOTO 322                                       CRY12790
              N=NCOV3                                                        CRY12800
              NP=NA+NCOV1+NCOV2                                              CRY12810
              NH=NB+NCOV1+NCOV2                                              CRY12820
              CALL RITCND(5,NCON,N,1,NP,1,NH,1,NARY,0,F,0,MATNMS(I))         CRY12830
              NCON=NCON+N                                                    CRY12840
 322          WRITE (MODU,124) I                                             CRY12850
              ENDIF                                                          CRY12860
              IF (NTSTHX.EQ.0) THEN                                          CRY12870
              IF (NLGS(NA).NE.NLGS(NB).AND.J.NE.1) THEN                      CRY12880
              FT=(DOUT+DOUT+(THICK(I)/NDIV))/2.                              CRY12890
              F2=(FT*(CYLHGT/NCYLAY))/((THICK(I)/NDIV)/2.)                   CRY12900
              CALL RITCND(7,NCON,N,1,NA,1,NB,1,NLGS(NA),NLGS(NB),F,          CRY12910
     *                F2,MATNMS(I))                                          CRY12920
              ELSE                                                           CRY12930
              CALL RITCND(5,NCON,NCYLAY,1,NA,1,NB,1,NARY,0,F,0,MATNMS(I))    CRY12940
              ENDIF                                                          CRY12950
              NCON=NCON+NCYLAY                                               CRY12960
              ENDIF                                                          CRY12970
 776        ENDIF                                                            CRY12980
                                                                             CRY12990
            IF (J.GT.1.AND.J.LT.NDIV) THEN                                   CRY13000
              DIN = DOUT                                                     CRY13010
              DOUT= DIN + (BETA*(THICK(I)/NDIV))                             CRY13020
              F=((DIN+DOUT)/2.)*(CYLHGT/NCYLAY)/((THICK(I)/NDIV))            CRY13030
              NA=NA+NCYLAY                                                   CRY13040
              NB=NB+NCYLAY                                                   CRY13050
              IF (I.EQ.4) NSAVE=NSAVE+NCYLAY                                 CRY13060
              NTSTHX=0                                                       CRY13070
              DO 23 K=1,INDEX                                                CRY13080
                IF (NDS(K).GE.NA.AND.NDS(K).LE.NA+NCYLAY) THEN               CRY13090
                  NUM=0                                                      CRY13100
                  NPART=0                                                    CRY13110
                  DO 33 IK=K,INDEX                                           CRY13120
                    IF (NCND(IK).EQ.NCND(IK-1).AND. IK.EQ.K) NPART=1         CRY13130
                    IF (NDS(IK+1).EQ.(NDS(IK)+1).AND.                        CRY13140
     *                 NCND(IK+1).EQ.NCND(IK)) NUM=NUM+1                     CRY13150
                    IF (NDS(IK+1).NE.(NDS(IK)+1)) GOTO 34                    CRY13160
 33               CONTINUE                                                   CRY13170
 34               NTSTHX=1                                                   CRY13180
                  NAHX=NDS(K)                                                CRY13190
                  NBHX=NCND(K)                                               CRY13200
                  N=ABS(20000+NCND(K))                                       CRY13210
                  NTH=NTHHX(N)-(NFBLAY+NEBLAY+NSBLAY)                        CRY13220
                  NCOV1=NTH-1                                                CRY13230
                  NCOV2=NUM+1                                                CRY13240
                  NCOV3=NCYLAY-NCOV1-NCOV2                                   CRY13250
                  IF (NPART.EQ.1) THEN                                       CRY13260
                    NCOV1=0                                                  CRY13270
                    NCOV2=NUM+1                                              CRY13280
                    NCOV3=NCYLAY-NCOV1-NCOV2                                 CRY13290
                  ENDIF                                                      CRY13300
```

```
            GOTO 24
          ENDIF
 23      CONTINUE
 24      N=NCOV1
         IF (NTSTHX.EQ.1) THEN
         WRITE (MODU,123) I
         IF (N.EQ.0) GOTO 93
         IF (NLGS(NA).NE.NLGS(NB)) THEN
         FT=(DOUT+DOUT+(THICK(I)/NDIV))/2.
         F2=(FT*(CYLHGT/NCYLAY))/((THICK(I)/NDIV)/2.)
         CALL RITCND(7,NCON,N,1,NA,1,NB,1,NLGS(NA),NLGS(NB),F,
     *            F2,MATNMS(I))
         ELSE
         CALL RITCND(5,NCON,N,1,NA,1,NB,1,NARY,0,F,0,MATNMS(I))
         ENDIF
 93      NP=NA+N
         NCON=NCON+N
         N=NCOV2
         NH=NBHX
         CALL RITCND(5,NCON,N,1,NH,1,NP,1,NARY,0,F,0,MATNMS(I))
         NCON=NCON+N
         NH=NB+NCOV1
         CALL RITCND(5,NCON,N,1,NP,1,NH,1,NARY,0,F,0,MATNMS(I))
         NCON=NCON+N
         IF (NCOV3.EQ.0) GOTO 323
         N=NCOV3
         NP=NA+NCOV1+NCOV2
         NH=NB+NCOV1+NCOV2
         CALL RITCND(5,NCON,N,1,NP,1,NH,1,NARY,0,F,0,MATNMS(I))
         NCON=NCON+N
 323     WRITE (MODU,124) I
         ENDIF
         IF (NTSTHX.EQ.0) THEN
         IF (NLGS(NA).NE.NLGS(NB)) THEN
         FT=(DOUT+DOUT+(THICK(I)/NDIV))/2.
         F2=(FT*(CYLHGT/NCYLAY))/((THICK(I)/NDIV)/2.)
         CALL RITCND(7,NCON,N,1,NA,1,NB,1,NLGS(NA),NLGS(NB),F,
     *            F2,MATNMS(I))
         ELSE
         CALL RITCND(5,NCON,NCYLAY,1,NA,1,NB,1,NARY,0,F,0,MATNMS(I))
         ENDIF
         NCON=NCON+NCYLAY
         ENDIF
      ENDIF

      IF (J.EQ.NDIV.AND.NDIV.NE.1) THEN
         IF (I.EQ.4.AND.(.NOT.REGNS(5))) GOTO 13
         IF (I.EQ.5.) GOTO 13
         DIN=BETA*(ROUT(I)-THICK(I))
         DOUT=DIN + (BETA*((THICK(I)/NDIV)/2.))
         F=(((DIN+DOUT)/2.)*(CYLHGT/NCYLAY))/((THICK(I)/NDIV)/2.)
         NA=NB
         IF (I.EQ.1) NB=3001+NFBLAY+NEBLAY+NSBLAY
         IF (I.EQ.2) NB=5001+NFBLAY+NSBLAY+NEBLAY
         IF (I.EQ.3) NB=7001+NFBLAY+NSBLAY+NEBLAY
         IF (I.EQ.4) NB=8001+((NFBLAY+NEBLAY+NSBLAY)*NLAYRS(I))+
     *                     (NCYLAY*NLAYRS(I))
         NTSTHX=0
         DO 25 K=1,INDEX
            IF (NDS(K).GE.NA.AND.NDS(K).LE.NA+NCYLAY) THEN
               NUM=0
               NPART=0
               DO 35 IK=K,INDEX
                  IF (NCND(IK).EQ.NCND(IK-1).AND.IK.EQ.K) NPART=1
                  IF (NDS(IK+1).EQ.(NDS(IK)+1).AND.
     *                NCND(IK+1).EQ.NCND(IK)) NUM=NUM+1
                  IF (NDS(IK+1).NE.(NDS(IK)+1)) GOTO 36
 35            CONTINUE
 36            NTSTHX=1
               NAHX=NDS(K)
```

```
               NBHX=NCND(K)
               N=ABS(20000+NCND(K))
               NTH=NTHHX(N)-(NFBLAY+NEBLAY+NSBLAY)
               NCOV1=NTH-1
               NCOV2=NUM+1
               NCOV3=NCYLAY-NCOV1-NCOV2
               IF (NPART.EQ.1) THEN
                  NCOV1=0
                  NCOV2=NUM+1
                  NCOV3=NCYLAY-NCOV1-NCOV2
               ENDIF
               GOTO 26
            ENDIF
25       CONTINUE
26       N=NCOV1
         IF (NTSTHX.EQ.1) THEN
         WRITE (MODU,123) I
         IF (N.EQ.0) GOTO 95
         IF (NLGS(NA).NE.NLGS(NB)) THEN
         FT=(DOUT+DOUT+(THICK(I)/NDIV))/2.
         F2=(FT*(CYLHGT/NCYLAY))/((THICK(I)/NDIV)/2.)
         CALL RITCND(7,NCON,N,1,NA,1,NB,1,NLGS(NA),NLGS(NB),F,
     *          F2,MATNMS(I))
         ELSE
         CALL RITCND(5,NCON,N,1,NA,1,NB,1,NARY,0,F,0,MATNMS(I))
         ENDIF
95       NP=NA+N
         NCON=NCON+N
         N=NCOV2
         NH=NBHX
         CALL RITCND(5,NCON,N,1,NH,1,NP,1,NARY,0,F,0,MATNMS(I))
         NCON=NCON+N
         NH=NB+NCOV1
         CALL RITCND(5,NCON,N,1,NP,1,NH,1,NARY,0,F,0,MATNMS(I))
         NCON=NCON+N
         IF (NCOV3.EQ.0) GOTO 331
         N=NCOV3
         NP=NA+NCOV1+NCOV2
         NH=NB+NCOV1+NCOV2
         CALL RITCND(5,NCON,N,1,NP,1,NH,1,NARY,0,F,0,MATNMS(I))
         NCON=NCON+N
331      WRITE (MODU,124) I
         ENDIF
         IF (NTSTHX.EQ.0) THEN
         IF (NLGS(NA).NE.NLGS(NB)) THEN
         FT=(DOUT+DOUT+(THICK(I)/NDIV))/2.
         F2=(FT*(CYLHGT/NCYLAY))/((THICK(I)/NDIV)/2.)
         CALL RITCND(7,NCON,N,1,NA,1,NB,1,NLGS(NA),NLGS(NB),F,
     *          F2,MATNMS(I))
         ELSE
         CALL RITCND(5,NCON,NCYLAY,1,NA,1,NB,1,NARY,0,F,0,MATNMS(I))
         ENDIF
         NCON=NCON+NCYLAY
         ENDIF
13      ENDIF
1     CONTINUE

10    LAYB=NFBLAY+NSBLAY+NEBLAY
      IF (I.EQ.1) NSTART= 2001+(LAYB*NLAYRS(I))
      IF (I.EQ.2) NSTART= 4001+(LAYB*NLAYRS(I))
      IF (I.EQ.3) NSTART= 6001+(LAYB*NLAYRS(I))
      IF (I.EQ.4) NSTART= 8001+(LAYB*NLAYRS(I))
      IF (I.EQ.5) NSTART= 9001+(LAYB*NLAYRS(I))
      ALEN=CYLHGT/NCYLAY
      DIN=ROUT(I)-THICK(I)
      DOUT=DIN+(THICK(I)/NDIV)
      DO 31 J=1,NDIV
         NA=NSTART
         NB=NSTART+1
         WIDTH=((DIN+DOUT)/2)*(THICK(I)/NDIV)
```

```
      F=WIDTH/ALEN
      NSAME=0
      FLAG=0
      DO 131 KI=NA,NA+NCYLAY-1
         IF (NLGS(KI).NE.NLGS(KI+1)) FLAG=1
         IF (NLGS(KI).EQ.NLGS(KI+1).AND.FLAG.EQ.0) NSAME = NSAME +1
131   CONTINUE
      IF (NSAME.NE.NCYLAY) NSAME=NSAME+1
      IF (NSAME.NE.NCYLAY) THEN
         NK=NCYLAY-NSAME
         CALL RITCND(5,NCON,NSAME-1,1,NA,1,NB,1,NARY,0,F,0,MATNMS(I))
         N1=NA+NSAME-1
         N2=NB+NSAME-1
         NCON=NCON+NSAME-1
         NLA=NLGS(N1)+5000
         NLB=NLGS(N2)+5000
         CALL RITCND(7,NCON,1,1,N1,1,N2,1,NLA,NLB,F,
     *               F,MATNMS(I))
         NCON=NCON+1
         NL=NLGS(N1+1)+5000
         CALL RITCND(5,NCON,NK,1,N1+1,1,N2+1,1,NL,0,F,0,MATNMS(I))
         NCON=NCON+NK
      ELSE
      CALL RITCND(5,NCON,NCYLAY-1,1,NA,1,NB,1,NARY,0,F,0,MATNMS(I))
      NCON=NCON+NCYLAY-1
      ENDIF

      NSTART=NSTART+NCYLAY
      DIN=DOUT
      DOUT=DIN+(THICK(I)/NDIV)
 31 CONTINUE
    WRITE (MODU,172) I

123 FORMAT(7X,'REM START OF H/X IN REGION #',I1)
124 FORMAT(7X,'REM END OF H/X IN REGION #',I1)
171 FORMAT(7X,'REM CONDUCTOR BLOCK FOR REGION #',I1,' BEGINS (CYL).')
172 FORMAT(7X,'REM CONDUCTOR BLOCK FOR REGION #',I1,' ENDS (CYL).')

    RETURN
    END

    SUBROUTINE FCND (I,NA,NB,NCON,NFLAY,FTHK,NWHICH)

    COMMON/REGION/NTHETA,NBETAS,BETA,RIN,TVOL,
   *              ROUT(9),REGNS(9),NLAYRS(9),TEMPS(9),THICK(9),
   *              THKLAY(9),MATRLS(9),MATNMS(9),RGNNMS(9)
    COMMON/TOPBOT/NTOP,NBOT,NFTLAY,NSTLAY,NETLAY,NFBLAY,NSBLAY,
   *                         NEBLAY,ETRAT,EBRAT,FTTHK,FBTHK
    COMMON/CYDATA/CYLHGT,NCYLAY
    COMMON/HTXGRS/ NHX,HXTEMP(10),NRHX(10),NLHX(10),NTHHX(10),
   *              LNGTHX(10)
    COMMON/UNITS/MODU,SINDA
    COMMON/HX/NDS(1000),NCND(1000),INDEX
    COMMON/NODDAT/NODNUM(10000),VOL(10000),NLGS(10000)
    COMMON/STUFF/ NHTT,PI,CONVY,CONVR,THETA0,DTHETA,NBASOS,ROUTSF,
   *  BNCOEF(2)

    LOGICAL REGNS
    CHARACTER*16 MLABL
    CHARACTER*16 RGNNMS,MNAME,MATNMS,RGNAM,MATN
    CHARACTER*6 TYPE

    IF (NWHICH.EQ.1) TYPE='BOTTOM'
    IF (NWHICH.EQ.2) TYPE='TOP   '

    IF (NWHICH.EQ.1) WRITE (MODU,171) I,TYPE
    IF (NWHICH.EQ.2) WRITE (MODU,173) I,TYPE

    NARY=6000+MATRLS(I)
    NDIV=NLAYRS(I)
```

```
      IF (NDIV.EQ.1) NTEMP=1
      IF (NDIV.GT.1) NTEMP=NDIV-1
      DO 1 J=1,NTEMP
         IF (J.EQ.1) THEN
            DIN=BETA*(ROUT(I)-THICK(I))
            DOUT=DIN + (BETA*((THICK(I)/NDIV)/2.))
            F=(((DIN+DOUT)/2.)*(FTHK/NFLAY))/((THICK(I)/NDIV)/2.)
            NTSTHX=0
            DO 71 K=1,INDEX
               IF (NDS(K).GE.NA.AND.NDS(K).LE.NA+NFLAY) THEN
                  NUM=0
                  DO 52 IK=K,INDEX
                     IF (NDS(IK+1).EQ.(NDS(IK)+1).AND.
     *                   NCND(IK+1).EQ.NCND(IK)) NUM=NUM+1
                     IF (NDS(IK+1).NE.(NDS(IK)+1)) GOTO 62
52                CONTINUE
62                NTSTHX=1
                  NAHX=NDS(K)
                  NBHX=NCND(K)
                  N=ABS(20000+NCND(K))
                  IF (NWHICH.EQ.2) NTH=NTHHX(N)-NCYLAY-(NFBLAY+NEBLAY
     *                                                 NSBLAY)
                  IF (NWHICH.EQ.1) NTH=NTHHX(N)
                  NCOV1=NTH-1
                  NCOV2=NUM+1
                  NCOV3=NFLAY-NCOV1-NCOV2
                  GOTO 72
               ENDIF
71          CONTINUE
72          N=NCOV1
            IF (NTSTHX.EQ.1) THEN
            WRITE (MODU,123) I
            IF (N.EQ.0) GOTO 63
            IF (NLGS(NA).NE.NLGS(NB).AND.J.NE.1) THEN
            FT=(DOUT+DOUT+(THICK(I)/NDIV))/2.
            F2=(FT*(FTHK/NFLAY))/((THICK(I)/NDIV)/2.)
            CALL RITCND(7,NCON,N,1,NA,1,NB,1,NLGS(NA),NLGS(NB),F,
     *              F2,MATNMS(I))
            ELSE
            CALL RITCND(5,NCON,N,1,NA,1,NB,1,NARY,0,F,0,MATNMS(I))
            ENDIF
63          NP=NA+N
            NCON=NCON+N
            N=NCOV2
            NH=NBHX
            CALL RITCND(5,NCON,N,1,NH,1,NP,1,NARY,0,F,0,MATNMS(I))
            NCON=NCON+N
            NH=NB+NCOV1
            CALL RITCND(5,NCON,N,1,NP,1,NH,1,NARY,0,F,0,MATNMS(I))
            NCON=NCON+N
            IF (NCOV3.EQ.0) GOTO 341
            N=NCOV3
            NP=NA+NCOV1+NCOV2
            NH=NB+NCOV1+NCOV2
            CALL RITCND(5,NCON,N,1,NP,1,NH,1,NARY,0,F,0,MATNMS(I))
            NCON=NCON+NCOV3
341         WRITE (MODU,124) I
            ENDIF
            IF (NTSTHX.EQ.0) THEN
            IF (NLGS(NA).NE.NLGS(NB).AND.J.NE.1) THEN
            FT=(DOUT+DOUT+(THICK(I)/NDIV))/2.
            F2=(FT*(FTHK/NFLAY))/((THICK(I)/NDIV)/2.)
            CALL RITCND(7,NCON,NFLAY,1,NA,1,NB,1,NLGS(NA),NLGS(NB),F,
     *              F2,MATNMS(I))
            ELSE
            CALL RITCND(5,NCON,NFLAY,1,NA,1,NB,1,NARY,0,F,0,MATNMS(I))
            ENDIF
            NCON=NCON+NFLAY
            ENDIF
            IF(NDIV.EQ.1.AND.I.EQ.5) GOTO 776
```

```
      DIN=DOUT
      DOUT=DIN + (BETA * ((THICK(I)/NDIV)/2.))
      F=(((DIN+DOUT)/2.)*(FTHK/NFLAY))/((THICK(I)/NDIV)/2.)
      NA=NB
      NB=NB+NFLAY
      IF (NDIV.EQ.1) THEN
         IF (NWHICH.EQ.1) THEN
            IF (I.EQ.1) NB=3001
            IF (I.EQ.2) NB=5001
            IF (I.EQ.3) NB=7001
         ENDIF
         IF (NWHICH.EQ.2) THEN
            IF (I.EQ.1) NB=3001+NCYLAY+NFBLAY+NSBLAY+NEBLAY
            IF (I.EQ.2) NB=5001+NCYLAY+NFBLAY+NSBLAY+NEBLAY
            IF (I.EQ.3) NB=7001+NCYLAY+NFBLAY+NSBLAY+NEBLAY
         ENDIF
      ENDIF
      NTSTHX=0
      DO 21 K=1,INDEX
         IF (NDS(K).GE.NA.AND.NDS(K).LE.NA+NFLAY) THEN
            NUM=0
            DO 51 IK=K,INDEX
               IF (NDS(IK+1).EQ.(NDS(IK)+1).AND.
     *             NCND(IK+1).EQ.NCND(IK)) NUM=NUM+1
               IF (NDS(IK+1).NE.(NDS(IK)+1)) GOTO 32
 51         CONTINUE
 32         NTSTHX=1
            NAHX=NDS(K)
            NBHX=NCND(K)
            N=ABS(20000+NCND(K))
            IF (NWHICH.EQ.2) NTH=NTHHX(N)-NCYLAY-(NFBLAY+NEBLAY
     *                                         NSBLAY)
            IF (NWHICH.EQ.1) NTH=NTHHX(N)
            NCOV1=NTH-1
            NCOV2=NUM+1
            NCOV3=NFLAY-NCOV1-NCOV2
            GOTO 22
         ENDIF
 21   CONTINUE
 22   N=NCOV1
      IF (NTSTHX.EQ.1) THEN
      WRITE (MODU,123) I
      IF (N.EQ.0) GOTO 64
      IF (NLGS(NA).NE.NLGS(NB).AND.J.NE.1) THEN
      FT=(DOUT+DOUT+(THICK(I)/NDIV))/2.
      F2=(FT*(FTHK/NFLAY))/((THICK(I)/NDIV)/2.)
      CALL RITCND(7,NCON,N,1,NA,1,NB,1,NLGS(NA),NLGS(NB),F,
     *        F2,MATNMS(I))
      ELSE
      CALL RITCND(5,NCON,N,1,NA,1,NB,1,NARY,0,F,0,MATNMS(I))
      ENDIF
 64   NP=NA+N
      NCON=NCON+N
      N=NCOV2
      NH=NBHX
      CALL RITCND(5,NCON,N,1,NH,1,NP,1,NARY,0,F,0,MATNMS(I))
      NCON=NCON+N
      NH=NB+NCOV1
      CALL RITCND(5,NCON,N,1,NP,1,NH,1,NARY,0,F,0,MATNMS(I))
      NCON=NCON+N
      IF(NCOV3.EQ.0) GOTO 391
      N=NCOV3
      NP=NA+NCOV1+NCOV2
      NH=NB+NCOV1+NCOV2
      CALL RITCND(5,NCON,N,1,NP,1,NH,1,NARY,0,F,0,MATNMS(I))
      NCON=NCON+N
 391  WRITE (MODU,124) I
      ENDIF
      IF (NTSTHX.EQ.0) THEN
      IF (NLGS(NA).NE.NLGS(NB).AND.J.NE.1) THEN
```

```
      FT=(DOUT+DOUT+(THICK(I)/NDIV))/2.
      F2=(FT*(FTHK/NFLAY))/((THICK(I)/NDIV)/2.)
      CALL RITCND(7,NCON,NFLAY,1,NA,1,NB,1,NLGS(NA),NLGS(NB),F,
     *     F2,MATNMS(I))
      ELSE
      CALL RITCND(5,NCON,NFLAY,1,NA,1,NB,1,NARY,0,F,0,MATNMS(I))
      ENDIF
      NCON=NCON+NFLAY
      ENDIF
776   ENDIF

      IF (J.GT.1.AND.J.LT.NDIV) THEN
        DIN = DOUT
        DOUT= DIN + (BETA*(THICK(I)/NDIV))
        F=((DIN+DOUT)/2.)*(FTHK/NFLAY)/((THICK(I)/NDIV))
        NA=NA+NFLAY
        NB=NB+NFLAY
        IF (I.EQ.4) NSAVE=NSAVE+NFLAY
        NTSTHX=0
        DO 23 K=1,INDEX
           IF (NDS(K).GE.NA.AND.NDS(K).LE.NA+NFLAY) THEN
              NUM=0
              DO 33 IK=K,INDEX
                 IF (NDS(IK+1).EQ.(NDS(IK)+1).AND.
     *              NCND(IK+1).EQ.NCND(IK)) NUM=NUM+1
                 IF (NDS(IK+1).NE.(NDS(IK)+1)) GOTO 34
33            CONTINUE
34            NTSTHX=1
              NAHX=NDS(K)
              NBHX=NCND(K)
              N=ABS(20000+NCND(K))
              IF (NWHICH.EQ.2) NTH=NTHHX(N)-NCYLAY-(NFBLAY+NEBLAY
     *                                       NSBLAY)
              IF (NWHICH.EQ.1) NTH=NTHHX(N)
              NCOV1=NTH-1
              NCOV2=NUM+1
              NCOV3=NFLAY-NCOV1-NCOV2
              GOTO 24
           ENDIF
23      CONTINUE
24      N=NCOV1
        IF (NTSTHX.EQ.1) THEN
        WRITE (MODU,123) I
        IF (N.EQ.0) GOTO 65
        IF (NLGS(NA).NE.NLGS(NB).AND.J.NE.1) THEN
        FT=(DOUT+DOUT+(THICK(I)/NDIV))/2.
        F2=(FT*(FTHK/NFLAY))/((THICK(I)/NDIV)/2.)
        CALL RITCND(7,NCON,N,1,NA,1,NB,1,NLGS(NA),NLGS(NB),F,
     *       F2,MATNMS(I))
        ELSE
        CALL RITCND(5,NCON,N,1,NA,1,NB,1,NARY,0,F,0,MATNMS(I))
        ENDIF
65      NP=NA+N
        NCON=NCON+N
        N=NCOV2
        NH=NBHX
        CALL RITCND(5,NCON,N,1,NH,1,NP,1,NARY,0,F,0,MATNMS(I))
        NCON=NCON+N
        NH=NB+NCOV1
        CALL RITCND(5,NCON,N,1,NP,1,NH,1,NARY,0,F,0,MATNMS(I))
        NCON=NCON+N
        IF (NCOV3.EQ.0) GOTO 311
        N=NCOV3
        NP=NA+NCOV1+NCOV2
        NH=NB+NCOV1+NCOV2
        CALL RITCND(5,NCON,N,1,NP,1,NH,1,NARY,0,F,0,MATNMS(I))
        NCON=NCON+N
311     WRITE (MODU,124) I
        ENDIF
        IF (NTSTHX.EQ.0) THEN
```

```
            IF (NLGS(NA).NE.NLGS(NB).AND.J.NE.1) THEN
            FT=(DOUT+DOUT+(THICK(I)/NDIV))/2.
            F2=(FT*(FTHK/NFLAY))/((THICK(I)/NDIV)/2.)
            CALL RITCND(7,NCON,NFLAY,1,NA,1,NB,1,NLGS(NA),NLGS(NB),F,
     *                  F2,MATNMS(I))
            ELSE
            CALL RITCND(5,NCON,NFLAY,1,NA,1,NB,1,NARY,0,F,0,MATNMS(I))
            ENDIF
            NCON=NCON+NFLAY
            ENDIF
         ENDIF

         IF (J.EQ.NDIV.AND.NDIV.NE.1) THEN
            IF (I.EQ.4.AND.(.NOT.REGNS(5))) GOTO 13
            IF (I.EQ.5.) GOTO 13
            DIN=BETA*(ROUT(I)-THICK(I))
            DOUT=DIN + (BETA*((THICK(I)/NDIV)/2.))
            F=(((DIN+DOUT)/2.)*(FTHK/NFLAY))/((THICK(I)/NDIV)/2.)
            NA=NB
            IF (NWHICH.EQ.2) THEN
            IF (I.EQ.1) NB=3001+NFBLAY+NEBLAY+NSBLAY+NCYLAY
            IF (I.EQ.2) NB=5001+NFBLAY+NSBLAY+NEBLAY+NCYLAY
            IF (I.EQ.3) NB=7001+NFBLAY+NSBLAY+NEBLAY+NCYLAY
            IF (I.EQ.4) NB=8001+((NFBLAY+NEBLAY+NSBLAY)*NLAYRS(I))+
     *                          (NCYLAY*NLAYRS(I))
            ENDIF
            IF (NWHICH.EQ.1) THEN
            IF (I.EQ.1) NB=3001
            IF (I.EQ.2) NB=5001
            IF (I.EQ.3) NB=7001
            IF (I.EQ.4) NB=8001
            ENDIF
            NTSTHX=0
            DO 25 K=1,INDEX
               IF (NDS(K).GE.NA.AND.NDS(K).LE.NA+NFLAY) THEN
                  NUM=0
                  DO 35 IK=K,INDEX
                     IF (NDS(IK+1).EQ.(NDS(IK)+1).AND.
     *                   NCND(IK+1).EQ.NCND(IK)) NUM=NUM+1
                     IF (NDS(IK+1).NE.(NDS(IK)+1)) GOTO 36
 35               CONTINUE
 36               NTSTHX=1
                  NAHX=NDS(K)
                  NBHX=NCND(K)
                  N=ABS(20000+NCND(K))
                  IF (NWHICH.EQ.2) NTH=NTHHX(N)-NCYLAY-(NFBLAY+NEBLAY
     *                                                 NSBLAY)
                  IF (NWHICH.EQ.1) NTH=NTHHX(N)
                  NCOV1=NTH-1
                  NCOV2=NUM+1
                  NCOV3=NFLAY-NCOV1-NCOV2
                  GOTO 26
               ENDIF
 25         CONTINUE
 26         N=NCOV1
            IF (NTSTHX.EQ.1) THEN
            WRITE (MODU,123) I
            IF (N.EQ.0) GOTO 66
            IF (NLGS(NA).NE.NLGS(NB).AND.J.NE.1) THEN
            FT=(DOUT+DOUT+(THICK(I)/NDIV))/2.
            F2=(FT*(FTHK/NFLAY))/((THICK(I)/NDIV)/2.)
            CALL RITCND(7,NCON,N,1,NA,1,NB,1,NLGS(NA),NLGS(NB),F,
     *                  F2,MATNMS(I))
            ELSE
            CALL RITCND(5,NCON,N,1,NA,1,NB,1,NARY,0,F,0,MATNMS(I))
            ENDIF
 66         NP=NA+N
            NCON=NCON+N
            N=NCOV2
            NH=NBHX
```

```
          CALL RITCND(5,NCON,N,1,NH,1,NP,1,NARY,0,F,0,MATNMS(I))
          NCON=NCON+N
          NH=NB+NCOV1
          CALL RITCND(5,NCON,N,1,NP,1,NH,1,NARY,0,F,0,MATNMS(I))
          NCON=NCON+N
          IF (NCOV3.EQ.0) GOTO 312
          N=NCOV3
          NP=NA+NCOV1+NCOV2
          NH=NB+NCOV1+NCOV2
          CALL RITCND(5,NCON,N,1,NP,1,NH,1,NARY,0,F,0,MATNMS(I))
          NCON=NCON+N
312       WRITE (MODU,124) I
          ENDIF
          IF (NTSTHX.EQ.0) THEN
          IF (NLGS(NA).NE.NLGS(NB).AND.J.NE.1) THEN
          FT=(DOUT+DOUT+(THICK(I)/NDIV))/2.
          F2=(FT*(FTHK/NFLAY))/((THICK(I)/NDIV)/2.)
          CALL RITCND(7,NCON,NFLAY,1,NA,1,NB,1,NLGS(NA),NLGS(NB),F,
     *              F2,MATNMS(I))
          ELSE
          CALL RITCND(5,NCON,NFLAY,1,NA,1,NB,1,NARY,0,F,0,MATNMS(I))
          ENDIF
          NCON=NCON+NFLAY
          ENDIF
13      ENDIF
 1    CONTINUE

10    LAYB=NFBLAY+NSBLAY+NEBLAY
      IF (NWHICH.EQ.1) LAYB=0
      IF (I.EQ.1) NSTART= 2001+(LAYB*NLAYRS(I))
      IF (I.EQ.2) NSTART= 4001+(LAYB*NLAYRS(I))
      IF (I.EQ.3) NSTART= 6001+(LAYB*NLAYRS(I))
      IF (I.EQ.4) NSTART= 8001+(LAYB*NLAYRS(I))
      IF (I.EQ.5) NSTART= 9001+(LAYB*NLAYRS(I))
      ALEN=FTHK/NFLAY
      DIN=ROUT(I)-THICK(I)
      DOUT=DIN+(THICK(I)/NDIV)
      DO 31 J=1,NDIV
        NA=NSTART
        NB=NSTART+1
        WIDTH=((DIN+DOUT)/2)*(THICK(I)/NDIV)
        F=WIDTH/ALEN
        IF (NLGS(NA).NE.NLGS(NB).AND.J.NE.1) THEN
        CALL RITCND(7,NCON,NFLAY-1,1,NA,1,NB,1,NLGS(NA),NLGS(NB),F,
     *              F,MATNMS(I))
        ELSE
        CALL RITCND(5,NCON,NFLAY-1,1,NA,1,NB,1,NARY,0,F,0,MATNMS(I))
        ENDIF
        NCON=NCON+NFLAY-1
        NSTART=NSTART+NFLAY
        DIN=DOUT
        DOUT=DIN+(THICK(I)/NDIV)
  31  CONTINUE
      IF (NWHICH.EQ.1) WRITE (MODU,172) I,TYPE
      IF (NWHICH.EQ.2) WRITE (MODU,174) I,TYPE

123   FORMAT(7X,'REM START OF H/X IN REGION #',I1)
124   FORMAT(7X,'REM END OF H/X IN REGION #',I1)
171   FORMAT(7X,'REM CONDUCTOR BLOCK FOR REGION #',I1,' BEGINS. (',A6,
     *')')
172   FORMAT(7X,'REM CONDUCTOR BLOCK FOR REGION #',I1,' ENDS. (',A6,
     *')')

173   FORMAT(7X,'REM CONDUCTOR BLOCK FOR REGION #',I1,' BEGINS. (',A3,
     *')')
174   FORMAT(7X,'REM CONDUCTOR BLOCK FOR REGION #',I1,' ENDS. (',A3,
     *')')
      RETURN
      END
```

```
      SUBROUTINE SCND (I,NA,NB,NCON,NSLAY,NWHICH)

      COMMON/REGION/NTHETA,NBETAS,BETA,RIN,TVOL,
     *              ROUT(9),REGNS(9),NLAYRS(9),TEMPS(9),THICK(9),
     *              THKLAY(9),MATRLS(9),MATNMS(9),RGNNMS(9)
      COMMON/TOPBOT/NTOP,NBOT,NFTLAY,NSTLAY,NETLAY,NFBLAY,NSBLAY,
     *                          NEBLAY,ETRAT,EBRAT,FTTHK,FBTHK
      COMMON/CYDATA/CYLHGT,NCYLAY
      COMMON/HTXGRS/ NHX,HXTEMP(10),NRHX(10),NLHX(10),NTHHX(10),
     *              LNGTHX(10)
      COMMON/UNITS/MODU,SINDA
      COMMON/HX/NDS(1000),NCND(1000),INDEX
      COMMON/NODDAT/NODNUM(10000),VOL(10000),NLGS(10000)
      COMMON/STUFF/ NHTT,PI,CONVY,CONVR,THETAO,DTHETA,NBASOS,ROUTSF,
     *  BNCOEF(2)

      LOGICAL REGNS
      CHARACTER*16 MLABL
      CHARACTER*16 RGNNMS,MNAME,MATNMS,RGNAM,MATN
      CHARACTER*6 TYPE

      NOUT=NB+1000
      IF (NWHICH.EQ.1) TYPE='BOTTOM'
      IF (NWHICH.EQ.2) TYPE='TOP   '


      IF (NWHICH.EQ.1) NSLAY = NSBLAY
      IF (NWHICH.EQ.2) NSLAY = NSTLAY

      NC2=NB
      NARY=6000+MATRLS(I)
      TH=THKLAY(I)
      DOUT =  RIN+THKLAY(I)/4.0
      BASE = NB
      DO 1 J=1,NLAYRS(I)
         IF (J.GT.1) WRITE (MODU,18) I,J-1,J,TYPE
         IF (J.EQ.1) NATEMP = NB
         IF (J.EQ.2) THEN
            NA = NATEMP
         ENDIF
         DO 2 IJ=0,NSLAY-1
            IF (IJ.EQ.0.AND.J.EQ.1) WRITE (MODU,94) I,TYPE
            NTSTHX = 0
            NBHX = 0
            DO 71 K = 1,INDEX
               IF (NDS(K).EQ.NA) THEN
                  NTBTHX = 1
                  NAHX = NA
                  NBHX = NCND(K)
                  GOTO 72
               ENDIF
71          CONTINUE
72          IF (NBHX.NE.0) THEN
               CALL AREACYL (1,IJ,DOUT,THICK(I),AREA,NWHICH)
               AREA=AREA/2.
               NARY=NLGS(NA)+5000
               CALL RITCND (5,NCON,1,1,NA,1,NBHX,1,NARY,0,
     *                      AREA,0,MATNMS(I))
               NCON=NCON+1
               NA = NA + 1
               DHALF=DOUT-(THICK(I)/NLAYRS(I))
               CALL AREACYL (1,IJ,DHALF,THICK(I),AREA,NWHICH)
               AREA=AREA/2.
               NARY=NLGS(NB)+5000
               CALL RITCND (5,NCON,1,1,NBHX,1,NB,1,NARY,0,
     *                      AREA,0,MATNMS(I))
               NB = NB + 1
               NCON=NCON+1
            ENDIF
            IF (NBHX.EQ.0) THEN
```

```
                CALL AREACYL (1,IJ,DOUT,THICK(I),AREA,NWHICH)
                AREA=(AREA/TH/2.)*4.
                IF (J.NE.1) THEN
                D2=DOUT+TH/4.
                CALL AREACYL (1,IJ,D2,THICK(I),AREA2,NWHICH)
                AREA2=(AREA2/TH/2.)*4.
                NL1=NLGS(NA)+5000
                NL2=NLGS(NB)+5000
                CALL RITCND(7,NCON,1,1,NA,1,NB,1,NL1,NL2,AREA,
     *              AREA2,MATNMS(I))
                ELSE
                NL1=NLGS(NB)+5000
                CALL RITCND(5,NCON,1,1,NA,1,NB,1,NL1,0,AREA,0
     *                       ,MATNMS(I))
                ENDIF
                NCON=NCON+1
                NA = NA + 1
                NB = NB + 1
             ENDIF
 2        CONTINUE
          DOUT = DOUT+TH/4.
 1     CONTINUE
       IF (I.EQ.5) GOTO 92
       IF (NWHICH.EQ.2) NOUT=(2001*I)+1000+(NCYLAY+NSBLAY+NEBLAY+NFBLAY)
       NIN=NA
       WRITE (MODU,123) I,NLAYRS(I),TYPE
       DO 32 J=0,NSLAY-1
          D2=DOUT+TH/4.
          CALL AREACYL(1,J,D2,THICK(I),AREA,NWHICH)
          AREA=(AREA/TH/2.)*4.
          NL1=NLGS(NIN)+5000
          CALL RITCND(5,NCON,1,1,NIN,1,NOUT,1,NL1,0,AREA,0,
     *    MATNMS(I))
          NIN=NIN+1
          NOUT=NOUT+1
          NCON=NCON+1
32     CONTINUE
92     CONTINUE
       DOUT=RIN+THKLAY(I)/4.0
       DO 988 J=1,NLAYRS(I)
       WRITE (MODU,987) I,J,TYPE
       DO 989 IJ=0,NSLAY-1
          NC=NC2+(NSLAY*(J-1))+IJ
          IF (IJ.NE.NSLAY-1) THEN
          CALL AREACYL(2,IJ,DOUT,THICK(I),AREA,NWHICH)
          IF (NWHICH.EQ.1) II=IJ+1
          IF (NWHICH.EQ.2) II=IJ-1
          CALL AREACYL (2,II,DOUT,THICK(I),AREA2,NWHICH)
          NL1=NLGS(NC)+5000
          NL2=NLGS(NC+1)+5000
          CALL RITCND(7,NCON,1,1,NC,1,NC+1,1,NL1,NL2
     *             ,AREA,AREA2,MATNMS(I))
          NCON = NCON + 1
          ENDIF
          IF (IJ.EQ.NSLAY-1) THEN
          IF (NWHICH.EQ.1) THEN
             CALL AREACYL(2,IJ,DOUT,THICK(I),AREA,NWHICH)
             NB = (2001*I)+(NSLAY*J)-1
             NBT= (2001*I)+(NSLAY*NLAYRS(I))+(NCYLAY*(J-1))
             IF (NWHICH.EQ.1) II=IJ+1
             IF (NWHICH.EQ.2) II=IJ-1
             CALL AREACYL (2,1,DOUT,THICK(I),AREA2,0)
             NL1=NLGS(NB)+5000
             NL2=NLGS(NBT)+5000
             CALL RITCND(7,NCON,1,1,NB,1,NBT,1,NL1
     *                ,NL2,AREA,AREA2,MATNMS(I))
             NCON=NCON+1
          ENDIF
          IF (NWHICH.EQ.2) THEN
             CALL AREACYL(2,1,DOUT,THICK(I),AREA,NWHICH)
```

```
          NBTEMP =  (2001*I)+((NSBLAY+NEBLAY+NFBLAY)*NLAYRS(I))+
     *                (NCYLAY*J)-1
          NAT = (2001*I)+((NCYLAY+NSBLAY+NEBLAY+NFBLAY)*NLAYRS(I))+
     *          (NSLAY*(J-1))
          IF (NWHICH.EQ.1) II=IJ+1
          IF (NWHICH.EQ.2) II=IJ-1
          CALL AREACYL (2,II,DOUT,THICK(I),AREA2,0)
          NL1=NLGS(NAT)+5000
          NL2=NLGS(NBTEMP)+5000
          CALL RITCND (7,NCON,1,1,NAT,1,NBTEMP,1,NL1,
     *                NL2,AREA,AREA2,MATNMS(I))
          NCON=NCON+1
        ENDIF
        ENDIF
 989  CONTINUE
      DOUT=DOUT+TH/4.
 988  CONTINUE

  18  FORMAT(7X,'REM RADIAL CONDUCTORS REGION ',I2,' LAYER ',I2,
     *       ' TO LAYER ',I2,' IN ',A6,' END.')
  88  FORMAT(7X,'REM RADIAL CONDUCTORS REGION ',I2,' LAYER ',I2,
     *       ' TO BOUNDRY NODES IN ',A6,' END.')
  94  FORMAT(7X,'REM RADIAL CONDUCTORS REGION ',I2,' BOUNDARY NODES ',
     *'TO LAYER 1 IN ',A6,' END.')
 123  FORMAT(7X,'REM RADIAL CONDUCTORS REGION ',I2,' LAYER ',I2,' TO ',
     *'BOUNDARY NODES IN ',A6,' END.')
 987  FORMAT (7X,'REM CIRCUMFERENTIAL CONDUCTORS REGION ',I2,' LAYER ',
     *       'NUMBER ',I2,' IN ',A6,' END.')

      RETURN
      END

      SUBROUTINE ECND (I,NA,NB,NCON,NELAY,ERAT,NWHICH)

      COMMON/REGION/NTHETA,NBETAS,BETA,RIN,TVOL,
     *              ROUT(9),REGNS(9),NLAYRS(9),TEMPS(9),THICK(9),
     *              THKLAY(9),MATRLS(9),MATNMS(9),RGNNMS(9)
      COMMON/TOPBOT/NTOP,NBOT,NFTLAY,NSTLAY,NETLAY,NFBLAY,NSBLAY,
     *              NEBLAY,ETRAT,EBRAT,FTTHK,FBTHK
      COMMON/CYDATA/CYLHGT,NCYLAY
      COMMON/HTXGRS/ NHX,HXTEMP(10),NRHX(10),NLHX(10),NTHHX(10),
     *              LNGTHX(10)
      COMMON/UNITS/MODU,SINDA
      COMMON/HX/NDS(1000),NCND(1000),INDEX
      COMMON/NODDAT/NODNUM(10000),VOL(10000),NLGS(10000)
      COMMON/STUFF/ NHTT,PI,CONVY,CONVR,THETA0,DTHETA,NBASOS,ROUTSF,
     * BNCOEF(2)

      LOGICAL REGNS
      CHARACTER*16 MLABL
      CHARACTER*16 RGNNMS,MNAME,MATNMS,RGNAM,MATN
      CHARACTER*6 TYPE

      NOUT=NB+1000
      IF (NWHICH.EQ.1) TYPE='BOTTOM'
      IF (NWHICH.EQ.2) TYPE='TOP   '


      IF (NWHICH.EQ.1) NELAY = NEBLAY
      IF (NWHICH.EQ.2) NELAY = NETLAY

      NC2=NB
      NARY=6000+MATRLS(I)
      TH=THKLAY(I)
      DOUT =  RIN+THKLAY(I)/4.0
      BASE = NB
      DO 1 J=1,NLAYRS(I)
         IF (J.GT.1) WRITE (MODU,18) I,J-1,J,TYPE
         IF (J.EQ.1) NATEMP = NB
         IF (J.EQ.2) THEN
```

```
         NA = NATEMP
      ENDIF
      DO 2 IJ=0,NELAY-1
         IF (IJ.EQ.0.AND.J.EQ.1) WRITE (MODU,94) I,TYPE
         NTSTHX = 0
         NBHX = 0
         DO 71 K = 1,INDEX
            IF (NDS(K).EQ.NA) THEN
               NTBTHX = 1
               NAHX = NA
               NBHX = NCND(K)
               GOTO 72
            ENDIF
71       CONTINUE
72       IF (NBHX.NE.0) THEN
            CALL AREACYL (2,IJ,DOUT,THICK(I),AREA,NWHICH)
            AREA=AREA/2.
            CALL RITCND (5,NCON,1,1,NA,1,NBHX,1,NARY,0,
     *                   AREA,0,MATNMS(I))
            NCON=NCON+1
            NA = NA + 1
            DHALF=DOUT-(THICK(I)/NLAYRS(I))
            CALL AREACYL (2,IJ,DHALF,THICK(I),AREA,NWHICH)
            AREA=AREA/2.
            CALL RITCND (5,NCON,1,1,NBHX,1,NB,1,NARY,0,
     *                   AREA,0,MATNMS(I))
            NB = NB + 1
            NCON=NCON+1
         ENDIF
         IF (NBHX.EQ.0) THEN
            CALL AREACYL (2,IJ,DOUT,THICK(I),AREA,NWHICH)
            AREA=(AREA/TH/2.)*4.
            IF (J.NE.1) THEN
            D2=DOUT+TH/4.
            CALL AREACYL (2,IJ,D2,THICK(I),AREA2,NWHICH)
            AREA2=(AREA2/TH/2.)*4.
            NL1=NLGS(NA)+5000
            NL2=NLGS(NB)+5000
            CALL RITCND(7,NCON,1,1,NA,1,NB,1,NL1,NL2,AREA,
     *          AREA2,MATNMS(I))
            ELSE
            NL1=NLGS(NB)+5000
            CALL RITCND(5,NCON,1,1,NA,1,NB,1,NL1,0,AREA,0
     *                   ,MATNMS(I))
            ENDIF
            NCON=NCON+1
            NA = NA + 1
            NB = NB + 1
         ENDIF
 2    CONTINUE
      DOUT = DOUT+TH/4.
 1    CONTINUE
      IF (I.EQ.5) GOTO 92
      IF (NWHICH.EQ.2) NOUT=(2001*I)+1000+(NCYLAY+NSBLAY+NEBLAY+NFBLAY)
      NIN=NA
      WRITE (MODU,123) I,NLAYRS(I),TYPE
      DO 32 J=0,NELAY-1
         D2=DOUT+TH/4.
         CALL AREACYL(2,J,D2,THICK(I),AREA,NWHICH)
         AREA=(AREA/TH/2.)*4.
         NL1=NLGS(NIN)+5000
         CALL RITCND(5,NCON,1,1,NIN,1,NOUT,1,NL1,0,AREA,0,
     *   MATNMS(I))
         NIN=NIN+1
         NOUT=NOUT+1
         NCON=NCON+1
32    CONTINUE
92    CONTINUE
      DOUT=RIN+THKLAY(I)/4.0
      DO 988 J=1,NLAYRS(I)
```

```
      WRITE (MODU,987) I,J,TYPE
      DO 989 IJ=0,NELAY-1
         NC=NC2+(NELAY*(J-1))+IJ
         IF (IJ.NE.NELAY-1) THEN
         CALL AREACYL(1,IJ,DOUT,THICK(I),AREA,NWHICH)
         IF (NWHICH.EQ.1) II=IJ+1
         IF (NWHICH.EQ.2) II=IJ-1
         CALL AREACYL (1,II,DOUT,THICK(I),AREA2,NWHICH)
         NL1=NLGS(NC)+5000
         NL2=NLGS(NC+1)+5000
         CALL RITCND(7,NCON,1,1,NC,1,NC+1,1,NL1,NL2
     *             ,AREA,AREA2,MATNMS(I))
         NCON = NCON + 1
         ENDIF
         IF (IJ.EQ.NELAY-1) THEN
         IF (NWHICH.EQ.1) THEN
            CALL AREACYL(1,IJ,DOUT,THICK(I),AREA,NWHICH)
            NB = (2001*I)+(NELAY*J)-1
            NBT= (2001*I)+(NELAY*NLAYRS(I))+(NCYLAY*(J-1))
            IF (NWHICH.EQ.1) II=IJ+1
            IF (NWHICH.EQ.2) II=IJ-1
            CALL AREACYL (1,1,DOUT,THICK(I),AREA2,0)
            NL1=NLGS(NB)+5000
            NL2=NLGS(NBT)+5000
            CALL RITCND(7,NCON,1,1,NB,1,NBT,1,NL1
     *                ,NL2,AREA,AREA2,MATNMS(I))
            NCON=NCON+1
         ENDIF
         IF (NWHICH.EQ.2) THEN
            CALL AREACYL(1,1,DOUT,THICK(I),AREA,NWHICH)
            NBTEMP =   (2001*I)+((NSBLAY+NEBLAY+NFBLAY)*NLAYRS(I))+
     *                 (NCYLAY*J)-1
            NAT = (2001*I)+((NCYLAY+NSBLAY+NEBLAY+NFBLAY)*NLAYRS(I))+
     *            (NELAY*(J-1))
            IF (NWHICH.EQ.1) II=IJ+1
            IF (NWHICH.EQ.2) II=IJ-1
            CALL AREACYL (1,II,DOUT,THICK(I),AREA2,0)
            NL1=NLGS(NAT)+5000
            NL2=NLGS(NBTEMP)+5000
            CALL RITCND (7,NCON,1,1,NAT,1,NBTEMP,1,NL1,
     *                NL2,AREA,AREA2,MATNMS(I))
            NCON=NCON+1
         ENDIF
         ENDIF
  989 CONTINUE
      DOUT=DOUT+TH/4.
  988 CONTINUE

   18 FORMAT(7X,'REM RADIAL CONDUCTORS REGION ',I2,' LAYER ',I2,
     *       ' TO LAYER ',I2,' IN ',A6,' END.')
   88 FORMAT(7X,'REM RADIAL CONDUCTORS REGION ',I2,' LAYER ',I2,
     *       ' TO BOUNDRY NODES IN ',A6,' END.')
   94 FORMAT(7X,'REM RADIAL CONDUCTORS REGION ',I2,' BOUNDARY NODES ',
     *'TO LAYER 1 IN ',A6,' END.')
  123 FORMAT(7X,'REM RADIAL CONDUCTORS REGION ',I2,' LAYER ',I2,' TO ',
     *'BOUNDARY NODES IN ',A6,' END.')
  987 FORMAT (7X,'REM CIRCUMFERENTIAL CONDUCTORS REGION ',I2,' LAYER ',
     *        'NUMBER ',I2,' IN ',A6,' END.')

      RETURN
      END

      SUBROUTINE AREACYL (NAREA,IJPOS,R,TH,AREA,NW)

      COMMON/REGION/NTHETA,NBETAS,BETA,RIN,TVOL,
     *             ROUT(9),REGNS(9),NLAYRS(9),TEMPS(9),THICK(9),
     *             THKLAY(9),MATRLS(9),MATNMS(9),RGNNMS(9)
      COMMON/TOPBOT/NTOP,NBOT,NFTLAY,NSTLAY,NETLAY,NFBLAY,NSBLAY,
     *                          NEBLAY,ETRAT,EBRAT,FTTHK,FBTHK
      COMMON/CYDATA/CYLHGT,NCYLAY
```

```
      COMMON/STUFF/ NHTT,PI,CONVY,CONVR,THETA0,DTHETA,NBASOS,ROUTSF,
     *  BNCOEF(2)

      CHARACTER*16 MATNMS

C SUBROUTINE TO COMPUTE AREAS IN A CYLINDER, SPHERE, ELLIPCE, OR FLAT
C ENDS.
C
C AREAS FOR NODES TO COMPUTE NODAL VOLUMES.  OUTSIDE AREAS FOR SOURCE
C TERMS (IF ANY) AREAS FOR CONDUCTOR PATHS.
C
C NAREA:  1,2 RADIAL AREA (IN & OUT),CIRCUMFERENTIAL AREA (UP & DOWN)
C JPOS:   POSITION OF THETA ANGLE COUNTING FROM THE SOUTH POLE.
C R:      RADIUS TO AREA SURFACE
C TH:     LAYER THICKNESS
C AREA:   VALUE RETURNED TO CALLING SUBROUTINES.

C NWHICH=0 THE LAYER IS IN THE CYLINDERICAL SHAPE.
C NWHICH=1 THE LAYER IS IN THE BOTTOM SHAPE.
C NWHICH=2 THE LAYER IS IN THE TOP SHAPE.

      JPOS=IJPOS
      NWHICH=NW
      IF (NWHICH.EQ.-1.OR.NWHICH.EQ.-2) THEN
      IF (NWHICH.EQ.-1) R=RIN
      IF (NWHICH.EQ.-2) R=RIN+THICK(1)+THICK(2)+THICK(3)
      NBL=NSBLAY+NEBLAY+NFBLAY
      IF (JPOS.GE.1.AND.JPOS.LE.NBL) NWHICH=1
      IF (JPOS.GT.NBL.AND.JPOS.LE.NBL+NCYLAY) NWHICH=0
      IF (JPOS.GT.NBL+NCYLAY) NWHICH=2
      IF (NWHICH.EQ.0) TH=CYLHGT/NCYLAY
      IF (NWHICH.EQ.1.AND.NBOT.EQ.2) TH=THICK(1)/NLAYRS(1)
      IF (NWHICH.EQ.2.AND.NTOP.EQ.2) TH=THICK(1)/NLAYRS(1)
      ENDIF


C THE NEXT SECTION IS FOR THE NODE AREAS OF NODES IN THE CYLINDER PART.

      IF (NWHICH.EQ.0) THEN
         IF (NAREA.EQ.1)
     *      AREA=BETA*R*TH
         IF (NAREA.EQ.2)
     *      AREA=(((R+(R+TH))/2.)*TH)/(CYLHGT/NCYLAY)
      ENDIF

C THE NEXT SECTION IS FOR THE NODE AREAS IN EITHER THE FLAT TOP
C OR FLAT BOTTOM.

      IF ((NWHICH.EQ.1.AND.NBOT.EQ.2).OR.
     *    (NWHICH.EQ.2.AND.NTOP.EQ.2)) THEN
          IF (NWHICH.EQ.1) THEN
             NFLAY=NFBLAY
             FTHK=FBTHK
          ELSE
             NFLAY=NFTLAY
             FTHK=FTTHK
          ENDIF
         IF (NAREA.EQ.1)
     *      AREA=(((R+(R+TH))/2.)*(FTHK/NFLAY))/(TH/2.)
         IF (NAREA.EQ.2)
     *      AREA=(((R+(R+TH))/2.)*TH)/(FTHK/NFLAY)
      ENDIF

C THIS SECTION CALCULATES THE NODE AREA FOR A NODE IN EITHER THE TOP
C OR BOTTOM SPHERE.

      IF ((NWHICH.EQ.1.AND.NBOT.EQ.3).OR.
     *    (NWHICH.EQ.2.AND.NTOP.EQ.3)) THEN
          IF (NWHICH.EQ.1) THEN
             NSLAY=NSBLAY
```

```
            THETA0=PI/2.
            POS=JPOS
         ELSE
            NSLAY=NSTLAY
            THETA0=0.0
            POS=-1*(JPOS+1)
         ENDIF
         DTHETA=PI/2./NSLAY

         THETA1=THETA0-POS*DTHETA
         THETA2=THETA1-DTHETA
         IF (NAREA.EQ.1) THEN
         AREA=BETA*R*R*(COS(THETA1)+COS(THETA2))*DTHETA/2.
         ENDIF
         IF (NAREA.EQ.2) THEN
         AREA=BETA*R*(COS(THETA1)+COS(THETA2))*TH/2.
         AREA=AREA/(DTHETA*R)
         ENDIF
      ENDIF

C THE NEXT SECTION IS FOR THE NODE AREAS IN EITHER THE ELIPTICAL TOP
C OR ELIPTICAL BOTTOM.


      IF ((NWHICH.EQ.1.AND.NBOT.EQ.4).OR.
     *    (NWHICH.EQ.2.AND.NTOP.EQ.4)) THEN
         IF (NWHICH.EQ.1) THEN
            NE=NEBLAY
            ERAT = EBRAT
            THETA0=PI/2.
            POS=JPOS
         ELSE
            NE=NETLAY
            ERAT = ETRAT
            THETA0=0.0
            POS=-1*(JPOS+1)
         ENDIF
         DTHETA=PI/2./NE

      JP=JPOS-1
      AI=R-TH
      AO=AI+TH
      BI=AI*ERAT
      BO=BI+TH
      THETA2=THETA0-POS*DTHETA
      THETA1=THETA2-DTHETA
      AAVG=(AO+AI)/2.
      BAVG=(BO+BI)/2.
      THAVG=(THETA1+THETA2)/2.
      COSAVG=COS(THAVG)
      SINAVG=SIN(THAVG)
      FRST=((BETA*COSAVG)/2.)*((AAVG*BAVG)/SQRT((BAVG*BAVG*
     1 COSAVG*COSAVG)+(AAVG*AAVG*SINAVG*SINAVG)))
      SND=AO*BO*(ATAN((AO/BO)*TAN(THETA2))-ATAN((AO/BO)*TAN(THETA1)))
      THR=AI*BI*(ATAN((AI/BI)*TAN(THETA2))-ATAN((AI/BI)*TAN(THETA1)))
      IF (NAREA.EQ.2) AREA=(FRST*(SND-THR))
      IF (NAREA.EQ.1) AREA=(FRST*(SND-THR))/(DTHETA*R)
      ENDIF
      RETURN
      END

      SUBROUTINE ULLIG

      COMMON/ULLAGE/ NLUL4,NLUL5,NTHU41,RINMHH,PCTFUL,RADULG,TVULFT,
     *               CT,LG(3),LIQVAP(3)
      COMMON/REGION/NTHETA,NBETAS,BETA,RIN,TVOL,
     *              ROUT(9),REGNS(9),NLAYRS(9),TEMPS(9),THICK(9),
     *              THKLAY(9),MATRLS(9),MATNMS(9),RGNNMS(9)
      COMMON/TOPBOT/NTOP,NBOT,NFTLAY,NSTLAY,NETLAY,NFBLAY,NSBLAY,
     *                        NEBLAY,ETRAT,EBRAT,FTTHK,FBTHK
```

```
      COMMON/CYDATA/CYLHGT,NCYLAY
      COMMON/HTXGRS/NHX,HXTEMP(10),NRHX(10),NLHX(10),NTHHX(10),
     *              LNGTHX(10)
      COMMON/UNITS/MODU,SINDA
      COMMON/NODDAT/NODNUM(10000),VOL(10000),NLGS(10000)
      COMMON/VOLUME/VOLLIQ,ACCLIQ

      CHARACTER*1 CT,LG
      CHARACTER*6 LIQVAP
      LOGICAL REGNS

      PI=3.141592654
      IF (.NOT.REGNS(4)) THEN
         IF (.NOT.REGNS(5)) GOTO 99
      ENDIF
      NTHU41=0
      DO 77 I=8001,10000
         TOTVOL=TOTVOL+VOL(I)
77    CONTINUE

      VOLLIQ=TOTVOL*(PCTFUL/100.)
      IF (NBOT.EQ.3.OR.NBOT.EQ.4) THEN
         IF (NBOT.EQ.3) LAYBOT=NSBLAY
         IF (NBOT.EQ.4) LAYBOT=NEBLAY
         NUMNOD=8001
         DO 1 I=1,NLAYRS(4)+NLAYRS(5)
            IF (I.LE.NLAYRS(4))NSTART=8001
            IF (I.GT.NLAYRS(4))NSTART=9001
            IF (I.LE.NLAYRS(4))IK = I
            IF (I.EQ.NLAYRS(4)+1)IK=1
            IF (I.GT.NLAYRS(4)+1)IK =IK+1
            NUMNOD=NSTART+((IK-1)*LAYBOT)
            ACCLIQ=ACCLIQ+VOL(NUMNOD)
            IF (ACCLIQ.GT.VOLLIQ.AND.NLGS(NUMNOD).GT.1100.AND.
     *          NLGS(NUMNOD).LE.1199) NLGS(NUMNOD)=NLGS(NUMNOD)+200
            IF (NTHU41.EQ.0.AND.NLGS(NUMNOD).GT.1300) NTHU41=IK
            IF (I.GT.1) THEN
               IF (I.LT.LAYBOT) IJ = I
               IF (I.GE.LAYBOT) IJ = LAYBOT
               DO 2 J=1,IJ-2
                  NUMNOD=NUMNOD+1
                  ACCLIQ=ACCLIQ+VOL(NUMNOD)
                  IF (ACCLIQ.GT.VOLLIQ.AND.NLGS(NUMNOD).GT.1100.AND.
     *            NLGS(NUMNOD).LE.1199) NLGS(NUMNOD)=NLGS(NUMNOD)+200
                 IF (NTHU41.EQ.0.AND.NLGS(NUMNOD).GT.1300) NTHU41=IK
2              CONTINUE
               IF (I.LE.LAYBOT) THEN
                  DO 3 J=1,I
                     IF(J.LE.NLAYRS(4))NSTART=8001
                     IF(J.GT.NLAYRS(4))NSTART=9001
                     IF (J.LE.NLAYRS(4)) K = J
                     IF (J.EQ.NLAYRS(4)+1) K=1
                     IF (J.GT.NLAYRS(4)+1) K = K+1
                     NUMNOD=NSTART+((K-1)*LAYBOT)+I-1
                     ACCLIQ=ACCLIQ+VOL(NUMNOD)
                     IF (ACCLIQ.GT.VOLLIQ.AND.NLGS(NUMNOD).GT.1100.AND.
     *               NLGS(NUMNOD).LE.1199) NLGS(NUMNOD)=NLGS(NUMNOD)+200
                     IF (NTHU41.EQ.0.AND.NLGS(NUMNOD).GT.1300) NTHU41=IK
3                 CONTINUE
               ENDIF
            ENDIF
1        CONTINUE
         NUMNOD=NUMNOD+1
         ACCLIQ=ACCLIQ+VOL(NUMNOD)
         IF (ACCLIQ.GT.VOLLIQ.AND.NLGS(NUMNOD).GT.1100.AND.
     *   NLGS(NUMNOD).LE.1199) NLGS(NUMNOD)=NLGS(NUMNOD)+200
         IF (NTHU41.EQ.0.AND.NLGS(NUMNOD).GT.1300) NTHU41=IK
      ENDIF
      IF (NBOT.EQ.2) THEN
         DO 4 I=1,NFBLAY
```

```
         NSTAT5=9001+(I-1)                                              CRY24510
         NSTAT4=8001+(I-1)                                              CRY24520
         DO 5 J=NLAYRS(5),1,-1                                          CRY24530
            NUMNOD=NSTAT5+((J-1)*NFBLAY)                                CRY24540
            ACCLIQ=ACCLIQ+VOL(NUMNOD)                                   CRY24550
            IF (ACCLIQ.GT.VOLLIQ.AND.NLGS(NUMNOD).GT.1100.AND.          CRY24560
     *      NLGS(NUMNOD).LE.1199) NLGS(NUMNOD)=NLGS(NUMNOD)+200         CRY24570
           IF (NTHU41.EQ.0.AND.NLGS(NUMNOD).GT.1300) NTHU41=I           CRY24580
    5    CONTINUE                                                       CRY24590
         DO 6 J=NLAYRS(4),1,-1                                          CRY24600
            NUMNOD=NSTAT4+((J-1)*NFBLAY)                                CRY24610
            ACCLIQ=ACCLIQ+VOL(NUMNOD)                                   CRY24620
            IF (ACCLIQ.GT.VOLLIQ.AND.NLGS(NUMNOD).GT.1100.AND.          CRY24630
     *      NLGS(NUMNOD).LE.1199) NLGS(NUMNOD)=NLGS(NUMNOD)+200         CRY24640
           IF (NTHU41.EQ.0.AND.NLGS(NUMNOD).GT.1300) NTHU41=I           CRY24650
    6    CONTINUE                                                       CRY24660
    4    CONTINUE                                                       CRY24670
      ENDIF                                                             CRY24680
      NSTA=9001+((NSBLAY+NFBLAY+NEBLAY)*NLAYRS(5))                      CRY24690
      NSTB=8001+((NSBLAY+NFBLAY+NEBLAY)*NLAYRS(4))                      CRY24700
      DO 7 I=1,NCYLAY                                                   CRY24710
         NSTAT5=NSTA+(I-1)                                              CRY24720
         NSTAT4=NSTB+(I-1)                                              CRY24730
         DO 9 J=NLAYRS(5),1,-1                                          CRY24740
            NUMNOD=NSTAT5+((J-1)*NCYLAY)                                CRY24750
            ACCLIQ=ACCLIQ+VOL(NUMNOD)                                   CRY24760
            IF (ACCLIQ.GT.VOLLIQ.AND.NLGS(NUMNOD).GT.1100.AND.          CRY24770
     *      NLGS(NUMNOD).LE.1199) NLGS(NUMNOD)=NLGS(NUMNOD)+200         CRY24780
              IF (NTHU41.EQ.0.AND.NLGS(NUMNOD).GT.1300)                 CRY24790
     *           NTHU41=I+NFBLAY+NSBLAY+NEBLAY                          CRY24800
    9    CONTINUE                                                       CRY24810
         DO 8 J=NLAYRS(4),1,-1                                          CRY24820
            NUMNOD=NSTAT4+((J-1)*NCYLAY)                                CRY24830
            ACCLIQ=ACCLIQ+VOL(NUMNOD)                                   CRY24840
            IF (ACCLIQ.GT.VOLLIQ.AND.NLGS(NUMNOD).GT.1100.AND.          CRY24850
     *      NLGS(NUMNOD).LE.1199) NLGS(NUMNOD)=NLGS(NUMNOD)+200         CRY24860
            IF (NTHU41.EQ.0.AND.NLGS(NUMNOD).GT.1300)                   CRY24870
     *         NTHU41=I+NFBLAY+NSBLAY+NEBLAY                            CRY24880
    8    CONTINUE                                                       CRY24890
    7 CONTINUE                                                          CRY24900
      IF (NTOP.EQ.2) THEN                                               CRY24910
         NSTA=9001+((NSBLAY+NFBLAY+NEBLAY+NCYLAY)*NLAYRS(5))            CRY24920
         NSTB=8001+((NSBLAY+NFBLAY+NEBLAY+NCYLAY)*NLAYRS(4))            CRY24930
         DO 14 I=1,NFTLAY                                               CRY24940
            NSTAT5=NSTA+(I-1)                                           CRY24950
            NSTAT4=NSTB+(I-1)                                           CRY24960
            DO 15 J=NLAYRS(5),1,-1                                      CRY24970
               NUMNOD=NSTAT5+((J-1)*NFTLAY)                             CRY24980
               ACCLIQ=ACCLIQ+VOL(NUMNOD)                                CRY24990
               IF (ACCLIQ.GT.VOLLIQ.AND.NLGS(NUMNOD).GT.1100.AND.       CRY25000
     *         NLGS(NUMNOD).LE.1199) NLGS(NUMNOD)=NLGS(NUMNOD)+200      CRY25010
               IF (NTHU41.EQ.0.AND.NLGS(NUMNOD).GT.1300)                CRY25020
     *         NTHU41=I+NFBLAY+NSBLAY+NEBLAY+NCYLAY                     CRY25030
   15       CONTINUE                                                    CRY25040
            DO 16 J=NLAYRS(4),1,-1                                      CRY25050
               NUMNOD=NSTAT4+((J-1)*NFTLAY)                             CRY25060
               ACCLIQ=ACCLIQ+VOL(NUMNOD)                                CRY25070
               IF (ACCLIQ.GT.VOLLIQ.AND.NLGS(NUMNOD).GT.1100.AND.       CRY25080
     *         NLGS(NUMNOD).LE.1199) NLGS(NUMNOD)=NLGS(NUMNOD)+200      CRY25090
               IF (NTHU41.EQ.0.AND.NLGS(NUMNOD).GT.1300)                CRY25100
     *            NTHU41=I+NFBLAY+NSBLAY+NEBLAY+NCYLAY                  CRY25110
   16       CONTINUE                                                    CRY25120
   14    CONTINUE                                                       CRY25130
      ENDIF                                                             CRY25140
      IF (NTOP.EQ.3.OR.NTOP.EQ.4) THEN                                  CRY25150
         NSTA=9001+((NSBLAY+NFBLAY+NEBLAY+NCYLAY)*NLAYRS(5))            CRY25160
         NSTB=8001+((NSBLAY+NFBLAY+NEBLAY+NCYLAY)*NLAYRS(4))            CRY25170
         IF (NTOP.EQ.3) LAYTOP=NSTLAY                                   CRY25180
         IF (NTOP.EQ.4) LAYTOP=NETLAY                                   CRY25190
         DO 24 I=1,LAYTOP                                               CRY25200
```

```
         NSTAT5=NSTA+(I-1)
         NSTAT4=NSTB+(I-1)
         DO 25 J=NLAYRS(5),1,-1
            NUMNOD=NSTAT5+((J-1)*LAYTOP)
            ACCLIQ=ACCLIQ+VOL(NUMNOD)
            IF (ACCLIQ.GT.VOLLIQ.AND.NLGS(NUMNOD).GT.1100.AND.
     *      NLGS(NUMNOD).LE.1199) NLGS(NUMNOD)=NLGS(NUMNOD)+200
           IF (NTHU41.EQ.0.AND.NLGS(NUMNOD).GT.1300)
     *         NTHU41=I+NFBLAY+NSBLAY+NEBLAY+NCYLAY
25       CONTINUE
         DO 26 J=NLAYRS(4),1,-1
            NUMNOD=NSTAT4+((J-1)*LAYTOP)
            ACCLIQ=ACCLIQ+VOL(NUMNOD)
            IF (ACCLIQ.GT.VOLLIQ.AND.NLGS(NUMNOD).GT.1100.AND.
     *      NLGS(NUMNOD).LE.1199) NLGS(NUMNOD)=NLGS(NUMNOD)+200
         IF (NTHU41.EQ.0.AND.NLGS(NUMNOD).GT.1300)
     *   NTHU41=I+NFBLAY+NSBLAY+NEBLAY+NCYLAY
26       CONTINUE
24    CONTINUE
      ENDIF
      GOTO 199
99    IF (NBOT.EQ.2) BOTVOL=(PI*RIN*RIN*FBTHK)/2.
      IF (NBOT.EQ.3) BOTVOL=((4./3.)*PI*RIN*RIN*RIN)/4.
      IF (NBOT.EQ.4) BOTVOL=((4./3.)*PI*RIN*RIN*RIN*EBRAT)/4.
      IF (NBOT.NE.1) BOTLAY=(BOTVOL/(NSBLAY+NEBLAY+NFBLAY))
      CYLVOL=(PI*RIN*RIN*CYLHGT)/2.
      CYLLAY=((PI*RIN*RIN*CYLHGT)/NCYLAY)/2.
      IF (NTOP.EQ.2) TOPVOL=(PI*RIN*RIN*FTTHK)/2.
      IF (NTOP.EQ.3) TOPVOL=((4./3.)*PI*RIN*RIN*RIN)/4.
      IF (NTOP.EQ.4) TOPVOL=((4./3.)*PI*RIN*RIN*RIN*ETRAT)/4.
      IF (NTOP.NE.1) TOPLAY=(TOPVOL/(NFTLAY+NSTLAY+NETLAY))
      VOLUM=BOTVOL+CYLVOL+TOPVOL
      VOLLIQ=VOLUM*(PCTFUL/100.)
      ACCLIQ=0
      DO 33 I=1,NFBLAY+NSBLAY+NEBLAY
         ACCLIQ=ACCLIQ+BOTLAY
         IF (ACCLIQ.GT.VOLLIQ.AND.NTHU41.EQ.0) NTHU41=I
33    CONTINUE
      IP=NFBLAY+NSBLAY+NEBLAY
      DO 34 I=IP,NCYLAY+IP
         ACCLIQ=ACCLIQ+CYLLAY
         IF (ACCLIQ.GT.VOLLIQ.AND.NTHU41.EQ.0) NTHU41=I
34    CONTINUE
      IP=NFBLAY+NSBLAY+NEBLAY+NCYLAY
      DO 35 I=IP,IP+NFTLAY+NSTLAY+NETLAY
         ACCLIQ=ACCLIQ+TOPLAY
         IF (ACCLIQ.GT.VOLLIQ.AND.NTHU41.EQ.0) NTHU41=I
35    CONTINUE
199   RETURN
      END

      SUBROUTINE ULLOG

      COMMON/ULLAGE/ NLUL4,NLUL5,NTHU41,RINMHH,PCTFUL,RADULG,TVULFT,
     *               CT,LG(3),LIQVAP(3)
      COMMON/REGION/NTHETA,NBETAS,BETA,RIN,TVOL,
     *               ROUT(9),REGNS(9),NLAYRS(9),TEMPS(9),THICK(9),
     *               THKLAY(9),MATRLS(9),MATNMS(9),RGNNMS(9)
      COMMON/TOPBOT/NTOP,NBOT,NFTLAY,NSTLAY,NETLAY,NFBLAY,NSBLAY,
     *                          NEBLAY,ETRAT,EBRAT,FTTHK,FBTHK
      COMMON/CYDATA/CYLHGT,NCYLAY
      COMMON/HTXGRS/NHX,HXTEMP(10),NRHX(10),NLHX(10),NTHHX(10),
     *               LNGTHX(10)
      COMMON/UNITS/MODU,SINDA
      COMMON/NODDAT/NODNUM(10000),VOL(10000),NLGS(10000)

      TOTVOL=0.0
      DO 56 I=8001,10000
         TOTVOL=TOTVOL+VOL(I)
56    CONTINUE
```

```
                                                                  CRY25910
      VOLLIQ=TOTVOL*(PCTFUL/100.)                                 CRY25920
      GASVOL=TOTVOL-VOLLIQ                                        CRY25930
                                                                  CRY25940
      NSTA=9001+((NSBLAY+NFBLAY+NEBLAY)*NLAYRS(5))                CRY25950
      NSTB=8001+((NSBLAY+NFBLAY+NEBLAY)*NLAYRS(4))                CRY25960
      DO 7 I=1,NCYLAY                                             CRY25970
         NSTAT5=NSTA+(I-1)                                        CRY25980
         NSTAT4=NSTB+(I-1)                                        CRY25990
         DO 9 J=NLAYRS(5),1,-1                                    CRY26000
            NUMNOD=NSTAT5+((J-1)*NCYLAY)                          CRY26010
            ACCLIQ=ACCLIQ+VOL(NUMNOD)                             CRY26020
            IF (ACCLIQ.GT.VOLLIQ.AND.NLGS(NUMNOD).GT.1100.AND.    CRY26030
     *      NLGS(NUMNOD).LE.1199) NLGS(NUMNOD)=NLGS(NUMNOD)+200   CRY26040
              IF (NTHU41.EQ.0.AND.NLGS(NUMNOD).GT.1300)           CRY26050
     *           NTHU41=I+NFBLAY+NSBLAY+NEBLAY                    CRY26060
 9       CONTINUE                                                 CRY26070
         DO 8 J=NLAYRS(4),1,-1                                    CRY26080
            NUMNOD=NSTAT4+((J-1)*NCYLAY)                          CRY26090
            ACCLIQ=ACCLIQ+VOL(NUMNOD)                             CRY26100
            IF (ACCLIQ.GT.VOLLIQ.AND.NLGS(NUMNOD).GT.1100.AND.    CRY26110
     *      NLGS(NUMNOD).LE.1199) NLGS(NUMNOD)=NLGS(NUMNOD)+200   CRY26120
            IF (NTHU41.EQ.0.AND.NLGS(NUMNOD).GT.1300)             CRY26130
     *         NTHU41=I+NFBLAY+NSBLAY+NEBLAY                      CRY26140
 8       CONTINUE                                                 CRY26150
 7    CONTINUE                                                    CRY26160
      IF (NBOT.EQ.3.OR.NBOT.EQ.4) THEN                            CRY26170
         IF (NBOT.EQ.3) LAYBOT=NSBLAY                             CRY26180
         IF (NBOT.EQ.4) LAYBOT=NEBLAY                             CRY26190
         NUMNOD=8001                                              CRY26200
         DO 1 I=1,NLAYRS(4)+NLAYRS(5)                             CRY26210
            IF (I.LE.NLAYRS(4))NSTART=8001                        CRY26220
            IF (I.GT.NLAYRS(4))NSTART=9001                        CRY26230
            IF (I.LE.NLAYRS(4))IK = I                             CRY26240
            IF (I.EQ.NLAYRS(4)+1)IK=1                             CRY26250
            IF (I.GT.NLAYRS(4)+1)IK =IK+1                         CRY26260
            NUMNOD=NSTART+((IK-1)*LAYBOT)                         CRY26270
            ACCLIQ=ACCLIQ+VOL(NUMNOD)                             CRY26280
            IF (ACCLIQ.GT.VOLLIQ.AND.NLGS(NUMNOD).GT.1100.AND.    CRY26290
     *          NLGS(NUMNOD).LE.1199) NLGS(NUMNOD)=NLGS(NUMNOD)+200 CRY26300
            IF (NTHU41.EQ.0.AND.NLGS(NUMNOD).GT.1300) NTHU41=IK   CRY26310
            IF (I.GT.1) THEN                                      CRY26320
               IF (I.LT.LAYBOT) IJ = I                            CRY26330
               IF (I.GE.LAYBOT) IJ = LAYBOT                       CRY26340
               DO 2 J=1,IJ-2                                      CRY26350
                  NUMNOD=NUMNOD+1                                 CRY26360
                  ACCLIQ=ACCLIQ+VOL(NUMNOD)                       CRY26370
                  IF (ACCLIQ.GT.VOLLIQ.AND.NLGS(NUMNOD).GT.1100.AND. CRY26380
     *            NLGS(NUMNOD).LE.1199) NLGS(NUMNOD)=NLGS(NUMNOD)+200 CRY26390
                 IF (NTHU41.EQ.0.AND.NLGS(NUMNOD).GT.1300) NTHU41=IK CRY26400
 2             CONTINUE                                           CRY26410
               IF (I.LE.LAYBOT) THEN                              CRY26420
                  DO 3 J=1,I                                      CRY26430
                     IF(J.LE.NLAYRS(4))NSTART=8001                CRY26440
                     IF(J.GT.NLAYRS(4))NSTART=9001                CRY26450
                     IF (J.LE.NLAYRS(4)) K = J                    CRY26460
                     IF (J.EQ.NLAYRS(4)+1) K=1                    CRY26470
                     IF (J.GT.NLAYRS(4)+1) K = K+1                CRY26480
                     NUMNOD=NSTART+((K-1)*LAYBOT)+I-1             CRY26490
                     ACCLIQ=ACCLIQ+VOL(NUMNOD)                    CRY26500
                     IF (ACCLIQ.GT.VOLLIQ.AND.NLGS(NUMNOD).GT.1100.AND. CRY26510
     *               NLGS(NUMNOD).LE.1199) NLGS(NUMNOD)=NLGS(NUMNOD)+200CRY26520
                     IF (NTHU41.EQ.0.AND.NLGS(NUMNOD).GT.1300) NTHU41=IKCRY26530
 3                CONTINUE                                        CRY26540
               ENDIF                                              CRY26550
            ENDIF                                                 CRY26560
 1       CONTINUE                                                 CRY26570
         NUMNOD=NUMNOD+1                                          CRY26580
         ACCLIQ=ACCLIQ+VOL(NUMNOD)                                CRY26590
         IF (ACCLIQ.GT.VOLLIQ.AND.NLGS(NUMNOD).GT.1100.AND.       CRY26600
```

```
     *    NLGS(NUMNOD).LE.1199)  NLGS(NUMNOD)=NLGS(NUMNOD)+200
          IF  (NTHU41.EQ.0.AND.NLGS(NUMNOD).GT.1300)  NTHU41=IK
        ENDIF
        IF  (NBOT.EQ.2)  THEN
          DO  4  I=1,NFBLAY
            NSTAT5=9001+(I-1)
            NSTAT4=8001+(I-1)
            DO  5  J=NLAYRS(5),1,-1
              NUMNOD=NSTAT5+((J-1)*NFBLAY)
              ACCLIQ=ACCLIQ+VOL(NUMNOD)
              IF  (ACCLIQ.GT.VOLLIQ.AND.NLGS(NUMNOD).GT.1100.AND.
     *        NLGS(NUMNOD).LE.1199)  NLGS(NUMNOD)=NLGS(NUMNOD)+200
             IF  (NTHU41.EQ.0.AND.NLGS(NUMNOD).GT.1300)  NTHU41=I
 5          CONTINUE
            DO  6  J=NLAYRS(4),1,-1
              NUMNOD=NSTAT4+((J-1)*NFBLAY)
              ACCLIQ=ACCLIQ+VOL(NUMNOD)
              IF  (ACCLIQ.GT.VOLLIQ.AND.NLGS(NUMNOD).GT.1100.AND.
     *        NLGS(NUMNOD).LE.1199)  NLGS(NUMNOD)=NLGS(NUMNOD)+200
             IF  (NTHU41.EQ.0.AND.NLGS(NUMNOD).GT.1300)  NTHU41=I
 6          CONTINUE
 4        CONTINUE
        ENDIF
        IF  (NTOP.EQ.2)  THEN
          NSTA=9001+((NSBLAY+NFBLAY+NEBLAY+NCYLAY)*NLAYRS(5))
          NSTB=8001+((NSBLAY+NFBLAY+NEBLAY+NCYLAY)*NLAYRS(4))
          DO  14  I=1,NFTLAY
            NSTAT5=NSTA+(I-1)
            NSTAT4=NSTB+(I-1)
            DO  15  J=NLAYRS(5),1,-1
              NUMNOD=NSTAT5+((J-1)*NFTLAY)
              ACCLIQ=ACCLIQ+VOL(NUMNOD)
              IF  (ACCLIQ.GT.VOLLIQ.AND.NLGS(NUMNOD).GT.1100.AND.
     *        NLGS(NUMNOD).LE.1199)  NLGS(NUMNOD)=NLGS(NUMNOD)+200
              IF  (NTHU41.EQ.0.AND.NLGS(NUMNOD).GT.1300)
     *        NTHU41=I+NFBLAY+NSBLAY+NEBLAY+NCYLAY
 15         CONTINUE
            DO  16  J=NLAYRS(4),1,-1
              NUMNOD=NSTAT4+((J-1)*NFTLAY)
              ACCLIQ=ACCLIQ+VOL(NUMNOD)
              IF  (ACCLIQ.GT.VOLLIQ.AND.NLGS(NUMNOD).GT.1100.AND.
     *        NLGS(NUMNOD).LE.1199)  NLGS(NUMNOD)=NLGS(NUMNOD)+200
              IF  (NTHU41.EQ.0.AND.NLGS(NUMNOD).GT.1300)
     *          NTHU41=I+NFBLAY+NSBLAY+NEBLAY+NCYLAY
 16         CONTINUE
 14       CONTINUE
        ENDIF
        IF  (NTOP.EQ.3.OR.NTOP.EQ.4)  THEN
          NSTA=9001+((NSBLAY+NFBLAY+NEBLAY+NCYLAY)*NLAYRS(5))
          NSTB=8001+((NSBLAY+NFBLAY+NEBLAY+NCYLAY)*NLAYRS(4))
          IF  (NTOP.EQ.3)  LAYTOP=NSTLAY
          IF  (NTOP.EQ.4)  LAYTOP=NETLAY
          DO  24  I=1,LAYTOP
            NSTAT5=NSTA+(I-1)
            NSTAT4=NSTB+(I-1)
            DO  25  J=NLAYRS(5),1,-1
              NUMNOD=NSTAT5+((J-1)*LAYTOP)
              ACCLIQ=ACCLIQ+VOL(NUMNOD)
              IF  (ACCLIQ.GT.VOLLIQ.AND.NLGS(NUMNOD).GT.1100.AND.
     *        NLGS(NUMNOD).LE.1199)  NLGS(NUMNOD)=NLGS(NUMNOD)+200
             IF  (NTHU41.EQ.0.AND.NLGS(NUMNOD).GT.1300)
     *          NTHU41=I+NFBLAY+NSBLAY+NEBLAY+NCYLAY
 25         CONTINUE
            DO  26  J=NLAYRS(4),1,-1
              NUMNOD=NSTAT4+((J-1)*LAYTOP)
              ACCLIQ=ACCLIQ+VOL(NUMNOD)
              IF  (ACCLIQ.GT.VOLLIQ.AND.NLGS(NUMNOD).GT.1100.AND.
     *        NLGS(NUMNOD).LE.1199)  NLGS(NUMNOD)=NLGS(NUMNOD)+200
            IF  (NTHU41.EQ.0.AND.NLGS(NUMNOD).GT.1300)
     *      NTHU41=I+NFBLAY+NSBLAY+NEBLAY+NCYLAY
```

```
 26         CONTINUE                                                        CRY27310
 24      CONTINUE                                                           CRY27320
      ENDIF                                                                 CRY27330
      GOTO 199                                                              CRY27340
 99   IF (NBOT.EQ.2) BOTVOL=(PI*RIN*RIN*FBTHK)/2.                           CRY27350
      IF (NBOT.EQ.3) BOTVOL=((4./3.)*PI*RIN*RIN*RIN)/4.                     CRY27360
      IF (NBOT.EQ.4) BOTVOL=((4./3.)*PI*RIN*RIN*RIN*EBRAT)/4.               CRY27370
      IF (NBOT.NE.1) BOTLAY=(BOTVOL/(NSBLAY+NEBLAY+NFBLAY))                 CRY27380
      CYLVOL=(PI*RIN*RIN*CYLHGT)/2.                                         CRY27390
      CYLLAY=((PI*RIN*RIN*CYLHGT)/NCYLAY)/2.                                CRY27400
      IF (NTOP.EQ.2) TOPVOL=(PI*RIN*RIN*FTTHK)/2.                           CRY27410
      IF (NTOP.EQ.3) TOPVOL=((4./3.)*PI*RIN*RIN*RIN)/4.                     CRY27420
      IF (NTOP.EQ.4) TOPVOL=((4./3.)*PI*RIN*RIN*RIN*ETRAT)/4.               CRY27430
      IF (NTOP.NE.1) TOPLAY=(TOPVOL/(NFTLAY+NSTLAY+NETLAY))                 CRY27440
      VOLUM=BOTVOL+CYLVOL+TOPVOL                                            CRY27450
      VOLLIQ=VOLUM*(PCTFUL/100.)                                            CRY27460
      ACCLIQ=0                                                              CRY27470
      DO 33 I=1,NFBLAY+NSBLAY+NEBLAY                                        CRY27480
         ACCLIQ=ACCLIQ+BOTLAY                                               CRY27490
         IF (ACCLIQ.GT.VOLLIQ.AND.NTHU41.EQ.0) NTHU41=I                     CRY27500
 33   CONTINUE                                                              CRY27510
      IP=NFBLAY+NSBLAY+NEBLAY                                               CRY27520
      DO 34 I=IP,NCYLAY+IP                                                  CRY27530
         ACCLIQ=ACCLIQ+CYLLAY                                               CRY27540
         IF (ACCLIQ.GT.VOLLIQ.AND.NTHU41.EQ.0) NTHU41=I                     CRY27550
 34   CONTINUE                                                              CRY27560
      IP=NFBLAY+NSBLAY+NEBLAY+NCYLAY                                        CRY27570
      DO 35 I=IP,IP+NFTLAY+NSTLAY+NETLAY                                    CRY27580
         ACCLIQ=ACCLIQ+TOPLAY                                               CRY27590
         IF (ACCLIQ.GT.VOLLIQ.AND.NTHU41.EQ.0) NTHU41=I                     CRY27600
 35   CONTINUE                                                              CRY27610
199   RETURN                                                                CRY27620
      END                                                                   CRY27630
^Z
```

APPENDIX E

CryoTran Program Listings

Part IV CRYOPLOT FORTRAN

```
C481SSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSS
C  PLOT ROUTINES FOR CRYOTRAN
C   THESE PLOT ROUTINES ARE CALLED FROM SUBROUTINE GEOPLT (38)
C   THEY PRODUCE PLOTS OF THE GEOMETRY, SPHERE OR CYLINDER,
C   THAT THE USER HAS DEFINED WITHIN THE CRYOTRAN SYSTEM.
C   THESE ROUTINES USE THE DISDPLA SYSTEM FOR SPHERES AND CYLINDERS.
C
      SUBROUTINE PLTSPH
CALLED FROM                                                 GEOPLT(48)
C   SUBROUTINE TO PLOT THE GEOMETRY
C    NTYP =1 SPHERE WEDGE MODEL
C    USING ISSCO DISSPLA
C
      COMMON /TITL/ PTITLE
      COMMON /REGION/ NTHETA,NBETAS,BETA,RIN,TVOL,ROUT(9),
     1                REGNS(9),NLAYRS(9),TEMPS(9),THICK(9),
     2                THKLAY(9),MATRLS(9),MATNMS(9),RGNNMS(9)
      COMMON /ULLAGE/ NLUL4,NLUL5,NTHU41,RINMHH,PCTFUL,RADULG,TVULFT,
     1                CT,LG(3),LIQVAP(3)
      COMMON /HTXGRS/ NHX,HXTEMP(10),NRHX(10),NLHX(10),
     1              NTHHX(10),LNGTHX(10)
      COMMON /STUFF/ NHTT,PI,CONVY,CONVR,THETA0,DTHETA,NBASOS,ROUTSF,
     1              BNCOEF(2)
      COMMON /OUTSRC/ NQIN,QEFF
C
      LOGICAL REGNS
      LOGICAL NOSCAL
C
      CHARACTER*1   CT,LG
      CHARACTER*6   LIQVAP
      CHARACTER*1   REGNO
      CHARACTER*16  MATNMS
      CHARACTER*25  RGNNMS
      CHARACTER*80  PTITLE
C
      CHARACTER*2   NUM
      CHARACTER*6   RLABLE,ULLG
      CHARACTER*8   REGLAB
      CHARACTER*10  RADIUS
      CHARACTER*17  NOSMSG
      CHARACTER*20  QMSG1,QMSG2, QMSG4, HXMSG1
      CHARACTER*4   QMSG3, TEQMSG
      CHARACTER*6   DEGMSG
      CHARACTER*10  NNOMSG
      CHARACTER*20  BNMSG1, BNMSG5
      CHARACTER*20  CONRAD(2)
      CHARACTER*5   TANKEQ
      CHARACTER*6   TVUNIT  .
      CHARACTER*7   PCTSIN
      CHARACTER*12  TNKVEQ
C
      DIMENSION PROUT(5),PTHICK(5)
      DIMENSION  R(500), THETA(500)
C
      DATA REGLAB/'REGION  '/,    RADIUS/'RADIUS(IN)'/
      DATA ULLG/'ULLAGE'/
      DATA NOSMSG/'PLOT NOT TO SCALE'/
      DATA TEQMSG/'T= $'/
      DATA DEGMSG/' DEG $'/
      DATA NNOMSG/'NODE NO. $'/
      DATA QMSG1 /'SOURCE Q INTO ALL$'/
      DATA QMSG2 /'OUTER SURFACE NODES$'/
      DATA QMSG3 /'Q= $'/
      DATA QMSG4 /' (BTU/(HR-IN2))$'/
      DATA BNMSG1 /'OUTSIDE BNDY NODE $'/
      DATA BNMSG5 /' TO SURFACE$'/
      DATA CONRAD(1) /'CONVECTION$'/
      DATA CONRAD(2) /'RADIATION$'/
      DATA HXMSG1 /'HEAT EXCHANGER NO. $'/
      DATA TNKVEQ /'TANK VOLUME='/
```

```
      DATA TVUNIT /'  (FT3)'/
      DATA TANKEQ /'TANK='/
      DATA PCTSIN /' % FULL'/
C
C  INITIALIZE OUTPUT TO (1) QMS PRINTER OR TO (2) TERMINAL SCREEN
      PRINT 2001
 2001 FORMAT(///'    IN THE SPHERE PLOTTING ROUTINE'/
     1         '    SEND THE GRAPH TO '/
     2         '    1.  THE QMS PRINTER'/
     3         '    2.  THE TERMINAL SCREEN'/
     4         '    3.  SOME OTHER DEVICE  '/
     5         '    TYPE IN  1      2   OR    3')
      CALL READIN(IDV,1,3)
      IF(IDV .EQ. 1) CALL QMS2
      IF(IDV .EQ. 2) CALL IBM52(3179,0,0,0)
C  NEW SUBROUTINE CALL FROM DAVE HUBLER TO ALLOW USER TO CHOOSE DEVICE
      IF(IDV .EQ. 3) CALL PDEV(' ',ISTAT)
C
C  SET PAGE SIZE
      CALL PAGE(11.,8.5)
C  SET SUBPLOT SIZE
      CALL AREA2D(10.5, 8.0)
C  SET CHARACTER STYLE TO TRIPLEX
      CALL TRIPLX
C   SCALE REGION THICKNESSES UP IF REAL SCALE IS TOO SMALL
      NOSCAL =.FALSE.
      SCALEF=RIN/20.
      DO 5 I=1,5
      PROUT(I)=ROUT(I)
      PTHICK(I)=THICK(I)
      IF(REGNS(I)) THEN
        IF(THICK(I) .LT. 1.) THEN
          PTHICK(I)= THICK(I)+SCALEF
          NOSCAL =.TRUE.
        ENDIF
      ENDIF
    5 CONTINUE
      IF(NOSCAL) THEN
        THKSUM=0.0
        DO 7 I=1,3
        IF(REGNS(I)) THEN
          THKSUM=THKSUM+PTHICK(I)
          PROUT(I)=RIN+THKSUM
        ENDIF
    7   CONTINUE
        IF(THICK(4) .LT. 1.) THEN
          PROUT(5)=RIN-PTHICK(4)
          PTHICK(5)=PROUT(5)
        ENDIF
      ENDIF
C
      RADMAX= AMAX1(PROUT(1),PROUT(2),PROUT(3))
C
      RSTEP=RADMAX/4.5
      PRINT *,'PLOT-- RADMAX,RSTEP=',RADMAX,RSTEP
      CALL POLAR(3.14159/180.,RSTEP,5.5,0.7)
C
C  WRITE THE PLOT TITLE
C
      CALL ANGLE(90.)
      CALL MESSAG(PTITLE(1:40),40,0.0 ,0.0)
      CALL MESSAG(PTITLE(41:),40,0.3,0.0)
C
      THETA(1)=- 3.
      DO 8 I=2,187
      THETA(I)=THETA(I-1)+1.
    8 CONTINUE
C     CALL ALNMES(0.0,0.5)
      CALL ANGLE(90)
      CALL HEIGHT(0.1)
```

```
      DO 9 IJ=1,5
      IF(REGNS(IJ))THEN
        NL=NLAYRS(IJ)
        TNL=NL
        DELTHK=PTHICK(IJ)/TNL
        NLL=NL
        IF(IJ .EQ. 1) NLL=NL+1
        DO 15 IJL=1,NLL
        R(1)=PROUT(IJ)-(IJL-1)*DELTHK
        IF(IJ .EQ. 1 .AND. IJL .GT. NL) R(1)=RIN
        DO 10 I=2,187
        R(I)=R(1)
 10     CONTINUE
        NPTS=181
        NTHP=4
        IF(IJL .EQ. 1 .OR. IJL .GT. NL) THEN
          NPTS=187
          NTHP=1
          CALL THKCRV(0.03)
        ENDIF
        CALL CURVE(THETA(NTHP),R,NPTS,0)
        CALL RESET('THKCRV')
 15     CONTINUE
C WRITE THE OUTER RADIUS OF THIS REGION IN THE MARGIN, TOP OF PLOT
        XPOS1= XPOSN(180.0,PROUT(IJ))
        CALL REALNO( ROUT(IJ),2,XPOS1,-0.35)
C  WRITE THE REGION NUMBER IN THE MARGIN, BOTTOM OF CIRCLE
        XPOS2=XPOSN(0.0,PROUT(IJ))
        CALL MESSAG(REGLAB,8,XPOS2,-0.35)
        CALL INTNO(IJ,'ABUT','ABUT')
C IF REGNS(4)=FALSE; EXTRA CALL TO WRITE INSIDE RADIUS, RIN
        IF(IJ .EQ. 1 .AND. .NOT. REGNS(4))THEN
        XPOS1= XPOSN(180.0,RIN)
        CALL REALNO( RIN,2,XPOS1,-0.35)
        ENDIF
      ENDIF
    9 CONTINUE
C     CALL RESET('ALNMES')
C WRITE LABEL 'RADIUS' ABOVE RADIUS VALUES IN MARGIN
      XPOS= XPOSN(180.0,RADMAX)
      CALL MESSAG(RADIUS,10,XPOS-0.2,-0.5 )
      CALL RESET('HEIGHT')
C IF SOME THICK CHANGED, WRITE NOSCALE MESSAGE
      IF(NOSCAL) CALL MESSAG(NOSMSG,17,9.95,5.5)
C NOW PLOT THE RADII;  NO. OF RADII = NTHETA+1
      NPTS=2
      R(1)=0.
      R(2)=RADMAX
      THETA(1)=0.
      THETA(2)=0.
      CALL CURVE(THETA,R,NPTS,0)
      THETB=0.
      DELTH=180./NTHETA
      IF(.NOT. REGNS(4)) R(1)=RIN
      DO 25 IA=2,NTHETA
      THETA(1)=THETB+(IA-1)*DELTH
      THETA(2)=THETA(1)
      CALL CURVE(THETA,R,NPTS,0)
   25 CONTINUE
      R(1)=0.
      THETA(1)=180.
      THETA(2)=THETA(1)
      CALL CURVE(THETA,R,NPTS,0)
C
C   PLOT LINES OR A SEMICIRCLE DENOTING THE ULLAGE
C
        IF(CT .EQ. 'C') THEN
          R(1)=RADULG
          DO 111 I=2,187
 111      R(I)=R(1)
```

```
          NPTS=181
          NTHP=4
          CALL MARKER(16)
          CALL THKCRV(.05)
          CALL CURVE(THETA(NTHP),R,NPTS,9)
          CALL RESET('THKCRV')
          XPOS=XPOSN(178.0,0.4)
          YPOS=YPOSN(178.0,0.4)
          CALL RLMESS(ULLG,6,XPOS,YPOS)
          CALL HEIGHT(0.09)
          CALL MESSAG(TNKVEQ,12,XPOS,-0.5)
          CALL REALNO(TVOL,1,XPOS+.15,-0.5)
          CALL MESSAG(TVUNIT,6,'ABUT','ABUT')
          CALL MESSAG(TANKEQ,5,XPOS+.35,-0.5)
          CALL REALNO(PCTFUL,0,XPOS+.50,-0.5)
          CALL MESSAG(PCTSIN,7,'ABUT','ABUT')
        ENDIF
C
        IF(CT .EQ. '1') THEN
          R(1)=RINMHH
          R(2)=RIN
          ANGR=(PI/2.-RADULG)
C   CONVERT ANGLE TO DEGREES
          ANGD=ANGR*180./PI
          THETA(1)=180.
          THETA(2)=ANGD+90.
          IF(PCTFUL .LE. 50.) THEN
            THETA(1)=0.0
            THETA(2)=RADULG*180./PI
            R(1)= -RINMHH
          ENDIF
          NPTS=2
          CALL MARKER(16)
          CALL THKCRV(.05)
C  HORIZONTAL LINE
          CALL CURVE(THETA,R,NPTS,1)
C  VERTICAL LINE
          THETA(2)=180.0
          CALL MARKER(16)
          CALL CURVE(THETA,R,NPTS,1)
C  CURVE ON REGION 4-1 BOUNDARY
          IF(PCTFUL .LE. 50.) THEN
            THETA(1)=RADULG*180./PI
          ELSE
            THETA(1)=ANGD+90.
          ENDIF
          THTEND=180.
          R(1)=RIN
          DO 205 I=2,181
          NPTS=I
          THETA(I)=THETA(I-1)+1.0
          R(I)=R(1)
          IF(THETA(I) .GE. THTEND) GO TO 210
  205     CONTINUE
  210     THETA(NPTS)=THTEND
          CALL CURVE(THETA,R,NPTS,0)
          CALL RESET('THKCRV')
          CALL RLMESS(ULLG,6,180.0,RINMHH+0.2)
          CALL HEIGHT(0.09)
          XPOS=XPOSN(180.0,RINMHH)
          CALL MESSAG(TNKVEQ,12,XPOS,-0.5)
          CALL REALNO(TVOL,1,XPOS+.15,-0.5)
          CALL MESSAG(TVUNIT,6,'ABUT','ABUT')
          CALL MESSAG(TANKEQ,5,XPOS+.35,-0.5)
          CALL REALNO(PCTFUL,0,XPOS+.50,-0.5)
          CALL MESSAG(PCTSIN,7,'ABUT','ABUT')
        ENDIF
C  HEAT EXCHANGERS
C
  300 IF(NHX .GT. 0) THEN
```

```
      CALL THKCRV(.05)
      DTHDEG=DTHETA*180./PI
      DO 310 I=1,NHX
      THETA(1)=(NTHHX(I)-1)*DTHDEG
      THTEND=THETA(1)+LNGTHX(I)*DTHDEG
      NRG=NRHX(I)
      RSUB=NLHX(I)-1
      TNL=NLAYRS(NRG)
      DELTHK=PTHICK(NRG)/TNL
      R(1)=PROUT(NRG)-RSUB*DELTHK
      DO 315 J=2,181
      NPTS=J
      THETA(J)=THETA(J-1)+1.0
      R(J)=R(1)
      IF(THETA(J) .GE. THTEND) GO TO 320
  315 CONTINUE
  320 THETA(NPTS)=THTEND
      CALL MARKER(17)
      CALL CURVE(THETA,R,NPTS,4)
C  MAKE ARROW AND LEGEND FOR HXGR
      CALL HEIGHT(0.1)
      VEND1=RADMAX+SCALEF
      CALL RLVEC(THETA(1),VEND1,THETA(1),R(1),1001)
      CALL RLMESS(HXMSG1,100,THETA(1),VEND1)
      CALL RLINT (I,'ABUT','ABUT')
      XPOS=XPOSN(THETA(1),VEND1)
      YPOS=YPOSN(THETA(1),VEND1)
      NODENO=20000+I
      CALL MESSAG(NNOMSG,100,XPOS+.17,YPOS+0.4)
      CALL INTNO (NODENO,'ABUT','ABUT')
      CALL MESSAG(TEQMSG,100,XPOS+.34,YPOS+0.4)
      CALL REALNO(HXTEMP(I),2,'ABUT','ABUT')
      CALL MESSAG(DEGMSG,100,'ABUT','ABUT')
      CALL MESSAG(MATNMS(9),1,'ABUT','ABUT')
  310 CONTINUE
      CALL RESET('THKCRV')
      CALL RESET('HEIGHT')
    ENDIF
C  PUT MESSAGE OF Q TO OUTSIDE SURFACE
    IF(NQIN .GT. 0) THEN
      CALL HEIGHT(0.1)
      XPOS=1.8
      YPOS=5.7
      CALL MESSAG(QMSG1,100,XPOS,YPOS)
      CALL MESSAG(QMSG2,100,XPOS+0.17,YPOS)
      CALL MESSAG(QMSG3,100,XPOS+0.34,YPOS)
      CALL REALNO(QEFF,4,'ABUT','ABUT')
      CALL MESSAG(QMSG4,100,'ABUT','ABUT')
      CALL VECTOR(XPOS,YPOS,XPOS,YPOS-0.6,1001)
      CALL VECTOR(XPOS,YPOS,XPOS+0.20,YPOS-0.5,1001)
      CALL VECTOR(XPOS,YPOS,XPOS+0.40,YPOS-0.3,1001)
      CALL RESET('HEIGHT')
    ENDIF
C  PUT MESSAGE OF OUTSIDE BOUNDARY NODES
    DO 501 IBND=1,2
    IF(TEMPS(IBND+5) .NE. -9999.9 .AND. NLAYRS(IBND+7) .GT. 0) THEN
      XPOS=0.7
      YPOS=3.6+(IBND-1)*2.3
      CALL HEIGHT(0.1)
      NODENO=20300+IBND
      CALL MESSAG(BNMSG1,100,XPOS,YPOS)
      CALL INTNO (IBND,'ABUT','ABUT')
      CALL MESSAG(NNOMSG,100,XPOS+0.17,YPOS)
      CALL INTNO (NODENO,'ABUT','ABUT')
      CALL MESSAG(TEQMSG,100,XPOS+0.34,YPOS)
      CALL REALNO(TEMPS(IBND+5),2,'ABUT','ABUT')
      CALL MESSAG(DEGMSG,100,'ABUT','ABUT')
      CALL MESSAG(MATNMS(9),1,'ABUT','ABUT')
      NCR=NLAYRS(IBND+7)
      CALL MESSAG(CONRAD(NCR),100,XPOS+0.51,YPOS)
```

```
      CALL MESSAG(BNMSG5,100,'ABUT','ABUT')
      IF(NCR .EQ. 1) THEN
C  CONVECTION, PUT OUT L/C  H
        CALL BASALF('L/CSTD')
        CALL MESSAG('H = $',100,XPOS+0.68,YPOS)
        CALL RESET('BASALF')
      ENDIF
      IF(NCR .EQ. 2) THEN
C  RADIATION, PUT OUT SCRIPT  F
        CALL BASALF('L/CGREEK')
        CALL MESSAG('S$',100,XPOS+0.68,YPOS)
        CALL BASALF('SCRIPT')
      CALL MESSAG('F = $',100,'ABUT','ABUT')
      ENDIF
      CALL RESET('BASALF')
      CALL TRIPLX
      CALL REALNO(BNCOEF(IBND),-5,'ABUT','ABUT')
      CALL RESET('HEIGHT')
    ENDIF
  501 CONTINUE
C  PUT NUMBERS ON OUTSIDE OF THE SPHERE AT EACH SECTOR
      DANGL=DTHETA*180./PI
      ANG=DANGL/2.
      RRRR=RADMAX+SCALEF*0.7
      CALL HEIGHT(0.10)
      DO 710 I=1,NTHETA
      EYEM1=I-1
      ANGL=ANG+EYEM1*DANGL
      CALL RLINT(I,ANGL,RRRR)
  710 CONTINUE
      CALL RESET('HEIGHT')
  800 CALL ENDPL(0)
      RETURN
C
      ENTRY DUNPLT
CALLED  FROM                                         GEOPLT (48)
C   ENTRY POINT TO CLOSE PLOT FILE WHEN EXITING FROM CRYOTRAN
C
  900 CALL DONEPL
      RETURN
      END
      SUBROUTINE PLTCYL

      DIMENSION XTEMP(100),YTEMP(100),PREC(5),XLINE(2),YLINE(2)
      COMMON /TITL/ PTITLE
      COMMON /REGION/ NTHETA,NBETAS,BETA,RIN,TVOL,ROUT(9),
     1                REGNS(9),NLAYRS(9),TEMPS(9),THICK(9),
     2                THKLAY(9),MATRLS(9),MATNMS(9),RGNNMS(9)
      COMMON /ULLAGE/ NLUL4,NLUL5,NTHU41,RINMHH,PCTFUL,RADULG,TVULFT,
     1                CT,LG(3),LIQVAP(3)
      COMMON /HTXGRS/ NHX,HXTEMP(10),NRHX(10),NLHX(10),
     1               NTHHX(10),LNGTHX(10)
      COMMON /STUFF/ NHTT,PI,CONVY,CONVR,THETA0,DTHETA,NBASOS,ROUTSF,
     1               BNCOEF(2)
      COMMON /OUTSRC/ NQIN,QEFF
      COMMON/TOPBOT/NTOP,NBOT,NFTLAY,NSTLAY,NETLAY,NFBLAY,NSBLAY,
     *                         NEBLAY,ETRAT,EBRAT,FTTHK,FBTHK
      COMMON/CYDATA/CYLHGT,NCYLAY
C
      LOGICAL REGNS
      LOGICAL NOSCAL
C
      CHARACTER*1   CT,LG
      CHARACTER*6   LIQVAP
      CHARACTER*1   REGNO
      CHARACTER*16  MATNMS
      CHARACTER*25  RGNNMS
      CHARACTER*80  PTITLE
C
      CHARACTER*2   NUM
```

```
      CHARACTER*6   RLABLE,ULLG
      CHARACTER*8   REGLAB
      CHARACTER*10  RADIUS
      CHARACTER*17  NOSMSG
      CHARACTER*20  QMSG1,QMSG2, QMSG4, HXMSG1
      CHARACTER*4   QMSG3, TEQMSG
      CHARACTER*6   DEGMSG
      CHARACTER*10  NNOMSG
      CHARACTER*20  NOHX
      CHARACTER*20  BNMSG1, BNMSG5
      CHARACTER*20  CONRAD(2)

      DIMENSION PROUT(5),PTHICK(5)
      DIMENSION R(500), THETA(500)

      DATA REGLAB/'REGION  '/,    RADIUS/'RADIUS(IN)'/
      DATA ULLG/'ULLAGE'/
      DATA NOSMSG/'PLOT NOT TO SCALE'/
      DATA NOHX/'NO HEAT EXCHANGER'/
      DATA TEQMSG/'T= $'/
      DATA DEGMSG/' DEG $'/
      DATA NNOMSG/'NODE NO. $'/
      DATA QMSG1 /'SOURCE Q INTO ALL$'/
      DATA QMSG2 /'OUTER SURFACE NODES$'/
      DATA QMSG3 /'Q= $'/
      DATA QMSG4 /'  (BTU/(HR-IN2))$'/
      DATA BNMSG1 /'OUTSIDE BNDY NODE $'/
      DATA BNMSG5 /' TO SURFACES$'/
      DATA CONRAD(1) /'CONVECTIONS'/
      DATA CONRAD(2) /'RADIATIONS'/
      DATA HXMSG1 /'HEAT EXCHANGER NO. $'/
C
C  INITIALIZE OUTPUT TO (1) QMS PRINTER OR TO (2) TERMINAL SCREEN
      PRINT 2001
 2001 FORMAT(///'    IN THE SPHERE PLOTTING ROUTINE'/
     1       '    SEND THE GRAPH TO '/
     2       '    1.  THE QMS PRINTER'/
     3       '    2.  THE TERMINAL SCREEN'/
     4       '    TYPE IN  1  OR  2')
      CALL READIN(IDV,1,3)
      IF(IDV .EQ. 1) CALL QMS2
      IF(IDV .EQ. 2) CALL IBM52(3179,0,0,0)
C  NEW SUBROUTINE CALL FROM DAVE HUBLER TO ALLOW USER TO CHOOSE DEVICE
      IF(IDV .EQ. 3) CALL PDEV(' ',ISTAT)
C  SET PAGE SIZE
      CALL PAGE(11.0,8.5)
C  SET SUBPLOT SIZE
      CALL AREA2D(8.0, 8.0)
      CALL GRAF (0.,10.,400.,0.,10.,400.)

      CALL TRIPLX
C   SCALE REGION THICKNESSES UP IF REAL SCALE IS TOO SMALL
      NOSCAL =.FALSE.
      SCALEF=RIN/20.
      DO 5 I=1,5
      PROUT(I)=ROUT(I)
      PTHICK(I)=THICK(I)
      IF(REGNS(I)) THEN
        IF(THICK(I) .LT. 1.) THEN
          PTHICK(I)= THICK(I)+SCALEF
          NOSCAL =.TRUE.
        ENDIF
      ENDIF
    5 CONTINUE
      IF(NOSCAL) THEN
        THKSUM=0.0
        DO 7 I=1,3
        IF(REGNS(I)) THEN
          THKSUM=THKSUM+PTHICK(I)
          PROUT(I)=RIN+THKSUM
```

```
         ENDIF
   7     CONTINUE
         IF(THICK(4) .LT. 1.) THEN
           PROUT(5)=RIN-PTHICK(4)
           PTHICK(5)=PROUT(5)
         ENDIF
       ENDIF
C
       RADMAX= AMAX1(PROUT(1),PROUT(2),PROUT(3))
C
       RSTEP=RADMAX/4.5
C
C   WRITE THE PLOT TITLE
C
       CALL ANGLE(90.)
       CALL MESSAG(NOSMSG,17,9.,5.0)
C

       IF (NBOT.EQ.2) THEN
       XTEMP(1)=300
       YTEMP(1)=150
       XTEMP(2)=325
       YTEMP(2)=150
       XTEMP(3)=325
       YTEMP(3)=250
       XTEMP(4)=300
       YTEMP(4)=250
       CALL THKCRV (0.02)
       CALL CURVE (XTEMP,YTEMP,4,0)
       CALL THKCRV (0.01)
       RAD=25./NFBLAY
       XTEMP(1)=300
       YTEMP(1)=150
       XTEMP(2)=300
       YTEMP(2)=250
       DO 33 I=1,NFBLAY-1
          XTEMP(1)=XTEMP(1)+RAD
          XTEMP(2)=XTEMP(1)
          CALL CURVE(XTEMP,YTEMP,2,0)
  33   CONTINUE

       YTEMP(1)=250.
       YTEMP(2)=250.
       DO 30 I=1,5
          IF (REGNS(I)) THEN
             IF (I.EQ.1) SCALE = 10
             IF (I.EQ.2) SCALE = 10
             IF (I.EQ.3) SCALE = 10
             IF (I.EQ.4) SCALE = 40
             IF (I.EQ.5) SCALE = 30
             CALL THKCRV(0.02)
             XTEMP(1)=300
             XTEMP(2)=325
             YTEMP(1)=YTEMP(1)-SCALE
             YTEMP(2)=YTEMP(2)-SCALE
             CALL CURVE(XTEMP,YTEMP,2,0)
             CALL RESET ('THKCRV')
          ENDIF
  30   CONTINUE

       RAD=250.
       XTEMP(1)=300
       XTEMP(2)=325
       DO 32 I=1,5
          IF (REGNS(I)) THEN
             IF (I.EQ.1) SCALE=10
             IF (I.EQ.2) SCALE=10
             IF (I.EQ.3) SCALE=10
             IF (I.EQ.4) SCALE=40
             IF (I.EQ.5) SCALE=30
```

```
            RAD = RAD - SCALE
            YTEMP(1)=RAD
            YTEMP(2)=RAD
            DO 31 J=1,NLAYRS(I)-1
               YTEMP(1)=YTEMP(1)+(SCALE/NLAYRS(I))
               YTEMP(2)=YTEMP(2)+(SCALE/NLAYRS(I))
               CALL THKCRV(0.01)
               CALL CURVE(XTEMP,YTEMP,2,0)
               CALL RESET('THKCRV')
 31         CONTINUE
         ENDIF
 32   CONTINUE
      ENDIF

      IF (NTOP.EQ.2) THEN
      XTEMP(1)=75
      YTEMP(1)=150
      XTEMP(2)=100
      YTEMP(2)=150
      XTEMP(3)=100
      YTEMP(3)=250
      XTEMP(4)=75
      YTEMP(4)=250
      XTEMP(5)=75
      YTEMP(5)=150
      CALL THKCRV (0.02)
      CALL CURVE (XTEMP,YTEMP,5,0)
      CALL THKCRV (0.01)
      RAD=25./NFTLAY
      XTEMP(1)=75
      YTEMP(1)=150
      XTEMP(2)=75
      YTEMP(2)=250
      DO 733 I=1,NFTLAY-1
         XTEMP(1)=XTEMP(1)+RAD
         XTEMP(2)=XTEMP(1)
         CALL CURVE(XTEMP,YTEMP,2,0)
 733  CONTINUE

      YTEMP(1)=250.
      YTEMP(2)=250.
      DO 730 I=1,5
         IF (REGNS(I)) THEN
            IF (I.EQ.1) SCALE = 10
            IF (I.EQ.2) SCALE = 10
            IF (I.EQ.3) SCALE = 10
            IF (I.EQ.4) SCALE = 40
            IF (I.EQ.5) SCALE = 30
            CALL THKCRV(0.02)
            XTEMP(1)=75
            XTEMP(2)=100
            YTEMP(1)=YTEMP(1)-SCALE
            YTEMP(2)=YTEMP(2)-SCALE
            CALL CURVE(XTEMP,YTEMP,2,0)
            CALL RESET ('THKCRV')
         ENDIF
730   CONTINUE

      RAD=250.
      XTEMP(1)=75
      XTEMP(2)=100
      DO 732 I=1,5
         IF (REGNS(I)) THEN
            IF (I.EQ.1) SCALE=10
            IF (I.EQ.2) SCALE=10
            IF (I.EQ.3) SCALE=10
            IF (I.EQ.4) SCALE=40
            IF (I.EQ.5) SCALE=30
            RAD = RAD - SCALE
            YTEMP(1)=RAD
```

```
         YTEMP(2)=RAD
         DO 731 J=1,NLAYRS(I)-1
            YTEMP(1)=YTEMP(1)+(SCALE/NLAYRS(I))
            YTEMP(2)=YTEMP(2)+(SCALE/NLAYRS(I))
            CALL THKCRV(0.01)
            CALL CURVE(XTEMP,YTEMP,2,0)
            CALL RESET('THKCRV')
731      CONTINUE
      ENDIF
732   CONTINUE
      ENDIF
      RAD = 100


      IF (NBOT.EQ.3.OR.NBOT.EQ.4) THEN
      IF (NBOT.EQ.3) NUMLAY = NSBLAY
      IF (NBOT.EQ.4) NUMLAY = NEBLAY
      NUMINT = INT(100/NUMLAY)
      INTER =  INT (100/NUMINT)
      X1 = 300
      Y1 = 150
      RAD = 100
      RADINT = RAD/100.
      XTEMP(1)= X1 + RAD
      YTEMP(1)=  (((RAD**2.) - ((XTEMP(1)-X1)**2.))**(1./2.)) + Y1
      DO 1 I=2,100
         XTEMP(I)=XTEMP(I-1) - RADINT
         YTEMP(I)=(((RAD**2.) - ((XTEMP(I)-X1)**2.))**(1./2.)) + Y1
1     CONTINUE
      CALL THKCRV (0.02)
      CALL CURVE (XTEMP,YTEMP,100,0)
      CALL RESET ('THKCRV')
      ANG = 90./NUMLAY
      ANG =  (PI/180.)*ANG
      DO 65 J = 1, NUMLAY-1
         TOTANG = J*ANG
         XLINE (1) =300
         YLINE (1) =150
         XLINE (2) =300 + (100 * COS (TOTANG))
         YLINE (2) =150 + (100 * SIN (TOTANG))
         CALL CURVE (XLINE,YLINE,2,0)
65    CONTINUE
      DO 11 J=1,5
      IF (REGNS(J)) THEN
         IF (J.EQ.1) SCALE = 10
         IF (J.EQ.2) SCALE = 10
         IF (J.EQ.3) SCALE = 10
         IF (J.EQ.4) SCALE = 40
         IF (J.EQ.5) SCALE = 30
         RAD = RAD - SCALE
         RADINT = RAD / 100.
         XTEMP(1) = X1 + RAD
         YTEMP(1)=(((RAD**2.)-((XTEMP(1)-X1)**2.))**(1./2.))+Y1
         DO 12 I=2,100
         XTEMP(I)=XTEMP(I-1) - RADINT
         YTEMP(I)=(((RAD**2.)-((XTEMP(I)-X1)**2.))**(1./2.)) + Y1
12       CONTINUE
         CALL THKCRV (0.02)
         CALL CURVE(XTEMP,YTEMP,100,0)
         CALL RESET ('THKCRV')
         RAD2 = RAD
         DO 71 I=1,NLAYRS(J)
            RAD2 = RAD2 + (SCALE/NLAYRS(J))
            RADINT = RAD2 / 100.
            XTEMP(1) = X1 + RAD2
            YTEMP(1)=(((RAD2**2.)-((XTEMP(1)-X1)**2.))**(1./2.)) + Y1
            DO 81 K=2,100
            XTEMP(K) = XTEMP(K-1) - RADINT
            YTEMP(K)=(((RAD2**2.)-((XTEMP(K)-X1)**2.))**(1./2.))+Y1
81          CONTINUE
```

```
            CALL THKCRV(0.01)
            CALL CURVE(XTEMP,YTEMP,100,0)
            CALL RESET ('THKCRV')
 71       CONTINUE
        ENDIF
 11     CONTINUE
        RAD = 100.
        XTEMP(1)=300
        XTEMP(2)=300 + RAD
        XVBOT=XTEMP(2)
        YTEMP(1)=150
        YTEMP(2)=150
        CALL THKCRV (0.02)
        CALL CURVE(XTEMP,YTEMP,2,0)
        CALL RESET ('THKCRV')
        ENDIF

        RAD = 100.
        XTEMP(1)=300
        XTEMP(2)=300
        XTEMP(3)=100
        XTEMP(4)=100
        XTEMP(5)=300
        YTEMP(1)=150
        YTEMP(2)=150 + RAD
        YTEMP(3)=150 + RAD
        YTEMP(4)=150
        YTEMP(5)=150
        CALL THKCRV (0.02)
        CALL CURVE (XTEMP,YTEMP,5,0)
        CALL RESET ('THKCRV')
        XTEMP(1) = 100
        XTEMP(2) = 300
        YTEMP(1)= 150 + RAD
        YTEMP(2)= 150 + RAD
        DO 13 J = 1 , 5
        IF (REGNS(J)) THEN
           IF (J.EQ.1) SCALE = 10
           IF (J.EQ.2) SCALE = 10
           IF (J.EQ.3) SCALE = 10
           IF (J.EQ.4) SCALE = 40
           IF (J.EQ.5) SCALE = 30
           YTEMP(1) = YTEMP(1) - SCALE
           YTEMP(2) = YTEMP(2) - SCALE
           YA = YTEMP(1)
           YB = YTEMP(2)
           CALL THKCRV (0.02)
           CALL CURVE (XTEMP,YTEMP,2,0)
           CALL RESET ('THKCRV')
           RAD2 = RAD
           DO 73 I=1,NLAYRS(J)
              RAD2 = RAD2 + (SCALE/NLAYRS(J))
              RADINT = SCALE/NLAYRS(J)
              XTEMP(1) = 100.
              YTEMP(1)= YTEMP(1) + RADINT
              XTEMP(2) = 300.
              YTEMP(2)= YTEMP(2) + RADINT
              CALL THKCRV(0.01)
              CALL CURVE(XTEMP,YTEMP,2,0)
              CALL RESET ('THKCRV')
 73        CONTINUE
           YTEMP(1) = YA
           YTEMP(2) = YB
        ENDIF
 13     CONTINUE
        XTEMP(1) = 100
        SCALE = 200./NCYLAY
        DO 14 I=1,NCYLAY
           XTEMP(1) = XTEMP(1) + SCALE
           XTEMP(2) = XTEMP(1)
```

```
         YTEMP(1) = 150
         YTEMP(2) = YTEMP(1) + RAD
         CALL THKCRV(0.01)
         CALL CURVE(XTEMP,YTEMP,2,0)
         CALL RESET ('THKCRV')
 14   CONTINUE

      IF (NTOP.EQ.3.OR.NTOP.EQ.4) THEN
      IF (NTOP.EQ.3) NUMLAY = NSTLAY
      IF (NTOP.EQ.4) NUMLAY = NETLAY
      X1 = 100
      Y1 = 150
      RAD = 100.
      NUMINT = INT (100/NUMLAY)
      RADINT = RAD / 100.
      XTEMP(1)= X1+RAD
      YTEMP(1)= (((RAD**2.) - ((XTEMP(1)-X1)**2.))**(1./2.)) + Y1
      DO 2 I=2,100
         XTEMP(I)=XTEMP(I-1) - RADINT
         YTEMP(I)=(((RAD**2.) - ((XTEMP(I)-X1)**2.))**(1./2.)) + Y1
 2    CONTINUE
      DO 3 I=1,100
         XTEMP(I) =200 - XTEMP(I)
 3    CONTINUE
      CALL THKCRV (0.02)
      CALL CURVE (XTEMP,YTEMP,100,0)
      CALL RESET ('THKCRV')
      ANG = 90./ NUMLAY
      ANG = (PI/180.)*ANG
      DO 66 J = 1, NUMLAY-1
         TOTANG = J* ANG
         XLINE (1) =100
         YLINE (1) =150
         XLINE (2) =100 + (100 * COS (TOTANG))
         YLINE (2) =150 + (100 * SIN (TOTANG))
         XLINE (1) = 200 - XLINE(1)
         XLINE (2) = 200 - XLINE(2)
         CALL CURVE (XLINE,YLINE,2,0)
 66   CONTINUE
      XTEMP(1)=0
      XTEMP(2)=100
      YTEMP(1)=150
      YTEMP(2)=150
      CALL THKCRV (0.02)
      CALL CURVE (XTEMP,YTEMP,2,0)
      CALL RESET ('THKCRV') .
      DO 21 J=1,5
      IF (REGNS(J)) THEN
         IF (J.EQ.1) SCALE = 10
         IF (J.EQ.2) SCALE = 10
         IF (J.EQ.3) SCALE = 10
         IF (J.EQ.4) SCALE = 40
         IF (J.EQ.5) SCALE = 30
         RAD = RAD - SCALE
         RADINT = RAD / 100.
         XTEMP(1) = X1 + RAD
         YTEMP(1)=(((RAD**2.)-((XTEMP(1)-X1)**2.))**(1./2.))+Y1
         DO 22 I=2,100
         XTEMP(I)=XTEMP(I-1) - RADINT
         YTEMP(I)=(((RAD**2.)-((XTEMP(I)-X1)**2.))**(1./2.)) + Y1
 22      CONTINUE
         DO 23 I=1,100
            XTEMP(I) =200 - XTEMP(I)
 23      CONTINUE
         CALL THKCRV (0.02)
         CALL CURVE(XTEMP,YTEMP,100,0)
         CALL RESET ('THKCRV')
         RAD2 = RAD
         DO 72 I=1,NLAYRS(J)
            RAD2 = RAD2 + (SCALE/NLAYRS(J))
```

```
          RADINT = RAD2 / 100.
          XTEMP(1) = X1 + RAD2
          YTEMP(1)=(((RAD2**2.)-((XTEMP(1)-X1)**2.))**(1./2.)) + Y1
          DO 82 K=2,100
          XTEMP(K) = XTEMP(K-1) - RADINT
          YTEMP(K)=(((RAD2**2.)-((XTEMP(K)-X1)**2.))**(1./2.))+Y1
 82       CONTINUE
          DO 53 IJ=1,100
             XTEMP(IJ) =200 - XTEMP(IJ)
 53       CONTINUE
          CALL THKCRV(0.01)
          CALL CURVE(XTEMP,YTEMP,100,0)
          CALL RESET ('THKCRV')
 72     CONTINUE
      ENDIF
 21   CONTINUE
      RAD = 100.
      ENDIF

      CALL REALNO(CYLHGT/2.,4,300,150)
      CALL REALNO(CYLHGT/2.,4,100,150)
      IF (NBOT.EQ.2) THEN
         VALUE=(CYLHGT/2.)+FBTHK
         CALL REALNO(VALUE,4,325 ,150)
      ENDIF
      IF (NTOP.EQ.2) THEN
         VALUE=(CYLHGT/2.) +FTTHK
         CALL REALNO(VALUE,4,75 ,150)
       ENDIF
       IF (NBOT.EQ.3.OR.NBOT.EQ.4) THEN
          VALUE=(CYLHGT/2.)+RIN
          CALL REALNO(VALUE,4,XVBOT,150)
       ENDIF
       IF (NTOP.EQ.3.OR.NTOP.EQ.4) THEN
          VALUE=(CYLHGT/2.)+RIN
          CALL REALNO(VALUE,4,0,150)
       ENDIF

C  PUT MESSAGE OF Q TO OUTSIDE SURFACE
      IF(NQIN .GT. 0) THEN
        CALL HEIGHT(0.1)
        XPOS=5.2
        YPOS=0.0
        CALL MESSAG(QMSG1,100,XPOS,YPOS)
        CALL MESSAG(QMSG2,100,XPOS+0.17,YPOS)
        CALL MESSAG(QMSG3,100,XPOS+0.34,YPOS)
        CALL REALNO(QEFF,4,'ABUT','ABUT')
        CALL MESSAG(QMSG4,100,'ABUT','ABUT')
        YPOS=0.15
        CALL VECTOR(XPOS,YPOS+2.0,XPOS-0.20,YPOS+2.5,1001)
        CALL VECTOR(XPOS,YPOS+2.0,XPOS-0.40,YPOS+2.3,1001)
        CALL VECTOR(XPOS,YPOS+2.0,XPOS,YPOS+2.6,1001)
        CALL VECTOR(XPOS,YPOS+2.0,XPOS+0.20,YPOS+2.5,1001)
        CALL VECTOR(XPOS,YPOS+2.0,XPOS+0.40,YPOS+2.3,1001)
        CALL RESET('HEIGHT')
      ENDIF

C  PUT MESSAGE OF OUTSIDE BOUNDARY NODES
      DO 501 IBND=1,2
      IF(TEMPS(IBND+5) .NE. -9999.9 .AND. NLAYRS(IBND+7) .GT. 0) THEN
        XPOS=2.5 + (IBND-1) *1.3
        YPOS=0.5
        CALL HEIGHT(0.1)
        NODENO=20300+IBND
        CALL MESSAG(BNMSG1,100,XPOS,YPOS)
        CALL INTNO (IBND,'ABUT','ABUT')
        CALL MESSAG(NNOMSG,100,XPOS+0.17,YPOS)
        CALL INTNO (NODENO,'ABUT','ABUT')
        CALL MESSAG(TEQMSG,100,XPOS+0.34,YPOS)
        CALL REALNO(TEMPS(IBND+5),2,'ABUT','ABUT')
```

```
      CALL MESSAG(DEGMSG,100,'ABUT','ABUT')
      CALL MESSAG(MATNMS(9),1,'ABUT','ABUT')
      NCR=NLAYRS(IBND+7)
      CALL MESSAG(CONRAD(NCR),100,XPOS+0.51,YPOS)
      CALL MESSAG(BNMSG5,100,'ABUT','ABUT')
      IF(NCR .EQ. 1) THEN
C  CONVECTION, PUT OUT L/C  H
        CALL BASALF('L/CSTD')
        CALL MESSAG('H = $',100,XPOS+0.68,YPOS)
        CALL RESET('BASALF')
      ENDIF
      IF(NCR .EQ. 2) THEN
C  RADIATION, PUT OUT SCRIPT  F
        CALL BASALF('L/CGREEK')
        CALL MESSAG('S$',100,XPOS+0.68,YPOS)
        CALL BASALF('SCRIPT')
      CALL MESSAG('F = $',100,'ABUT','ABUT')
      ENDIF
      CALL RESET('BASALF')
      CALL TRIPLX
      CALL REALNO(BNCOEF(IBND),-5,'ABUT','ABUT')
    ENDIF
  501 CONTINUE

    IF (NHX.EQ.0) THEN
      XPOS=0.6
      YPOS=5.2
      CALL MESSAGE  (NOHX,100,XPOS-0.17,YPOS)
    ENDIF

    IF (NHX.GT.0) THEN
      DO 503 I=1,NHX
        XPOS=0.6+(I-1)*1.1
        YPOS=5.2
        NODENO=20000+I
        CALL MESSAG(HXMSG1,100,XPOS-0.17,YPOS)
        CALL INTNO(I,'ABUT','ABUT')
        CALL MESSAG(NNOMSG,100,XPOS,YPOS)
        CALL INTNO(NODENO,'ABUT','ABUT')
        CALL MESSAG(TEQMSG,100,XPOS+0.17,YPOS)
        CALL REALNO(HXTEMP(I),2,'ABUT','ABUT')
        CALL MESSAG(DEGMSG,100,'ABUT','ABUT')
        CALL MESSAG(MATNMS(9),1,'ABUT','ABUT')
        CALL MESSAG('ON LAYER $',9,XPOS+0.34,YPOS)
        CALL INTNO(NRHX(I),'ABUT','ABUT')
        CALL MESSAG(' IN REGION $',11,'ABUT','ABUT')
        CALL INTNO(NLHX(I),'ABUT','ABUT')
        CALL MESSAG('STARTING AT LEVEL  $',19,XPOS+0.51,YPOS)
        CALL INTNO(NTHHX(I),'ABUT','ABUT')
        CALL MESSAG('AND COVERING $',13,XPOS+0.68,YPOS)
        CALL INTNO(LNGTHX(I),'ABUT','ABUT')
        CALL MESSAG(' NODE(S).$',9,'ABUT','ABUT')
  503   CONTINUE
    ENDIF

    CALL ENDPL(0)
    RETURN
    END
```

APPENDIX E

CryoTran Program Listings

Part V VM Exec Files

VM Exec File RUNCRYO EXEC

```
/* THIS EXECUTES PROGRAM CRYOTRAN */
/* THIS EXEC DOES NOT ACCESS THE PLOTTING ROUTINES  */
/* USE WHEN RUNNING NON-SINDA TYPE CASES OR WHEN    */
/* PLOTS ARE NOT NEEDED.                            */
/*FILEDEF FT04F001 DISK MATERIAL DBASE FOR THE MATERIAL DBASE*/
/*FILEDEF FT10F001 DISK FN FT FM*/
FILEDEF FT04F001 DISK MATERIAL DBASE M
FILEDEF FT09F001 DISK CRYOTRAN INPUTEKO
FILEDEF FT10F001 DISK CRYOTRAN MODEL
FILEDEF FT17F001 DISK PROGRAM OUTPUT
FILEDEF FT25F001 DISK H2 TABLE M
FILEDEF FT26F001 DISK O2 TABLE M
FILEDEF FT27F001 DISK N2 TABLE M
FILEDEF FT35F001 DISK SCRATCH
FTNLIB
LOAD CRYOTRAN '('CLEAR
INCLUDE CRYOSPHR
INCLUDE CRYOCYL
INCLUDE CRYVMSUB
INCLUDE CRYOPLOT
START
FILEDEF '*' CLEAR
```

VM Exec RUNCRYO

```
/* THIS EXECUTES PROGRAM CRYOTRAN  */
/*ACCESS GRAPH3D  OR NECESSARY JCL TO ACCESS DISSPLA*/
/*FILEDEF FT04F001 DISK MATERIAL DBASE FOR THE MATERIAL DBASE*/
/*FILEDEF FT10F001 DISK FN FT FM*/
SETUP DISSPLA
SETUP GDDM
DRUN CRYOPLOT
FILEDEF FT04F001 DISK MATERIAL DBASE M
FILEDEF FT09F001 DISK CRYOTRAN INPUTEKO
FILEDEF FT10F001 DISK CRYOTRAN MODEL
FILEDEF FT20F001 DISK H2 TABLE M
FILEDEF FT21F001 DISK O2 TABLE M
FILEDEF FT22F001 DISK N2 TABLE M
FILEDEF FT17F001 DISK PROGRAM OUTPUT
FTNLIB
LOAD CRYOTRAN '('CLEAR
INCLUDE CRYOSPHR
INCLUDE CRYOPLOT
INCLUDE CRYOCYL
INCLUDE CRYCHATO
START
FILEDEF '*' CLEAR
```

VM Exec CRYOLINK

```
/* THIS EXECUTES contains the commands to link the
PROGRAM CRYOTRAN  */
FTNLIB
LOAD CRYOTRAN '('CLEAR
INCLUDE CRYOSPHR
INCLUDE CRYOCYL
INCLUDE CRYVMSUB
INCLUDE CRYOPLOT
START
FILEDEF '*' CLEAR
```

```
/*******************************************************************/
/*******************************************************************/
/*****                                                        *****/
/*****    EXEC TO RUN STAND-ALONE DISSPLA  version 11.0       *****/
/*****    with Utilization of Temporary Working Storage       *****/
/*****                                                        *****/
/**********                                              **********/
/**********                                              **********/
/**********  Based on Vendor-Supplied Tellaplan Exec     **********/
/**********  With File Handlers by TAC and Jim McKim     **********/
/***************   Development by Todd Cebriak    ***************/
/***************   For Greg Follen  PBX 3-5193    ***************/
/***************   modified for Disspla by        ***************/
/***************      Dale Hubler 11/14/88        ***************/
/***************         phone 61-6697            ***************/
/********************                        ********************/
/********************  Installed 16 JAN 87   ********************/
/********************  NASA LEWIS RESEARCH   ********************/
/********************                        ********************/
/*************************             *************************/
/************************* Graphics by *************************/
/*************************   CA-ISSCO  *************************/
/*************************             *************************/
/*******************************************************************/
/*******************************************************************/


/*TRACE E      */           /* for debugging*/
arg fname '(' options ')'


/********* GET FILE NAME AND OPTIONS OR OFFER HELP SCREEN *******/

if fname = '?' | fname = 'HELP' then do
call Getoptions ?
end

if fname = '' then   /*A valid filename must be given*/
   do
   VMFCLEAR
   say;say;say;say;say
   SAY 'A valid filename of the form "filename FORTRAN" is required'
   say 'please enter the name of your FORTRAN source file'
   parse upper pull fname .
   state fname fortran
     if rc ^= 0   then do
     say 'DISSPLA source file ' fname 'FORTRAN not found'
     call exit_exec -93
     end
   end

'globalv select ISSCOGRP'   /*temporary global variables indicate*/
'globalv stack DIS110'/*if user has seen option screen once*/
pull oncethru/*during current IPL*/
if oncethru = 1 then do
   options = options||' fake_option'
   end
/*y 'options now are ' options      */
call Getoptions options  /*parse options entered on command line*/
DISSPOPT = 1
'globalv select ISSCOGRP set DIS110' DISSPOPT


/***** DETERMINE NEED FOR FURTHER STORAGE ACQUISITION *****/
makebuf
'query stor (stack'    /*check user's memory - DISSPLA needs 6meg*/
```

```
pull . . storage .
storage = left(storage,length(storage)-1) /*drop the K*/
dropbuf
if storage < 6144 then do     /*test for 6 meg of memory*/
   say

   say 'There is not enough virtual storage for DISSPLA 11.0'
   say 'More virtual storage has been allocated.'
   say 'Please type IPL CMS, and then restart DISSPLA.'
   say 'To permanently change your memory enter;'
   say '     ==> VMSECURE MAI STOR 6M  '
   say ' and then logoff and log back on to make the new'
   say ' storage allocation available '
   'cp def stor 6m'
end

/************** SET UP ACCOUNTING OF DISSPLA USE *********/
/*  user got filename and options right                */
/*  and he has enough memory so record usage of software */

set cmstype ht
vmacct pack start disspla
vmacct pack end    /*set up vmaccount software to count # of uses*/
set cmstype rt

/***** ACQUIRE TEMPORARY STORAGE  *****/
call qdisk
workdisk = result
wd = result /* I am lazy, workdisk is too long & takes too much space*/

   say
   say 'Assigning temporary storage destination to disk ' workdisk
   say
   TDISK 10 workdisk

/************  SETUP LIBRARIES NEEDED BY ISSCO **********/

GLOBAL TXTLIB D110MOD        /*ADD LIBRARIES USED FOR PACKAGE*/
                        /*libraries are added in the same order as
                          the execs supplied by CA-ISSCO*/
if testing='YES'
then do                 /* if TEST option is called*/
addlib disman           /*add library of test plots*/
end

select
when gksfile='YES' then do  /*if GKS option is called*/
addlib gksliba              /*add gks library*/
end
otherwise do
addlib dis110a             /*otherwise add disspla A-library*/
end
end /*end the select clause*/

addlib dis110b          /*add disspla B-library in either case*/
addlib intlib           /*always need device driver library*/
if rc ^= 0 then say 'DISSPLA product not linked - do SETUP DISSPL11'

/*'q loadlib'
cp sleep 5 sec*/

global loadlib dynlib  /*load dldd drivers*/

if versatec = 'VERS11' | versatec = 'VERS42' | versatec = 'VERSVU'
then do
addlib clr      /*add versatec color random library*/
end
/*addlib clr */   /*add it to resolve references in testing*/

SELECT
```

```
when tektronx = 'TEK' then do
                 /* do nothing - do not use gddm library - it will*/
end                /*cause problems with tek terminals*/
otherwise do
setup gddm       /*gddm library interferes with tek calls*/
end
END

setup ftn    /*add fortran libraries*/
 if tlib = YES then do
 say 'You have requested an additional txtlib to be searched for'
 say 'programs'
 say 'Please enter the name of the library ==> '
 parse upper pull addlib_name .
 addlib addlib_name
 end


/*'QUERY TXTLIB'      */ /* USED FOR DEBUGGING*/
/*'CP SLEEP 5 SEC'   */

/***** SAVE ENVIRONMENT AND BEGIN ISSCO INITIALIZATION *****/



/***** SET TERMINAL ENVIRONMENT AS REQUESTED BY ISSCO PRODUCTS *****/

call SaveTerminalEnvironment
makebuf
'query blip (stack'
pull . . blip_state .
'query ldrtbls (stack'
pull . . loader_tables .
dropbuf
'set blip off'
'set ldrtbls 15'
'set msg off'
'set wng off'
'terminal linesize 255'
'terminal escape off'
'terminal linend off'
'terminal linedel off'
'terminal chardel off'

/***** ISSUE ISSCO-REQUIRED AND SITE-SPECIFIC FILEDEFS *****/
/*' q filedef';say 'are the fdefs'*/
/*cp sleep 5 sec*/
call file_definitions
/*' q filedef';say 'are the filedefs after '*/
/*cl sleep 5 sec*/


/*********** COMPILE PROGRAM AND RUN *******************/

if ^cryoflag then do /*this do group created to bypass normal*/
                     /*normal way to load and run*/
                     /*added for G. Cowgill at Analex*/
                     /*end of this loop has commands for runcryo*/
                     /*program*/

genmodule=0

call GetFileAge fname fortran
src_age = result

call GetFileAge fname text
txt_age = result

call GetFileAge fname module
mod_age = result
```

```
 if src_age<0 & txt_age<0 & mod_age<0 then
   do
     SAY 'DISSPLA source program ' fname ' FORTRAN not found'
     call scratch_tdisk workdisk
     call exit_exec -93
   end

 if src_age > txt_age & src_age > mod_age then
   do
     genmodule=1
 /*Y 'THE SOURCE AGE IS '   SRC_AGE
 say 'the txt age is ' txt_age
 SAY 'THE MODULE AGE IS ' MOD_AGE
 CP SLEEP 5 SEC   */
     fortvs fname
     if rc > 4 then do
         say 'there are errors in the source program ' fname
         call scratch_tdisk workdisk
         call exit_exec rc
         end
     mod_age = -99
   end

 if txt_age > mod_age then
   do
     genmodule=1
     say relinking
     load fname
     if rc > 4 then do
         say 'there are errors in the link edit - condition code ' rc
         call scratch_tdisk workdisk
         call exit_exec rc
     end

     /* create a module if so directed */
     if genmodule then
       do
         say fname ' load module being generated.........'
         genmod fname
       end
end

/***** RUN DISSPLA MODULE *****/

say
say 'Now loading DISSPLA . . . '
say

     set msg off
if txt_age > mod_age then
     do
     start
     end
if mod_age > txt_age then
     do
     'run' fname 'module'
     end

if rc<>0 then
        do
        say 'non-zero return code from DISSPLA. Return code is ' rc
        return_code = rc
        end
        else do
        return_code=0
        end
 set msg on

end /*end of do if not cryo*/
```

```
/*cryocryo*/
else do /*must be cryoflag is 1*/
/*y 'into the cryo part for compiling'*/
cryolink
return_code = 0
genmodule = 0
end

/***** OFFLINE GRAPHICS DATA FILE DETECTION AND PROCESSING *****/

if noplot ^= 1 then noplot = 0
if noplot then do
   call Scratch_tdisk workdisk
   call exit_exec return_code
   end
call SavePrinterEnvironment


/*** QMS FILES ***/
call IsThereFile 'HP7550 or TALARIS, QMS LASER PRINTER', 'STD* DATA A'

if queued() > 0 then do                      /*if no files in queue */
                                             /*skip this part of exec*/

valid_response = 0
do until valid_response   /*if they don't get it right the 1st*/
   dropbuf                /*time make them answer till they do*/
   say
   say 'Please choose the plotter to route your file to.'
   say 'Enter;'
   say '         Q - to route the file to a QMS plotter'
   say '         T - to route the file to a LIMS Talaris printer'
   say '         WP - to save an HPGL file to import into Wordperfect'
   say '         H - to route the file to a LIMS HP7550 plotter'
/**/
/*DH  Remove following comment to enable users Postscript access*/
/**/
/*say '         P - to route Postscript file to the VAX LPS40 printer'*/

   parse upper pull plotter_response
/*SAY 'THE RESPONSE WAS ***'PLOTTER_RESPONSE'***' */

   if plotter_response = Q |,
      plotter_response = T |,
      plotter_response = P |,
      plotter_response = DH |,
      plotter_response = WP |,
      plotter_response = H then valid_response=1
   else valid_response = 0

   end /*end of do until valid_response loop*/

if PLOTTER_RESPONSE = DH then do  /*hubler testing exit*/
   exit -7550
   end /* end of do for HP7550 problems*/

select
when plotter_response = WP then do
   say 'Please enter file mode for HPGL file'
   parse upper pull file_mode
   listfile 'std* data a (stack'  /*put all QMS files (STD0000x) files*/
   do while queued() > 0         /* on the stack*/
      pull filename typemode
      'copyf ' filename typemode filename ' hpgl ' file_mode
      if rc = 0 then erase filename typemode
      end
/* hpgl_file=1    */
   end    /*end of when WP*/

when plotter_response = Q then do
```

```
    done = 'false'
    do while done = 'false'
       say
       say 'Please choose a QMS printer site for your data.'
       say '  1) RAC'
       say '  2) ERB'
       say '  3) LGAOS (Analex)'
       say 'Enter the number of your choice:'
       pull choice
       select
          when choice = 1 then do
             tag dev prt mvslercl rmt7
             done = 'true'
          end
          when choice = 2 then do
             tag dev prt mvslercl rmt10
             done = 'true'
          end
          when choice = 3 then do
             tag dev prt mvslercl rmt34
             done = 'true'
          end
          otherwise do
             say
             say 'Improper selection ... Try again.'
          end /*end of otherwise clause*/
       end    /*end of select QMS from choiceof three*/
    end      /*end of do while statement*/
    spool prt nohold rscs
    listfile 'std* data a (stack'  /*put all QMS files (STD0000x) files*/
    do while queued() > 0          /* on the stack*/
       pull filename
                                               /*we must reset QMS*/
                                               /*to landscape mode*/
       execio 1 diskw filename '( string ^PY^-'
/*note that there are no spaces prior to execio string with cc opt*/
       execio 1 diskw filename '( string ^IOL^PN^-' /*cause ISSCO*/
                                                   /*doesn't*/

       print filename '(nocc notrc 11 00'

       erase filename
    end      /*end of do while queued after listfile*/
end /*end of the first select clause for plotter_response*/


/************************************************************/
/*This part of the exec sends an ISSCO QMS plot file to the */
/*LIMS Talaris printers or HP 7550 plotters*/

when plotter_response = T | plotter_response = H then do

                                  /*** send to Talaris or HP7550? ***/
if plotter_response = T then do
tp = T
end
else do
tp = P
end

                                  /* get the user and device ID's **/
makebuf
'q cons (stack'
pull
pull
pull . . user . /*get the user id*/
dropbuf

vmfclear
SAY 'Please enter the Talaris printer or HP plotter ID you want your'
```

```
say 'plot sent to'
say '  for example;'
say '  enter B142B1 for the Talaris or HP7550 on the RAC second floor'
say '     or B500B1 for the Talaris or HP7550 on the DEB second floor'
say '     or B501L1 for the Talaris or HP7550 in the DEB annex'
say '  etc.'
parse upper pull t_d

            /** check for Interlink software and link if not found **/

call Access_Interlink


                                /** send to device **/

'listfile std* data a (stack'  /*put list of plot files on stack*/

do while queued() > 0
   pull filename               /*take names off stack and send them*/


/*********************************************************************/
/**** Interlink Modification due to VMS upgrade  ********************/
/*********************************************************************/
   'nft send lims02::'t_d]]tp':'user'.vm ' filename  '/nocc'
/*                                                                   */
/* above is replacement nft command until LIMS bug due to VMS 5.1    */
/* upgrade of June 25 is fixed.  Then below 2 nft commamnds will also*/
/* work.                                                             */
/*                                                                   */
/*                                                                   */
/*   'nft send lims01::'user'.vm ' filename ' /nocc'                 */
/* 'cp smsg decmcs cmd lims01 print/delete/queue='t_d'_'tp  user'.vm'*/
/*********************************************************************/

                      /********** erase file sent to device **********/
   erase filename             /*clean up after ourselves*/
   end                       /*end of do while*/

                           /****** remove link to nft software ******/
if we_linked_to_nft then do
   set cmstype ht
   'release nftmode (det'          /*bye bye nft software minidisk*/
   set cmstype rt
   end

end /*end of select clause for plotter_response = T*/

when plotter_response = P then do   /*this is for postscript files*/

say 'The file will be sent to the Postscript printer'
set cmstype ht
call Access_Interlink

'makebuf'             /*get user's bin number*/
bufno = rc
'q cons (stack'
pull;pull;pull . . . . bin .
'dropbuf ' bufno


'listfile std* data a (stack'  /*put list of plot files on stack*/

do while queued() > 0
   pull filename               /*take names off stack and send them*/

   xxxxx = strip(userid()) ]] strip(time('s')) /*make unique filename*/


   'MAKEBUF'
```

```
   bufno=rc
   queue "$ ASSIGN" bin "NASA$BIN"
   queue "$ LPS40/P" xxxxx".LPS"
   queue "$ DELETE" xxxxx".LPS;*"
   queue "$ DELETE" xxxxx".COM;*"
   queue "$ RENAME" xxxxx".LOG RACCESS.LOG"
   'execio 5 DISKW CA-LPS40 COM A (FINIS'
   dropbuf bufno


                                                      /*send the files*/
   'nft send venus"RACCESS REMACC2"::'xxxxx'.lps ' filename
   'nft send venus"RACCESS REMACC2"::'xxxxx'.com CA-LPS40 COM A'
   'nft submit venus"RACCESS REMACC2"::'xxxxx'.com'

    end                                  /*end of queued file on stack*/

                                          /*cleanup time*/
if we_linked_to_nft then 'release 'nftmode '(det'
                                         /*REMOVE LINK TO NFT MINIDISK*/
'erase ca-lps40 com a'                   /*erase VMS COM file we made*/
'erase ' filename                        /*erase CA plot file*/
end                       /*end of Postscript portion of select clause*/


otherwise                  /*if user entered anything other than Q or T*/
   do
    set cmstype ht
   'listfile std* data a (stack' /*list files left on user's minidisk*/
    set cmstype rt
   do while queued() > 0
      pull filename
      say 'DISSPLA:INVALID plotter_response - file not plotted'
/*    say 'plot file ' filename ' saved on disk without plotting'  */
      end  /*end of do while queued>0*/
   end  /*end of otherwise part of select clause*/

end  /*end of entire large select clause*/

  END   /*END OF IF QUEUED>0 THEN DO AT TOP OF ROUTINE*/




/************* 3800 FILES  and 3820 FILES ********************/

call IsThereFile 'IBM 3800/3820', 'TAG* ADMIMAGE A'
if queued() > 0 then do
   dropbuf
   say
   say 'Please choose an IBM printer:'
   say
   say ' 1)    IBM MODEL 3800'
   say ' 2)    IBM MODEL 3820'
   say
   do until (opt=1 | opt=2 | opt=3)
      say 'Enter 1 or 2:'
      pull opt
   end
   if opt=3 then do   /*hubler uses option 3 to bail out*/
      call exit_exec -3800
      end
   if opt=1 then do
      say
      say 'Your graphic data is being routed to the 3800 printer.'
      38XX 'A'  OPT
   end
   else do
        say
        say 'Which IBM 3820 printer should the output be sent to?'
```


C-4

```
        say
        say ' 1)    RAC'
        say ' 2)    10 X 10'
        say ' 3)    DEB 1st floor'
        say ' 4)    DEB 3rd floor'
        say ' 5)    IRT'
        say ' 6)    Sverdrup Middleburg Hts. office'
        say
     do until (loc=1 | loc=2 | loc=3 | loc=4 |loc=5 |loc=6)
        say 'Enter 1,2,3,4,5 or 6:'  /*choose location*/
        pull loc
     end
     if loc = 1 then locname = 'RAC'
     if loc = 2 then locname = '10 X 10'
     if loc = 3 then locname = 'DEB 1st floor'
     if loc = 4 then locname = 'DEB 3rd floor'
     if loc = 5 then locname = 'IRT'
     if loc = 6 then locname = 'Sverdrup Middleburg Hts. office'
     say
     say 'Your graphic data is being routed to the'
     say 'IBM 3820 printer at the 'locname
     say
     opt = loc+1                              /* augment opt for 38XX */
     38XX 'A'  opt
  end
dropbuf
end


/*** MATRIX FILM RECORDER ***/
call IsThereFile 'matrix film recorder', laser_offline
if queued() > 0 then do
   dropbuf
   say
   say 'Your graphic data is being routed to the matrix film recorder.'
   'datesend'
   wd = workdisk
   'copyf lerc31 header 'wd' lerc31 data 'wd' lerc31 data 'wd' (replace'
   'erase lerc31 header 'workdisk
   'listfile ' laser_offline ' (stack'
   set imsg off /*set to off after debugging*/
   detach 00e
   define 3800 as 00e
   'tag dev prt mvslercl rmt12'
   'spool prt nohold rscs'
   CALL PRINTSTACKEDFILES '(NOCC NOTRC LI 00)'
   detach 00e
   define printer as 00e
   set imsg on
end


/*** VERSATEC FILES ***/
call IsThereFile 'Versatec plotter', 'file vrfdata 'workdisk
if queued() > 0 then do         /*if true a file exists*/
      dropbuf
      say
      say 'Your graphic data is being routed to the Versatec plotter.'
      randout
      erase file vrfdata workdisk
/*    erase vers diag workdisk   */
      listfile 'file vrfout 'workdisk' (stack'
      set imsg off
      detach 00e
      define 3800 as 00e
      select
        when versatec = "VERS42" then do
        'tag dev prt mvslercl u4'
        end
        when versatec = "VERS11" then do
```

```
        'tag dev prt mvslercl u10'
        end
        when versatec = "VERS11VU" then do
        'tag dev prt mvslercl u10'
        end
        otherwise do
        say '***Invalid Versatec plotter - 'versatec'***'
        end
      end
      spool prt nohold rscs
      call PrintStackedFiles '(nocc notrc li 00)'
      detach 00e
      define printer as 00e
      set imsg on
end


/***** DETECTION OF FILE ERROR  *****/

set emsg off
state file ft00f001 a
if rc=0 then do
say
   say 'The plot failed because of invalid options in PLOTPARM DATA'
   type file ft00f001 a
   erase file ft00f001 a
end

'state ' fname ' module a'        /*offer user option of deleting*/
if rc = 0 & genmodule then do      /*source file load module*/
   say;say;say
   say 'A file -- ' fname 'MODULE -- has been created on your A disk'
   say 'Would you like to have it deleted to conserve disk space? '
   say 'Reply Y to have the module deleted'
   say '        or just hit enter to keep the file'
   parse upper pull delete_response
   if delete_response = 'Y' then do
       'erase ' fname ' module a'
       end
   'erase load map'
   end

call scratch_tdisk workdisk  /*now scratch temporary minidisk*/



set emsg on


/***** RESTORE PRINTER AND TERMINAL ENVIRONMENTS PRIOR TO ISSCO *****/
set cmstype ht
'filedef * clear'          /*we are done - clear all filedefs*/
call RestorePrinterEnvironment /*reset virtual printer settings*/

call RestoreTerminalEnvironment
set blip blip_state
set ldrtbls loader_tables
set msg on
set wng on
  say 'return_code value is ' return_code
erase vscr tmp
set cmstype rt
call exit_exec return_code


/***** SUBROUTINE:  Access_Interlink *************/

Access_Interlink: procedure expose we_linked_to_nft nftmode

set cmstype ht
```

```
we_linked_to_nft=0
state nft module      /*see whether nft software is linked yet*/
if rc ^= 0 then do
   we_linked_to_nft = 1
   call qvirt            /*find an unused address for the minidisk*/
   ddsk=result
   call qdisk            /*find the next available filemode letter*/
   nftmode = result
   link decrtr 200 ddsk rr   /*link to nft minidisk*/
   access ddsk nftmode
   end
set cmstype rt
return


/*** SUBROUTINE: SaveTerminalEnvironment ***/

SaveTerminalEnvironment: procedure expose terminal_environment
/* save the current terminal environment in <terminal_environment> */
terminal_environment = ''
makebuf
query terminal '(stack'
do while queued() > 0
   pull tmp
   terminal_environment = terminal_environment ',' tmp
end
terminal_environment = substr(terminal_environment,2)
dropbuf
return


/*** SUBROUTINE: RestoreTerminalEnvironment ***/

RestoreTerminalEnvironment: procedure expose terminal_environment
/* restore the terminal environment saved in <terminal_environment> */
do while length(terminal_environment) > 0
   i = index(terminal_environment,',')
   if i = 0 then i = length(terminal_environment) + 1
   strg = left(terminal_environment,i-1)
   if length(strg) > 0 then do
      set emsg off
      terminal strg
      set emsg on
   end
   terminal_environment = substr(terminal_environment,i+1)
end
return


/*** SUBROUTINE: IsThereFile ***/

IsThereFile: procedure          /*This subroutine has been commented */
                                /*to the point that it is merely a */
arg device, filename            /*return.  We are now sending directly*/
                                /*to the device and not allowing the*/
makebuf                         /*the user the choice to store file on*/
set emsg off                    /*disk*/
listfile filename '(stack'  /*look for the given file name*/
temp = rc
set emsg on
dropbuf

if temp = 0 then do  /*the file exists*/
/* VMFCLEAR
   say
   say
   say
   say 'There are graphic data file(s) for the offline' device
   say 'Do you want to send them to the device? (Y/N)'
   pull ans                  */
```

```
/* if ans = 'Y' then do    */    /*put filename on stack and return */
      listfile filename '(stack' /*temporarily while within the loop*/
      return
/* end    */

/* say 'Do you want to delete them? (Y/N)'
   pull ans                      /*after file has been output pull*/
   if ans = 'Y' then do   */     /*name off stack and delete files*/
      listfile filename '(stack'
      do while queued() > 0
         pull name
         erase name
      end                       /*end of do while*/
      return
/* end*/                        /*end of if ans=y*/
end                             /*end of if temp=0*/
return


/*** SUBROUTINE: SavePrinterEnvironment ***/

SavePrinterEnvironment: procedure expose tag_text spool_text
/* copied from <print38 exec> */
makebuf
before = queued()
execio '*' cp '(' fifo string query virtual ur
pull response
parse var response device .
after = queued()

do while device ^= 'PRT' & after > before
   pull response
   parse var response device .
   after = after - 1
end

if after = before then do
   dropbuf
   say
   say 'virtual printer missing *error*'
   call exit_exec -99
end
parse var response . . . prt.cl prt.cont prt.hold 'COPY' prt.copy .
pull . prt.for_to prt.whom .
dropbuf

makebuf
/* get tag text */
rest = ''
tag_text = ''
execio '*' cp '(' fifo string tag query dev prt
pull . . . rest
if rest ^= 'NOT SET' then pull tag_text
if prt_for_to = 'TO'
   then spool_text = prt.whom prt.cont copy prt.copy
   else spool_text = system prt.cont copy prt.copy
dropbuf
return


/*** SUBROUTINE: RestorePrinterEnvironment ***/

RestorePrinterEnvironment: procedure expose tag_text spool_text
/* copied from print38 */
tag dev prt tag_text
spool prt spool_text
return

/**** SUBROUTINE: Scratch_tdisk ****/
```

```
scratch_tdisk: procedure          /*used if compile or link goes wrong*/
arg workdisk_mode                 /*also used at end of program*/

/*say 'scratch tdisk routine entered & workdisk is' workdisk_mode*/

'q disk (stack'                            /*put disks on stack*/
pull                                       /* pull off header */
do while queued()>0
   pull . cuuadd mod .                     /*get vaddr and mode*/
   if (mod = workdisk_mode) then do        /*look for our workdisk*/
     set cmstype ht
     'release ' workdisk_mode ' (det'  /*release mode and detach cuu*/
     set cmstype rt
     end
   end
return

/*** SUBROUTINE: PrintStackedFiles ***/

PrintStackedFiles: procedure
/* stack has queued filenames, print them all */
arg print_opts

do while queued() > 0
   pull filename
/*say 'the filename stacked is ' filename  */
   print filename print_opts
   erase filename
end
return

/*** SUBROUTINE: TestPrintStackedFiles ***/

TestPrintStackedFiles: procedure
/* stack has queued filenames, print them all */
arg print_opts

do while queued() > 0
   pull filename
say 'the filename stacked is ' filename
/* print filename print_opts
   erase filename   */
end
return

/*********** HELP SCREEN SUBROUTINE ************************/

Helpuser: procedure
VMFCLEAR
say 'This exec is for use in compiling and running your '
say 'DISSPLA program'
say
say '      ENTER:'
say
say '                    DISSPLA fname (option'
say
say '                                            at the CMS prompt'
say
say 'where fname is the filename of your FORTRAN source program'
say 'and option is one of the following output devices:'
say
say 'TEK - a Tektronix model terminal'
say 'VERS42 - the 42 inch Versatec plotter'
say 'VERS11 - the 11 inch Versatec plotter'
say 'VERS11VU - the Versatec viewgraph plotter'
say 'GKS - a GKS standard file'
say 'TEST - to use the library of test plots supplied by CA-ISSCO'
say 'TXTLIB - to add a txtlib'
say 'NOPLOT - to create plot file without sending to plot device'
return
```

```
GetOptions: procedure expose versatec tektronx gksfile testing,
                              tlib noplot cryoflag
arg options

versatec=' '
tektronx=' '
gksfile=' '
testing=' '
tlib=' '
noplot = 0
cryoflag = 0 /*cryoflag added for use by Glenn Cowgill at Analex*/

do i = 1  until i >= words(options)
option.i = word(options,i)
end


if option.1 = '' | option.1 = '?' | option.1 = 'HELP' then do
    vmfclear
    SAY;SAY;SAY;SAY;SAY;SAY
    SAY '           Some options may be required'
    CP SLEEP 1 SEC
    call Helpuser
    say;say;say  'Would you like to continue?  '
    say
    say '               Enter  Q  to quit the exec '
    say '            or Enter  O  to supply the options '
    say '            or hit ENTER to continue'

    parse upper pull restart_response
    select;
    when restart_response = 'Q' then do
       call exit_exec -92 /*exit exec so user can restart*/
       end
    when restart_response = 'O' then do
       say 'Please type all desired options and hit ENTER'
       parse upper pull options
          do i = 1  until i >= words(options)
          option.i = word(options,i)
          end
       end
       otherwise do        /*do nothing - continue with exec*/
       end
    end/*end of select clause*/
end /*end of if options.1 = ?*/


do j = 1 to words(options)
call Identify_option option.j
end /*end of identify option loop*/



return

Identify_option: procedure expose versatec tektronx gksfile testing,
                              tlib noplot cryoflag
arg option

/*y 'option passed to identify subroutine is ' option*/

        select;
           when abbrev('TEK',option) then
                tektronx = TEK
           when abbrev('VERS11',option,4) then /*chars 'VERS' will*/
                versatec=VERS11               /*default to 2552 */
           when abbrev('VERS42',option,4) then
                versatec = VERS42
```

```
          when abbrev('VERS11VU',option,4) then
               versatec = VERS11VU
          when abbrev('GKS',option) then
               gksfile = YES
          when abbrev('TEST',option) then
               testing = YES
          when abbrev('TXTLIB',option) then
               tlib = YES
          when abbrev('NOPLOT',option) then
               noplot = 1
          when abbrev('CRYO',option) then
               cryoflag = 1
          when abbrev('FAKE_OPTION',option) then
               nop
          otherwise
             do
               say 'unrecognized option: 'option
               'cp sleep 3 sec'
               call Helpuser
               call exit_exec  -94
             end       /*end otherwise*/
         end       /*end of select clause*/
/*y versatec tektronx gksfile testing tlib   */

    return

GetFileAge: procedure      /*procedure to determine if compilation*/
    arg ffname             /*of user program is needed*/
    makebuf
    bufno = rc
    set emsg off
   'listfile' ffname '* ( date stack'
    rcode = rc
    set emsg on
    if rcode = 0 then
      do
        parse pull fname . . . . . . mo'/'da'/'yr hr':'mn':'sc
        tim = sc + mn*100 + hr*10000 + da*1.0e+6 + mo*1.0e+8 + yr*1.0e+1
      end
    else
        tim = -1
    dropbuf bufno
    return tim

/***** ISSUE ISSCO-REQUIRED AND SITE-SPECIFIC FILEDEFS *****/
/***********************************************************/
/*WARNING WARNING WARNING **********************************/
/* IF THE USER HAS HIS OWN COPY OF PLOTPARM OR IF SOME OTHER*/
/* MINIDISK HAS ONE THEN RC>0 AND PLOTPARM WILL NOT BE FILEDEFED*/
/* VERSATEC SOFTWARE WILL NOT BE RUN AND EXEC WILL END WITH AN ERROR*/
/* USER MUST NOT HAVE HIS OWN PLOTPARM FILE*/


file_definitions: procedure expose versatec workdisk laser_offline

/*say 'versatec value is ' "****"versatec"******"*/ /*for debugging*/
IF versatec ^= ' ' THEN DO
   makebuf
   bufno = rc
   'LISTFILE' VERS11 PLOTPARM '* ( LIFO AL'
   rclist = rc
   nfiles = queued()
/*SAY RCLIST ' IS THE RETURN CODE'*/
/*SAY NFILES ' IS THE NUMBER OF TIMES IT WAS FOUND' */
say
   if rclist = 0
      then do queued()
        parse pull . . fmode .
/*SAY  FMODE '  IS THE FILEMODE OF VERS11 PLOTPARM' */
```

```
   end
   dropbuf bufno
   if rclist = 0 & nfiles > 0
      then fm = substr(fmode,1,1)
/*SAY FM ' IS THE FILEMODE DERIVED FOR VERS11'*/

  IF versatec = 'VERS11' then do
          'FILEDEF PLOTPARM DISK VERS11 PLOTPARM ' FM
          end
  IF versatec = 'VERS11VU' then do
          'FILEDEF PLOTPARM DISK VERSVU PLOTPARM ' FM
          end
  IF versatec = 'VERS42' then do
          'FILEDEF PLOTPARM DISK VERS42 PLOTPARM ' FM
          end
end

'FILEDEF VRFDATA DISK FILE VRFDATA ' WORKDISK '(XTENT 65535'
'filedef vrfout disk file vrfout ' workdisk
/*ILEDEF 23 DISK VSCR TMP ' WORKDISK' (XTENT 5000'  */ /*COMMENTED
by hubler to solve fortran traceback with A Lagin problem*/
'filedef 59 disk vers diag ' workdisk '(recfm f lrecl 132 blksize 132'

laser_offline = 'lerc31 data 'workdisk /*QCR film recorder file*/
laser_header = 'lerc31 header ' workdisk /*QCR header info*/

b_offline = 'lerc32 data 'workdisk
/* qms_offline = 'lerc50 data 'workdisk */

/* set emsg off */
/* erase laser_offline */
/* erase b_offline */
/* erase qms_offline */
set emsg on

/*'filedef 5 term (recfm f lrecl 80 blksize 80'
'filedef 6 term (recfm f lrecl 132 blksize 132'*/

'filedef 31 disk ' laser_offline
'filedef 68 disk ' laser_header
'filedef 32 disk ' b_offline
/* filedef 50 disk qms_offline */

return

/******* SUBROUTINE: EXIT_EXEC *****************/

/*  exit can have following return codes
0 -  normal completion
-92 - no options provided so user chose to exit
-93 - FORTRAN source file not found
-94 - invalid option
-99 - virtual printer missing
8,12,or 16 - VSFORTRAN or link edit errors
-3800 - my own personal exit from 3800 part of exec (used to debug)
*/

exit_exec: procedure
arg exit_code
exit exit_code
return
```

```
/* plotq - print graphic stuff to the qms */
arg file_name '(' destination .

default_name = "std00001 data a"

if length(file_name) = 0 then file_name = default_name
state file_name
rcode = rc
if rcode <> 0 then exit rcode

/* tellagraf doesn't switch back to portrait orientation
so we must issue the proper qms commands to do that */
execio 1 diskw file_name "( string ^PY^-"
execio 1 diskw file_name "( string ^IOL^PN^-"

/* determine the destination qms printer */
select;
    WHEN DESTINATION = 'ANALEX' THEN DESTINATION_NODE = RMT34
    when destination = 'RAC' then destination_node = rmt7
    when destination = 'ERB' then destination_node = rmt10
    when destination = 'DEB' then destination_node = rmt9
    otherwise do
        dropbuf
        done = "false"
        do while done = "false"
            say "Which QMS printer would you like to have your output sent to?"
            SAY "  1) ANALEX"
            SAY "  2) RAC"
            SAY "  3) ERB"
            SAY "  4) DEB"
            say "Enter the number of your choice:"
            parse upper pull choice
            select;
                when choice = 1 then do
                    DESTINATION_NODE = RMT34
                    done = "true"
                    end
                WHEN CHOICE = 2 THEN DO
                    destination_node = rmt7
                    done = "true"
                    end
                WHEN CHOICE = 3 THEN DO
                    destination_node = rmt10
                    done = "true"
                    end
                WHEN CHOICE = 4 THEN DO
                    destination_node = rmt9
                    done = "true"
                    end
                otherwise
                    say "That is not an acceptable choice.  Try again."
            end;
        end
    end
end;
tag dev prt mvslercl destination_node
spool prt nohold rscs
print file_name '(' nocc notrc 11 00
erase file_name
```

```
/* THIS EXECUTES PROGRAM ECLPLOT TO PRODUCE PLOTS FROM ECL PLOTFILE*/
/* WHICH CAME FROM CRAY.  NAMED  -- SOLAPLOT CARDS --  */
/*  THE FILE FN FT IS A BINARY FILE  WITH LRECL=2024  */
/* COPY THIS FILE TO B-DISK USING  COPYFILE*/
/*    COPYFILE DOECLPLT EXEC A DOECLPLT EXEC B   */
/*                                              */
ARG FN FT FM .
IF FN =''
  THEN
    DO
      SAY "ENTER FILENAME,  FILETYPE  AND  FILEMODE"
      PULL FN FT FM
    END
IF FT =''
  THEN
    DO
      SAY "ENTER FILENAME,  FILETYPE  AND  FILEMODE"
      PULL FN FT FM
    END
SETUP CONVDISK
SETUP FTN
GRAPH3D
FILEDEF 08 CLEAR
FILEDEF 09 CLEAR
FILEDEF 59 CLEAR
FILEDEF 08 DISK ECLPLOT INPTECHO
FILEDEF 09 DISK FN FT FM
FILEDEF 59 DISK ECLPLOT DEBUGOUT '(LRECL 132'
LOAD ECLGRAPH '(CLEAR NOMAP ORIGIN 30000'
INCLUDE CHCFTR '(NOMAP'
START
GTERM
```

APPENDIX E

CryoTran Program Listings

Part VI CRAY Script File to Execute SOLA ECLIPSE

```
#SOLA ECLIPSE SCRIPT FILE FOR UNICOS (BOURNE SHELL)
#VERSION 1.0   05/23/89  BY Glenn Cowgill
#  SOLA ECLIPSE ** SOLA ECLIPSE ** SOLA ECLIPSE ** SOLA ECLIPSE
#
# The invocation of the script is as follows:
#    solaecl  filename
#        where filename contains your input sola deck
#        which is on CRAY in the users root directory.
#
# The exit status is as follows:
#   0 - Successful sola run
#   1 - Unable to create temporary directory or input file does not exist
#   2 - Loading errors from segldr
#   3 - Errors in the execution of sola_eclipse
#
# The script variables are as follows:
#   exe_dir      -  directory where sola libraries, (solaxxxx.o), exist.
#                   solaecl.o,  solaheat.o,  solatherm.o
#   user_dir     -  this is directory from where the job is submitted
#   root_name    -  this is filename prefix of the input filename
#
exe_dir="/space/cryolib"
user_dir= pwd
root_name= basename "$1"
#
banner SOLA
banner ECLIPSE
echo This is the Hochstein Version of SOLA ECLIPSE.
echo
#
# Let's check to see if the input file exists
#
IF [ -F "$1" ]
   then
      :
   else
      echo File "$1" does not exist in $user_dir.
      echo Try again.
      exit 0
fi
#
echo Using "pwd" as the temporary directory for all user files.
echo "user directory is" ${user_dir}
#
#  echo "The model is file $1 $2"
#  fetch model -t'fn-'$1',ft-'$2',addr-191'
#   the fetch command is not in this procedure (shell)
#   the shell that the user makes up should  fetch the model
#                         and  invoke this shell to execute sola.
#    the user then submits this shell to the CRAY
#
#####  generate and compile main program
cat >mainpgm.f << EOFM
      program solecl
      call mainpg
      end
EOFM
cft77 mainpgm.f
#####     RUN PROGRAM
# Linking main run
cat >libdir<< libend
lib- ${exe_dir}/solaecl.o
lib- ${exe_dir}/solaheat.o
lib- ${exe_dir}/solatherm.o
libend
#
segldr -k -M,s  -o xqtecl mainpgm.o libdir >>"${user_dir}".err
IF [ $? -NE 0 ]
# Linking errors!  Exit status - 2
   then
```

```
        echo Unable to link your sola run with the sola libraries.
        echo Contact Dave Chato, 216-433-2845
        echo your output is in file: "${user_dir}".solarun
      cat "${root_dir}".err >> "${user_dir}".solarun
        dispose "${user_dir}".solarun
        exit 2
    else
echo " begin execution of sola eclipse"
xqtecl < $1 > "${user_dir}".solarun
#
fi
#
echo Your exit status from the sola run is "$?"
IF [ $? -NE 0 ]
# Errors detected!  Exit status = 3
   then
        echo Errors were detected in the sola eclipse run.
        echo check file: "${user_dir}".solarun for your output.
dispose  "${user_dir}".histry  -t'fn=sola,ft=history'
dispose  "${user_dir}".bugfyl  -t'fn=sola,ft=bugfile'
        mv core "${user_dir}".cor
        dispose "${user_dir}".solarun
        dispose "${user_dir}".cor
        exit 3
   else
#####    Successful run
#####    dispose all files to front end
echo "   Successful sola eclipse run."
echo "    - dispose output files"
echo output is in file: "${user_dir}".solarun
        dispose "${user_dir}".solarun
      dispose  fort.9  -t'fn=sola,ft=plotfile'
## save restart file in Home directory  filename= solarestart
cat      fort.11 >> $HOME/solarestart
rm  mainpgm.f mainpgm.o xqtecl libdir model
rm "${root_dir}".err  "${user_dir}".solarun  fort.7  fort.9  fort.11
        exit 0
fi
```

APPENDIX E

CryoTran Program Listings

Part VII CRAY Script File to Execute CSAM

```
#CSAM   SCRIPT FILE FOR UNICOS (BOURNE SHELL)
#VERSION 1.0   05/23/89  BY Glenn Cowgill
#  CSAM         ** CSAM         ** CSAM         ** CSAM
#
# The invocation of the script is as follows:
#    crcsam   filename
#        where filename contains your input csam deck
#        which is on CRAY in the users root directory.
#
# The exit status is as follows:
#   0 - Successful csam run
#   1 = Unable to create temporary directory or input file does not exist
#   2 - Loading errors from segldr
#   3 - Errors in the execution of csam/sinda
#
# The script variables are as follows:
#   csam_dir     -  directory where csam library, (csam.o), exists.
#   user_dir     -  this is directory from where the job is submitted
#
#
csam_dir="/space/cryolib"
user_dir= pwd
#
banner CSAM
banner    CSAM
echo    "  This is  CSAM"
#
echo Using "pwd" as the temporary directory for all user files.
echo "user directory is" ${user_dir}
#
echo " generate the main program"
cat >mainpgm.f << EOFM
       program csam
       call mpcsam
       end
EOFM
echo " compile the main program"
cft77 mainpgm.f
#####    RUN PROGRAM
echo  " Linking main run"
cat >libdir<< libend
lib= ${csam_dir}/csam.o
libend
#
echo  "   segldr"
segldr -k -M,s  -o xqtcsam mainpgm.o libdir >>"${user_dir}".err
IF ( $? -NE 0 )
# Linking errors!  Exit status = 2
   then
       echo Unable to link your csam run with the csam library.
       echo Contact Dave Chato, 216-433-2845
       echo Your output is in file: "${user_dir}".csamrun
     cat "${user_dir}".err >> "${user_dir}".csamrun
       dispose "${user_dir}".csamrun
       exit 2
    else
echo " begin execution of csam"
xqtcsam  < $1 > "${user_dir}".csamrun
#####
#
fi
#
echo Your exit status from the csam run is "$?"
IF ( $? -NE 0 )
# Errors detected!  Exit status = 3
   then
       echo Errors were detected in the csam run.
       echo Check file: "${user_dir}".csamrun for your output.
      dispose "${user_dir}".csamrun
##        exit 3
```

```
   else
#####     Successful run
#####     dispose all files to front end
echo "   Successful csam run."
echo "     - dispose output files"
echo Output is in file: "${user_dir}".csamrun
       dispose "${user_dir}".csamrun
##dispose  plots  -fBB  -t'fn=sola,ft=plotfile'
rm  mainpgm.f mainpgm.o xqtcsam libdir model
rm "${user_dir}".err  "${user_dir}".csamrun
       exit 0
fi
```

REFERENCES

1. Wright, Alfred C.: Cryogenic Systems Analysis Model (CSAM). NASA Contract 3-233355, Martin Marietta Corp., MCR 85-1375, Denver, CO, November 1985.

2. Hochstein, J.I., Ji, H.-C., and Aydelott, J.C.: Effect of Subcooling on the On-Orbit Pressurization Rate of Cryogenic Propellant Tankage. AIAA Paper 86-1253, June 1986.

3. Hochstein, J.I., Ji, H.-C., and Aydelott, J.C.: Temperature Fields Due to Jet Induced Mixing in a Typical OTV Tank. AIAA Paper 87-2017, June 1987.

4. Chato, D.J.: Thermodynamic Modeling of the No-Vent Fill Methodology for Transferring Cryogens in Low-Gravity. AIAA Paper 88-3403, July 1988 (NASA TM-100932).

5. Chato, David J.: NVFILL Computer User Guide. CFTO Project Information Report No. 113, Cryogenic Fluids Technology Office, NASA Lewis Research Center, May 4, 1988.

6. DeFelice, D.M. and Aydelott, J.C.: Thermodynamic Analysis and Subscale Modeling of Space-Based Orbit Transfer Vehicle Cryogenic Propellant Resupply. AIAA Paper 87-1764, June 1987 (NASA TM-89921).

7. DeFelice, David M.: COSMIC Submittal of the TARGET and CRYOCHIL Computer Codes. November 1, 1988.

8. Smith, James P.: SINDA User's Manual. NASA Contract 9-10435, Johnson Space Center, Houston, TX 77058, Cosmic Program #Msc-13805, April 1971.

9. VS FORTRAN Version 2. Language and Library Reference, SC26-4221-2, Release 2, IBM Corp, June 1987.

10. System Product Editor Command and Macro Reference, Release 4, SC24-5221-3, IBM, December 1984.

11. DISSPLA User's Manual. Integrated Software Systems Corp., (ISSCO), 1985.

12. System Product Interpreter User's Guide, Release 4, SC24-5238-2, IBM, December 1984.

Table 1

Units Used in CryoTran

Input Variable	Symbol	Units
Time		Hrs
Time Increment		Hrs
All Temperatures	T	°F or °R
All Lengths	l	in
Areas	A	in^2
Internal heat source (heat generation in a node or on a surface)	Q	BTU/hr
Capacitance of each diffusion node	$C=C_p*\rho$	BTU/°F
Conductor Values	G	BTU/hr-°F
Conduction Conductor	$G=A*k/l$	
Convection Conductor	$G=Ah$	
Radiation Conductor	$G=\sigma*\varepsilon*f*A$	
(where: cross section area of heat flow)	A	in^2
Thermal conductivity of material	k	BTU/hr-in-°F
Heat capacity of material	C_p	BTU/lb-°F
Density of material	rho	lb/in^3
Length of conductor path	l	in
Film coefficient	h	BTU/hr-ft^2-°F
Stefan-Boltzman Constant	$\sigma=0.173x10^{-8}$	BTU/hr-ft^2-°R^4
Surface emissivity	ε	
View Factor	f	$0<f<1$

Table 2

Fortran Files and Units

FORTRAN units and file names used in CryoTran:

Logical Unit No.	File Name (alias)	Description	Status at end of Program
04	MATERIAL DBASE M	Material properties database	CRYOLIB M disk
05		Standard input	
06		Standard output	
09	CRYOTRAN INPUTEKO	Echo of input typed in by user	User A disk
10	CRYOTRAN MODEL	Model output	User A disk
17	PROGRAM OUTPUT	Output of program executed interactively on VM	User A disk
25	H2 TABLE M	H2 property data	CRYOLIB M disk
26	O2 TABLE M	O2 property data	CRYOLIB M disk
27	N2 TABLE M	N2 property data	CRYOLIB M disk
35	Scratch file	Used in sub READAL	Gone
36	Scratch file	Used in sub INSERT	Gone
		Used in sub INSERT1	Gone

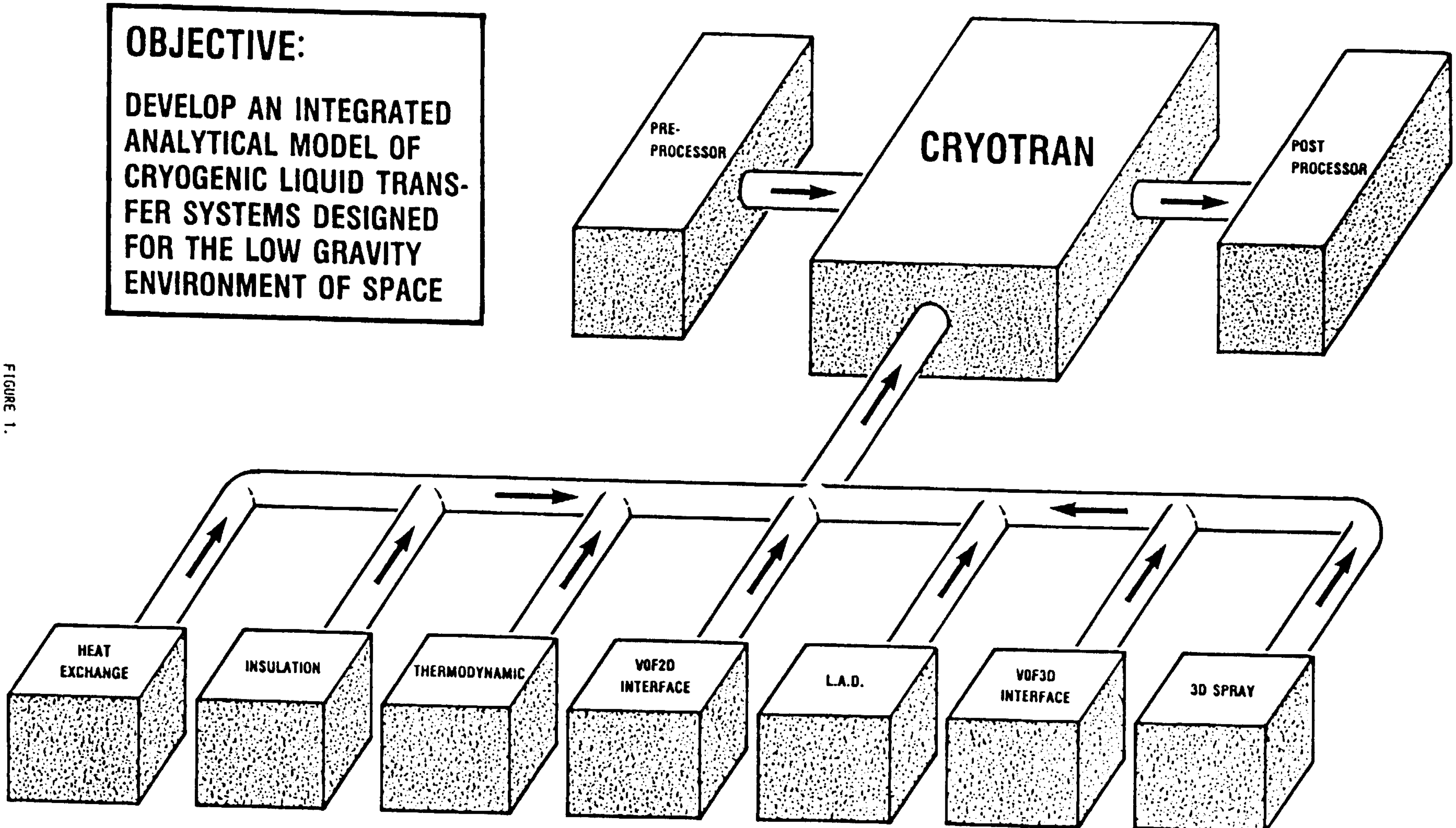
FORTRAN units used by SINDA on the Cray:

Logical Unit No.	File Name (alias)	Description
05		Standard input
06		Standard output
04	LUT1	Actual/relative dictionary
12	LB3D	Input data after the SINDA preprocessor has executed
13	LB4P	5 FORTRAN programs generated by the SINDA preprocessor
14	MIN	Matrix input tape
15	LUT3	Parameters runs data
16	MOUT	Matrix output unit
21	LUT7	Recall data file
22	STAPE	Store data file
27	INTERN	Prepro scratch unit
28	NEDIN	EDIT input
29	nedout	EDIT output

CRYOTRAN—AN INTEGRATED CRYOGENIC FLUID SYSTEM MODEL

OBJECTIVE:

DEVELOP AN INTEGRATED ANALYTICAL MODEL OF CRYOGENIC LIQUID TRANSFER SYSTEMS DESIGNED FOR THE LOW GRAVITY ENVIRONMENT OF SPACE



INDIVIDUAL CRYOGENIC FLUID ANALYTICAL MODELS

CD-88-32465

FIGURE 1.

FLOW CHART OF CRYOTRAN

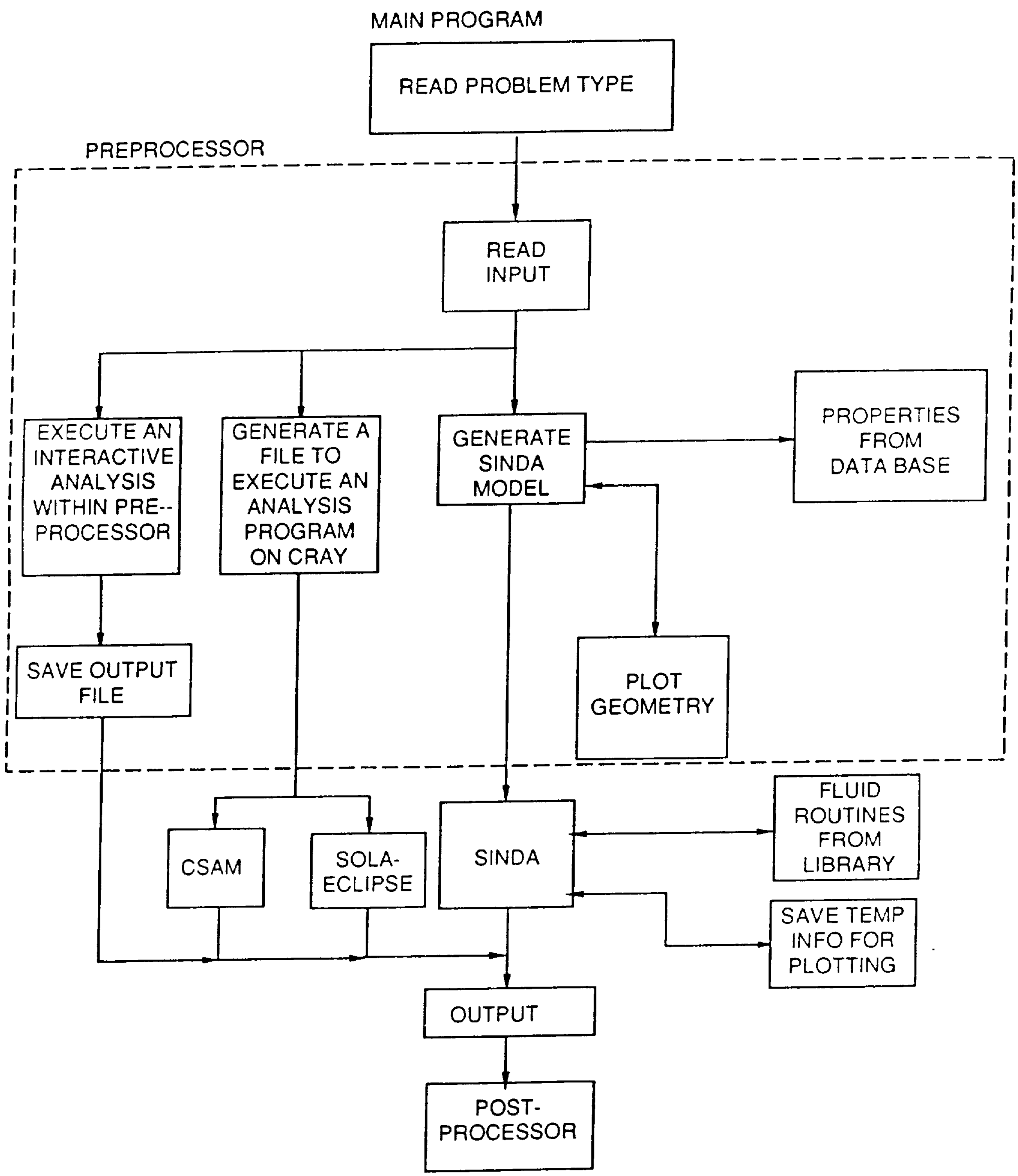
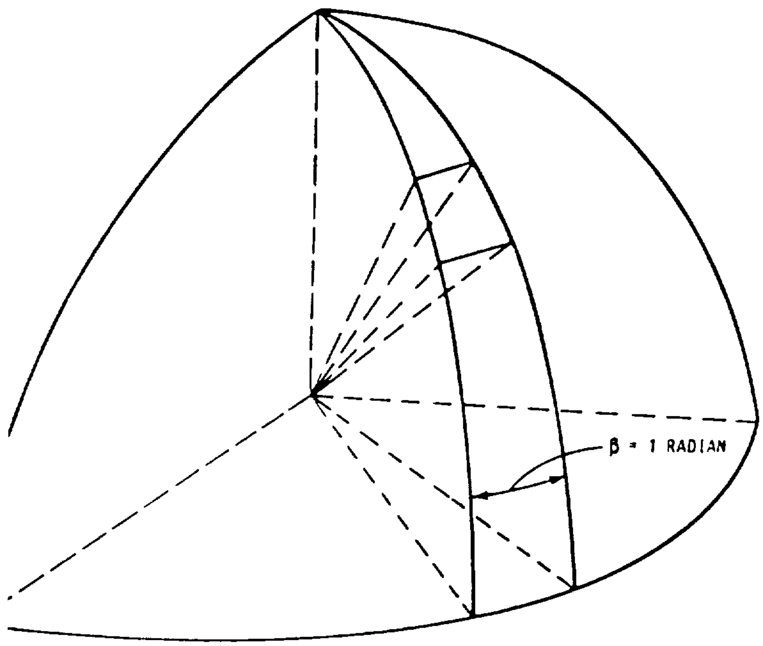
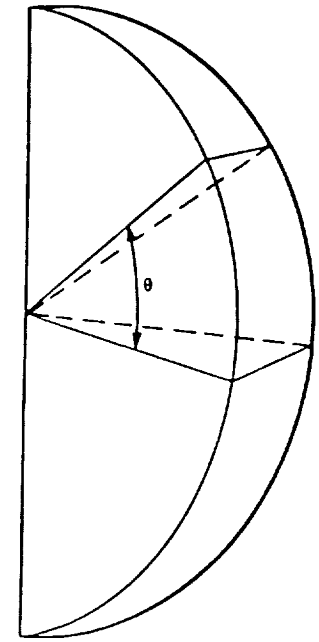


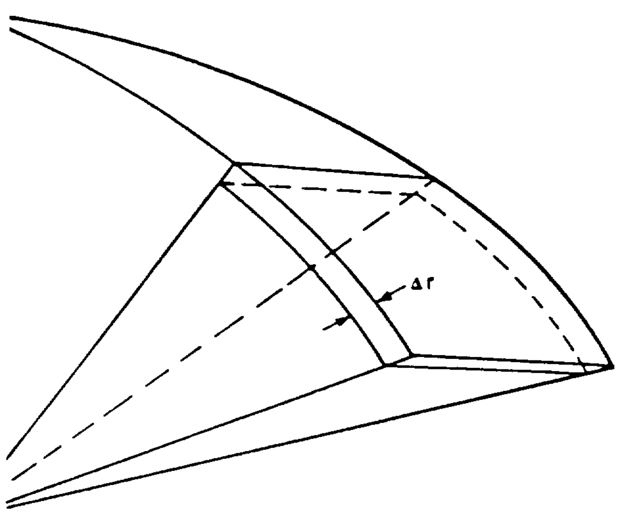
FIGURE 2



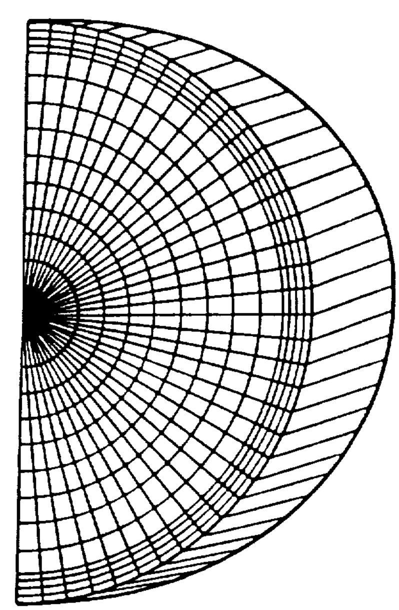
TOP QUARTER OF SPHERE WITH WEDGE



WEDGE SHOWING ANGLE THETA

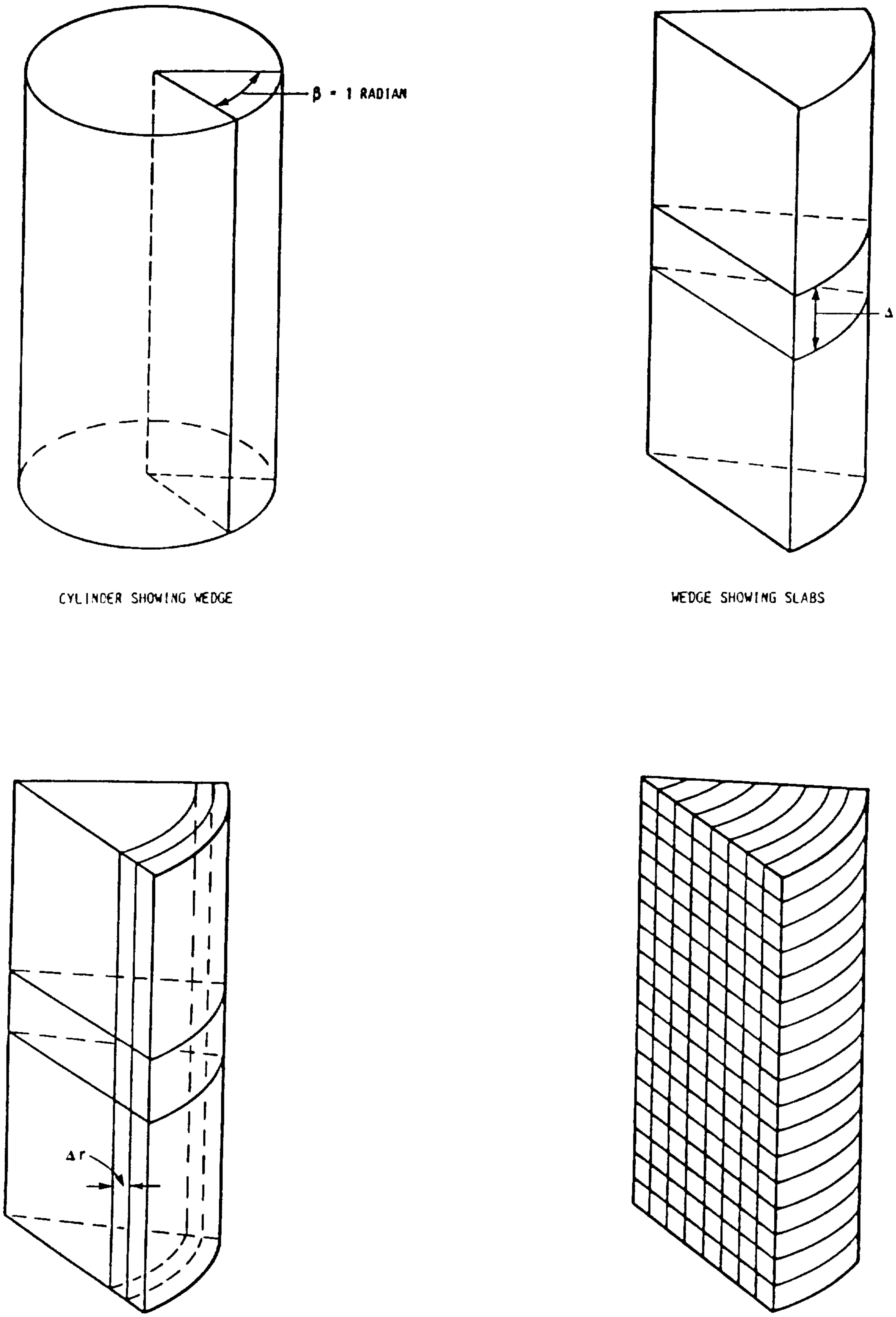


TYPICAL NODE



TYPICAL NODAL CONFIGURATION

FIGURE 3. - SKETCHES SHOWING SPHERICAL WEDGE.



CYLINDER SHOWING WEDGE

WEDGE SHOWING SLABS

TYPICAL NODE

TYPICAL NODAL CONFIGURATION

FIGURE 4. - SKETCHES SHOWING CYLINDRICAL WEDGE.

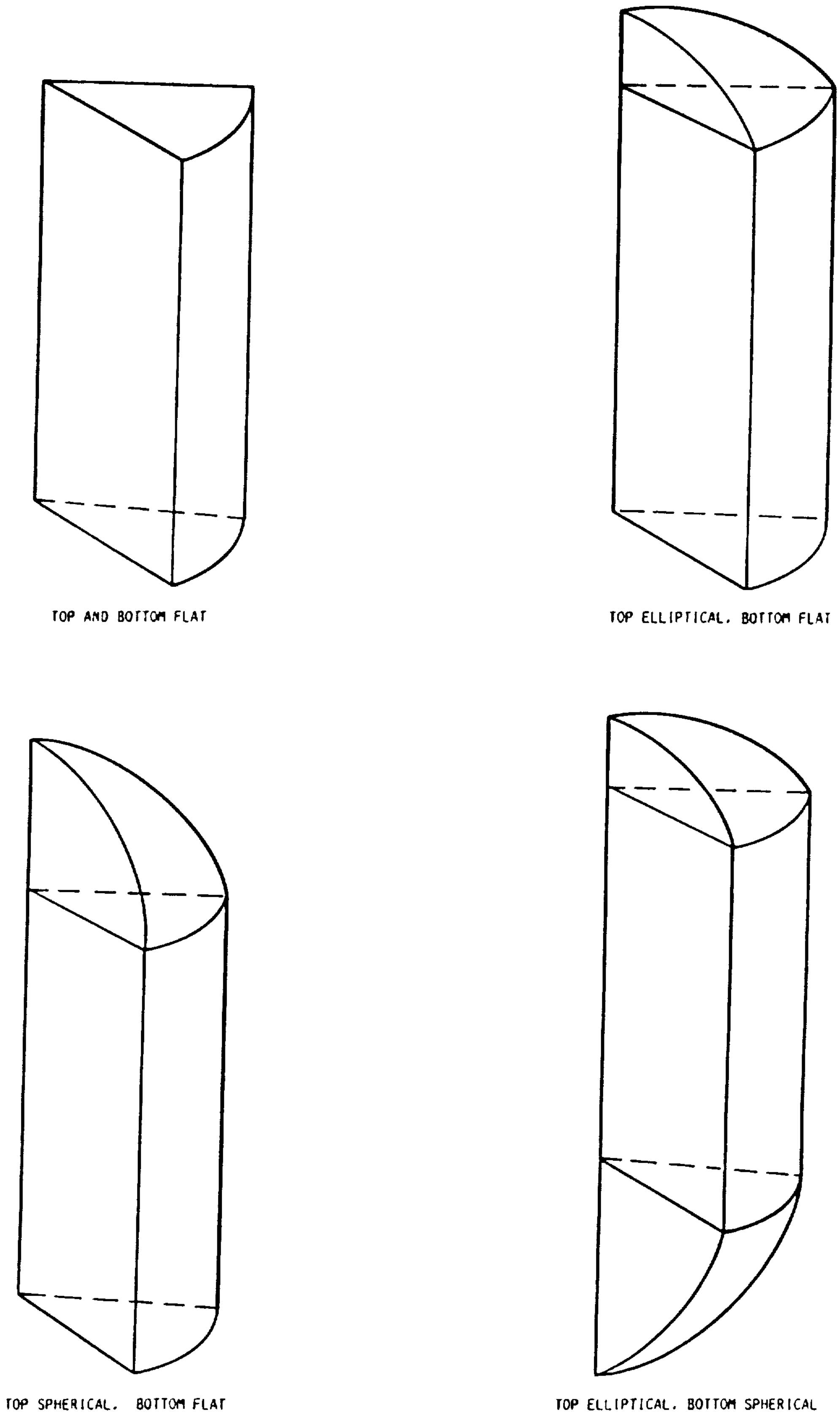


FIGURE 5. - SKETCHES SHOWING POSSIBLE AND CONFIGURATIONS OF CYLINDRICAL WEDGE.

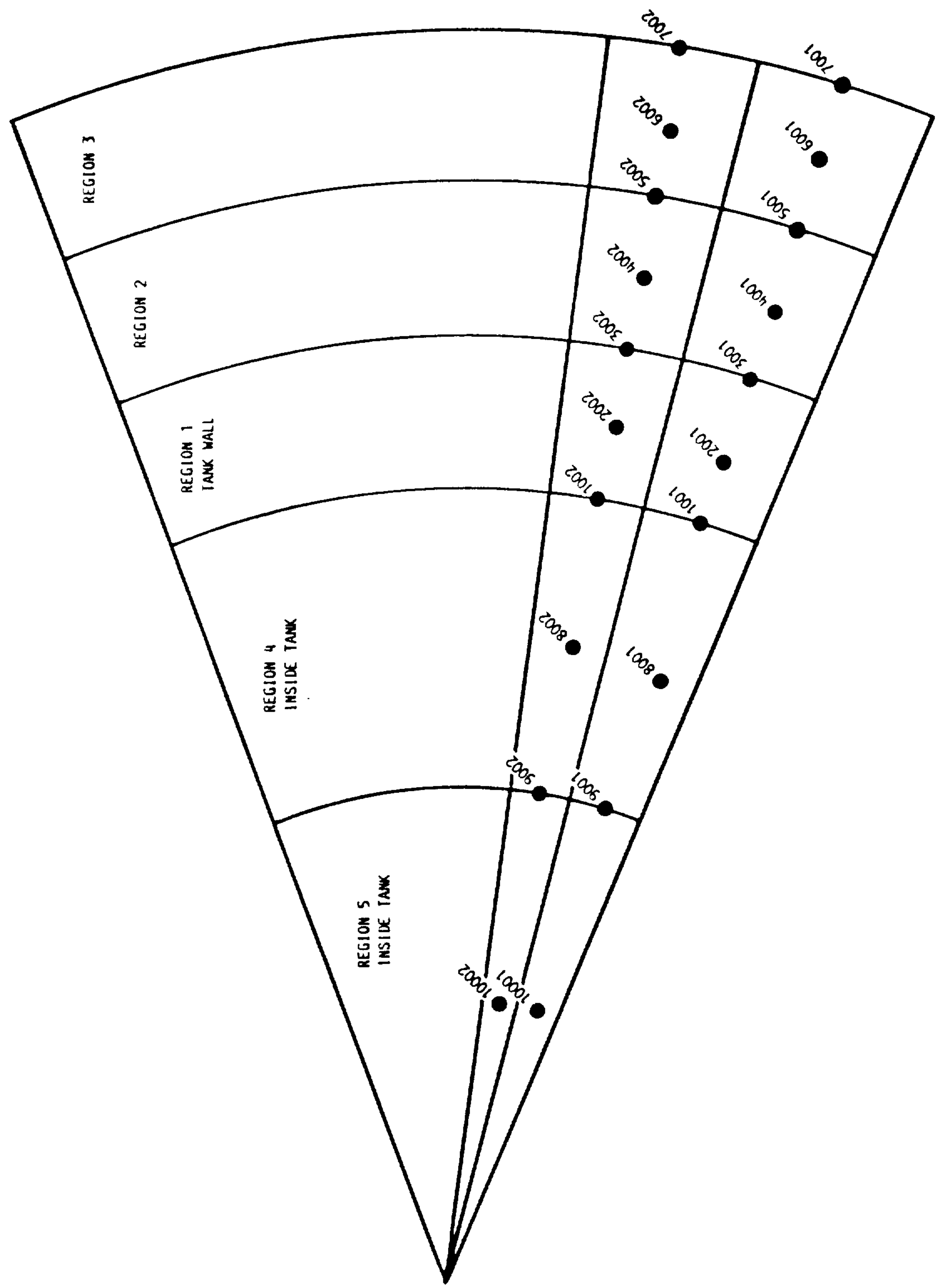

REGION 3
REGION 2
REGION 1
TANK WALL
REGION 4
INSIDE TANK
REGION 5
INSIDE TANK
7002
7001
6002
6001
5002
5001
4002
4001
3002
3001
2002
2001
1002
1001
8002
8001
9002
9001
10002
10001

FIGURE 6.

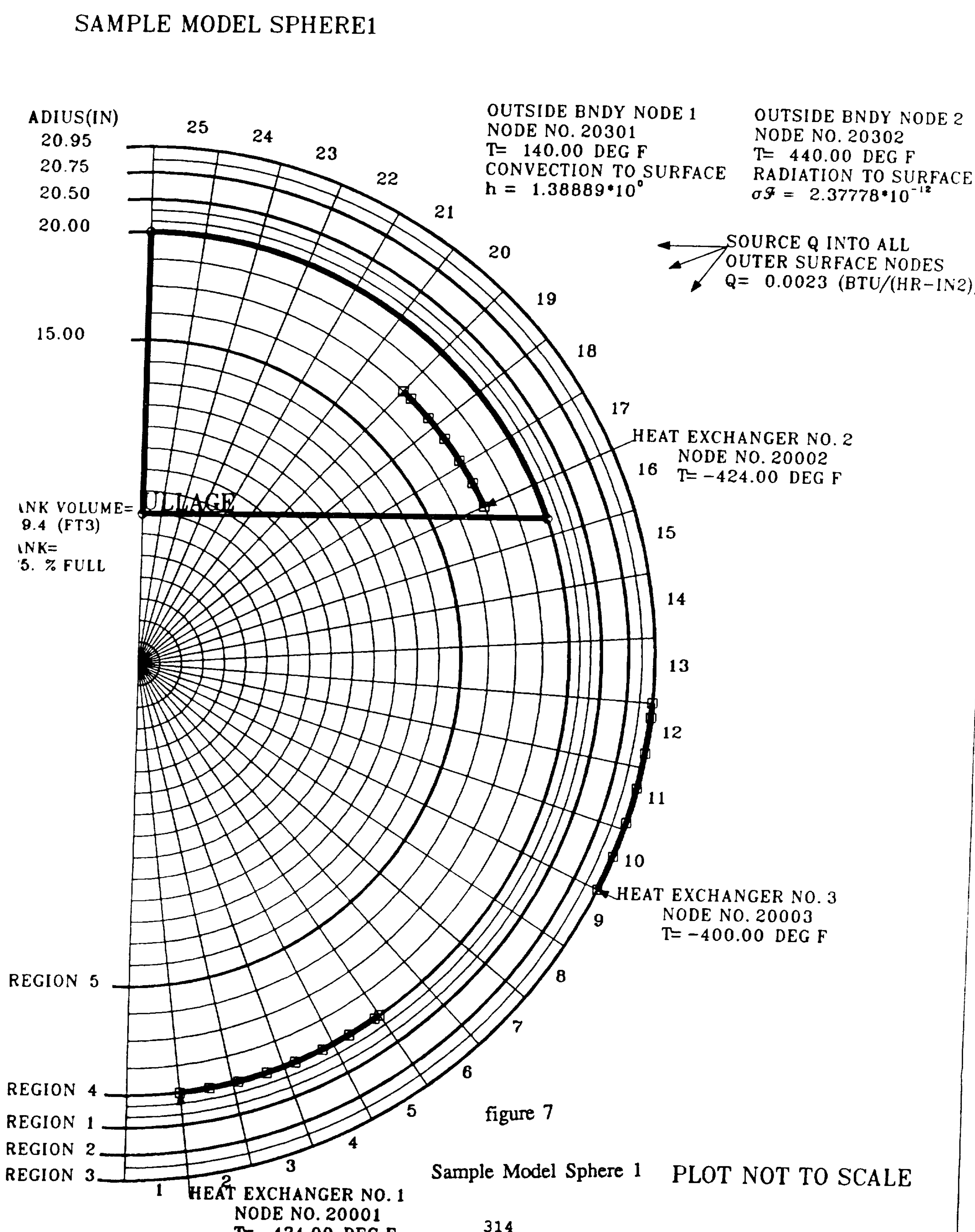


figure 7

Sample Model Sphere 1

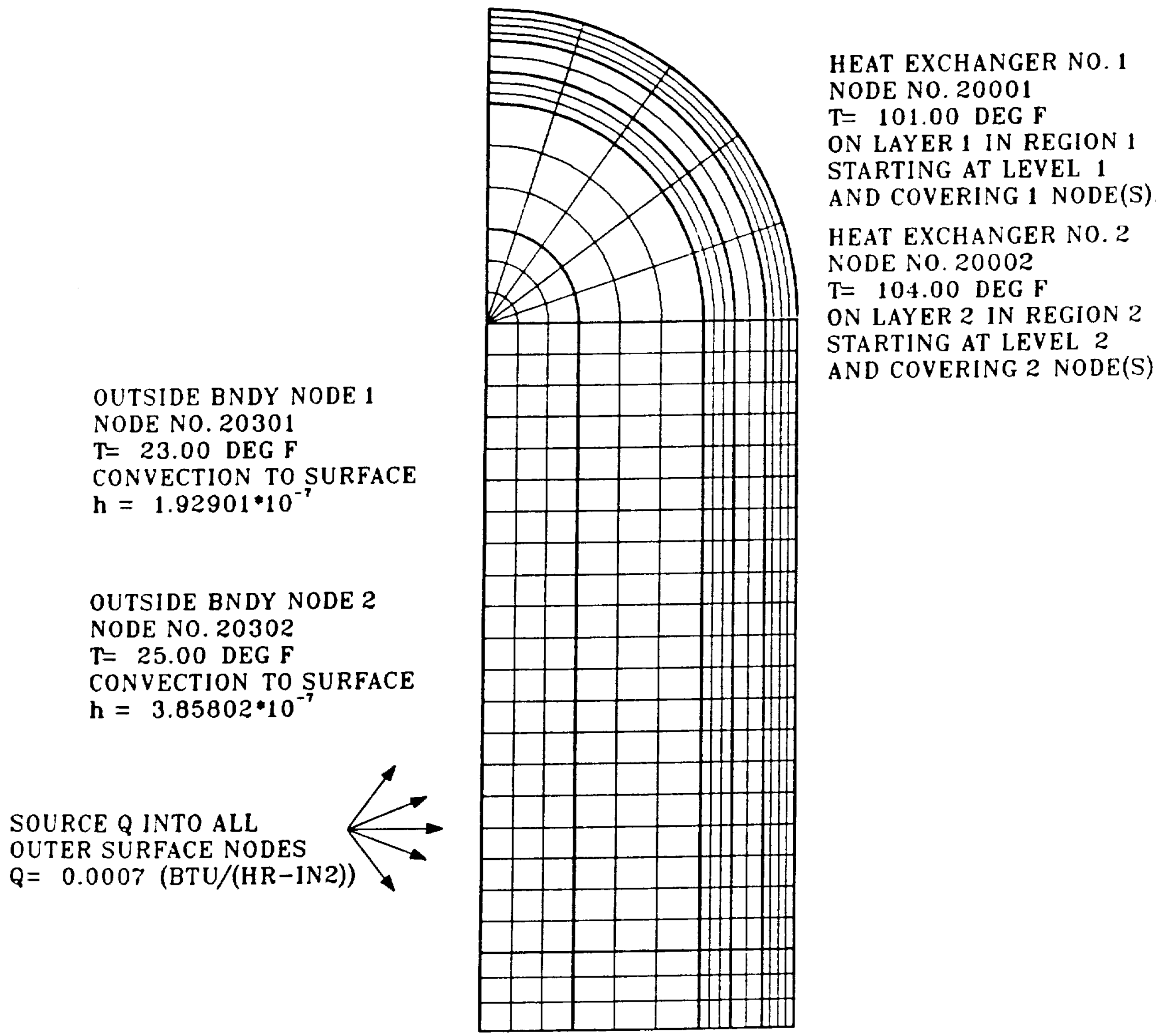


figure 8 Plot Sample of Cylinder

PLOT NOT TO SCALE

FLOW DIAGRAM OF CRYOTRAN 1

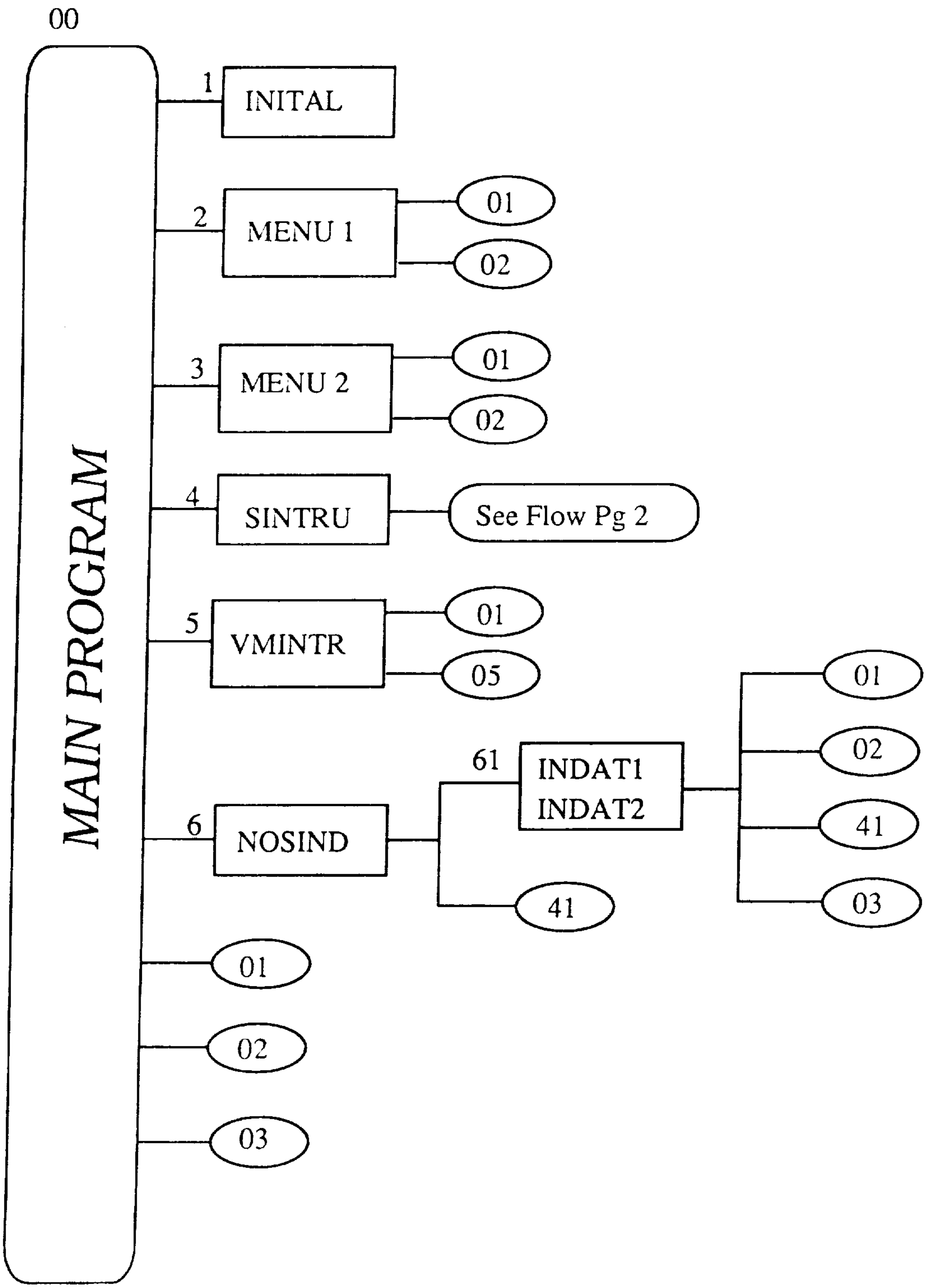


FIGURE 9-1

FLOW DIAGRAM OF CRYOTRAN 2

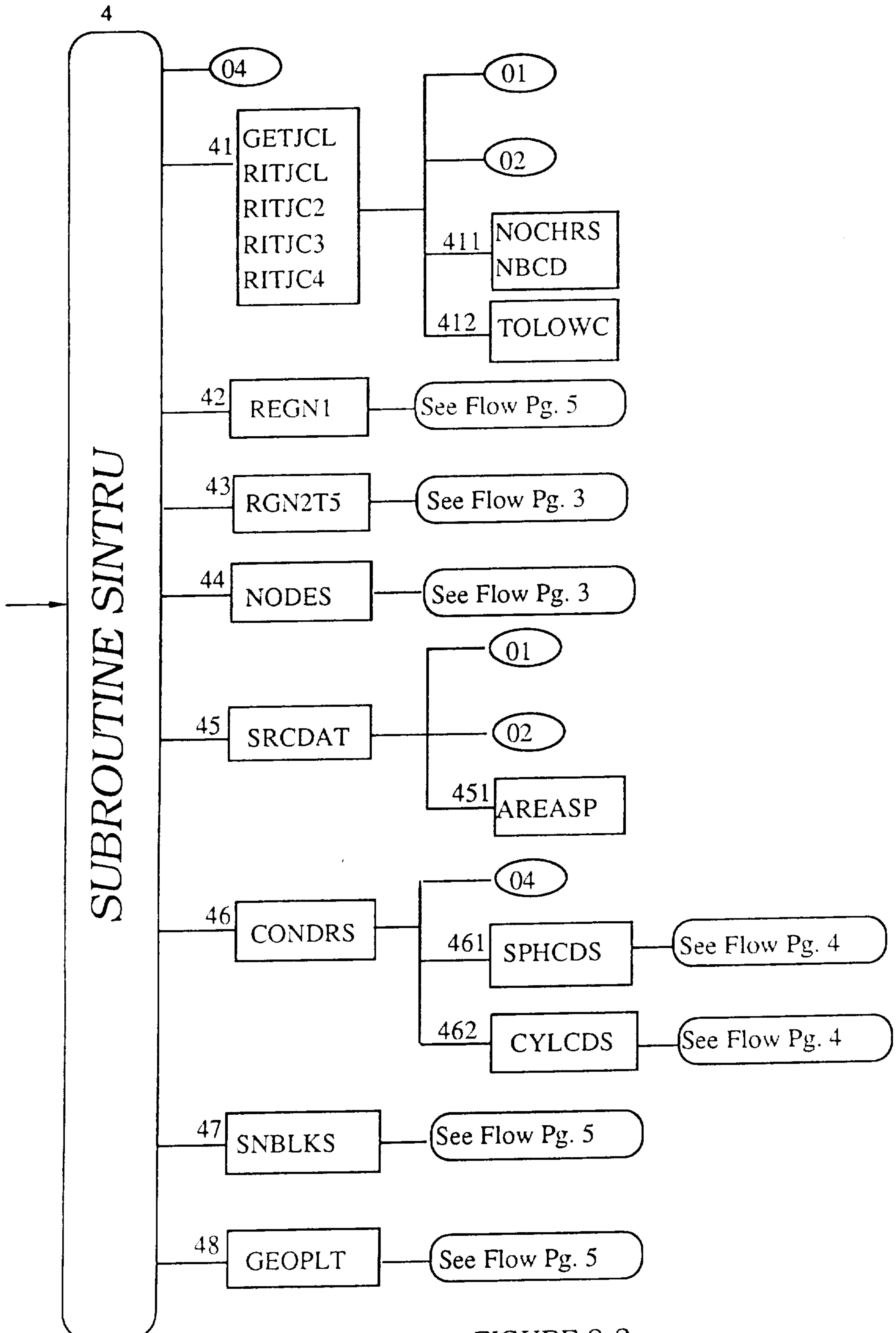


FIGURE 9-2

FLOW DIAGRAM OF CRYOTRAN 3

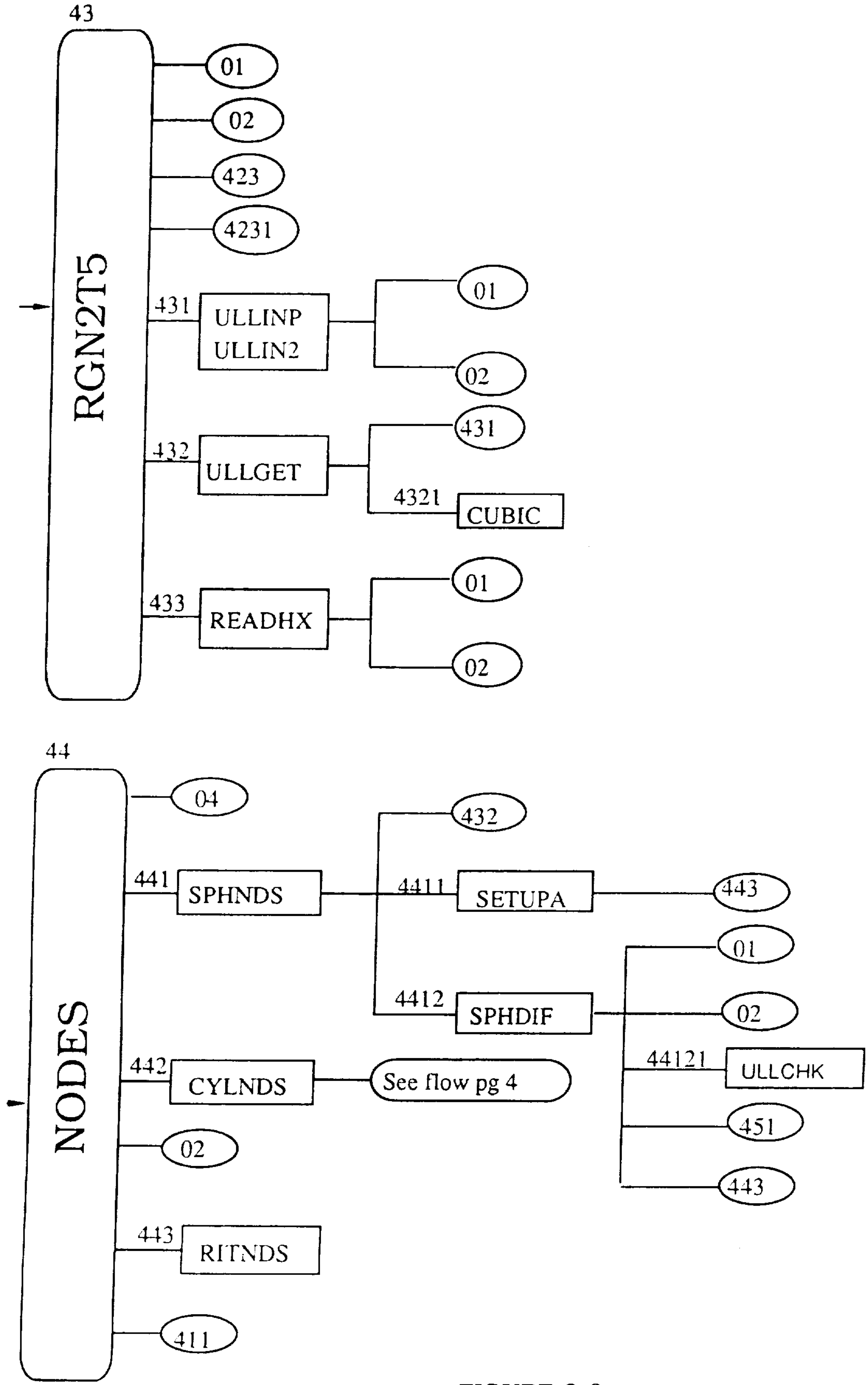


FIGURE 9-3

FLOW DIAGRAM OF CRYOTRAN 4

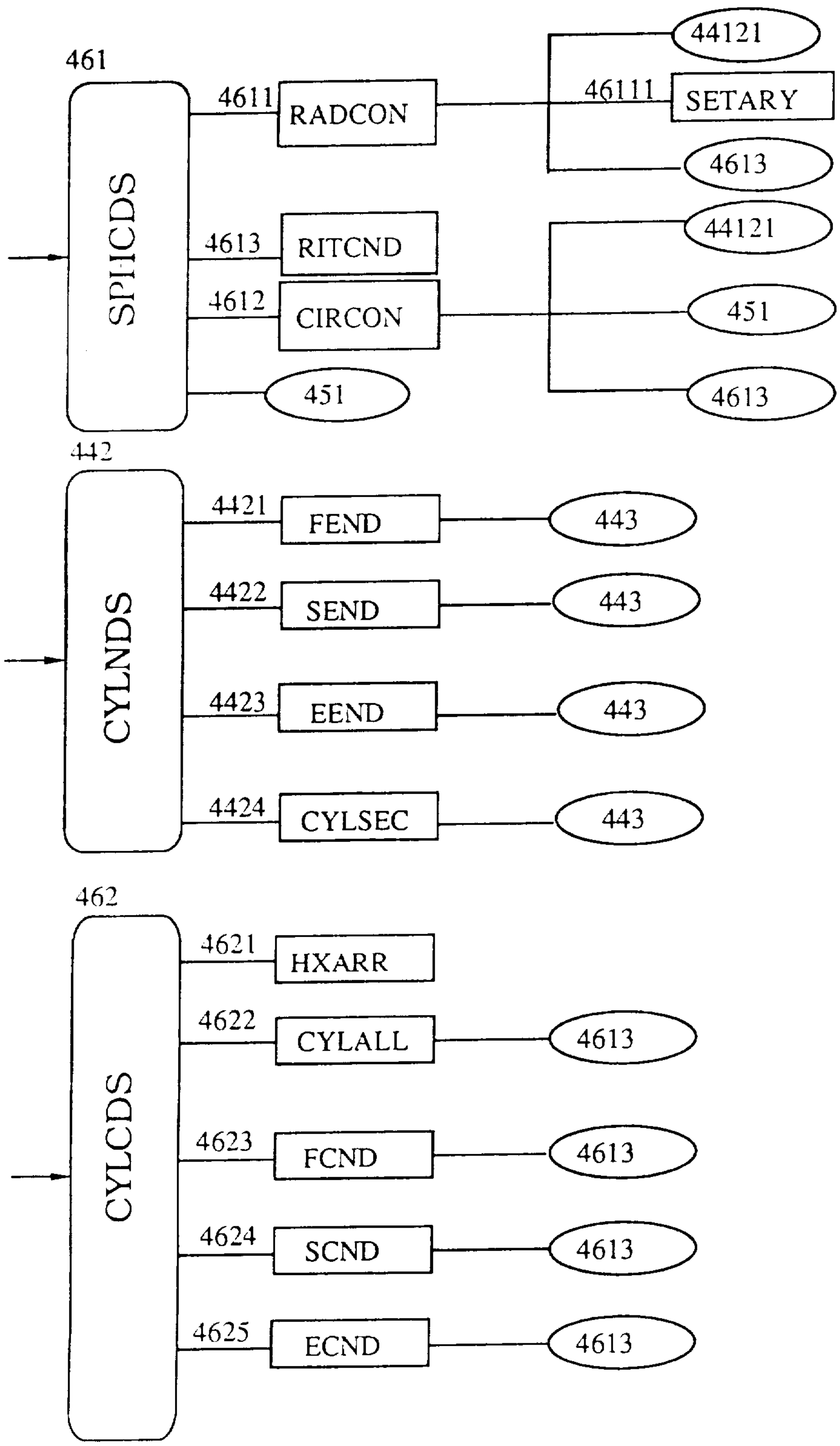


FIGURE 9-4

FLOW DIAGRAM OF CRYOTRAN 5

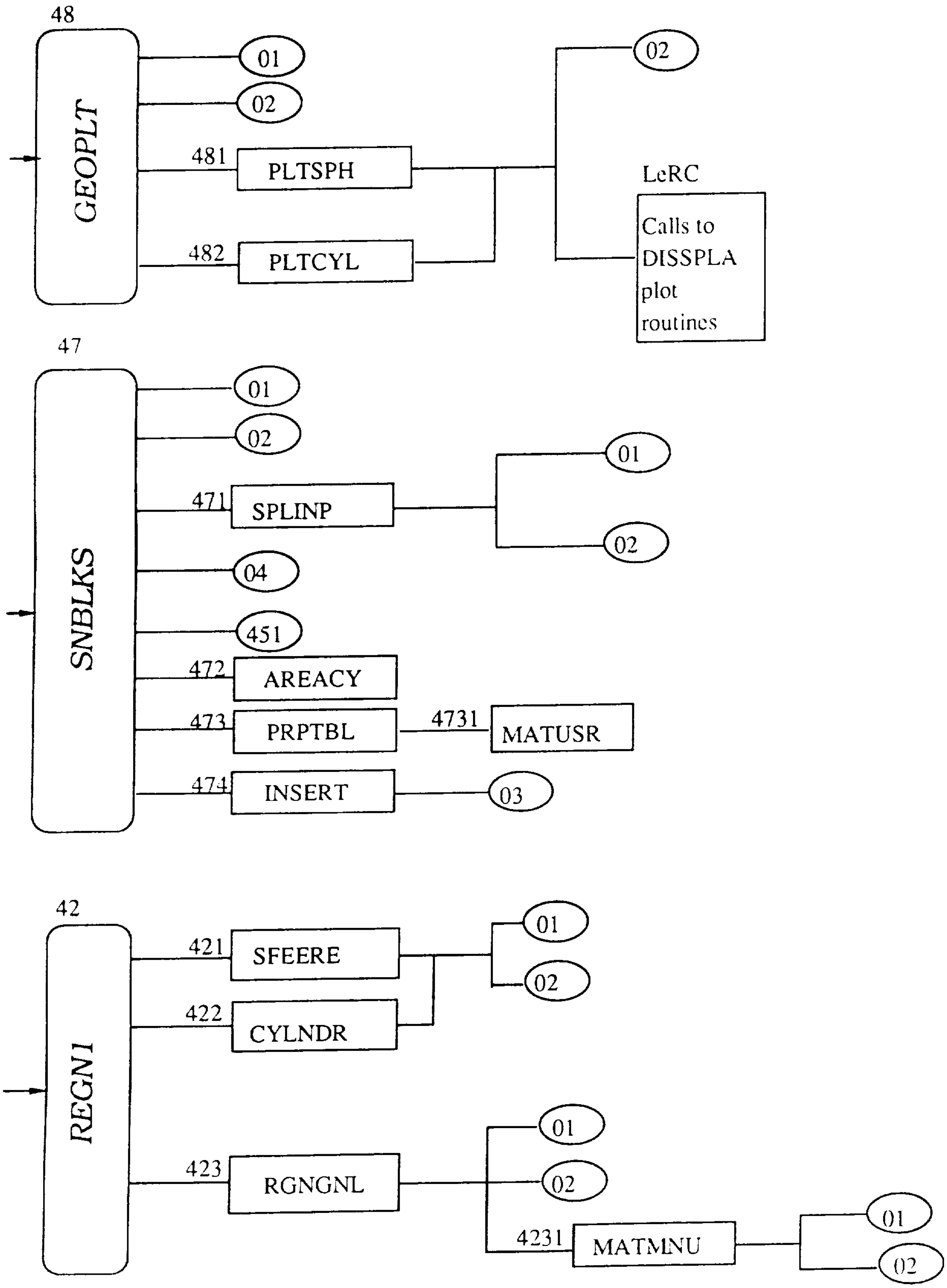


FIGURE 9-5

FLOW DIAGRAM OF CRYOTRAN 6

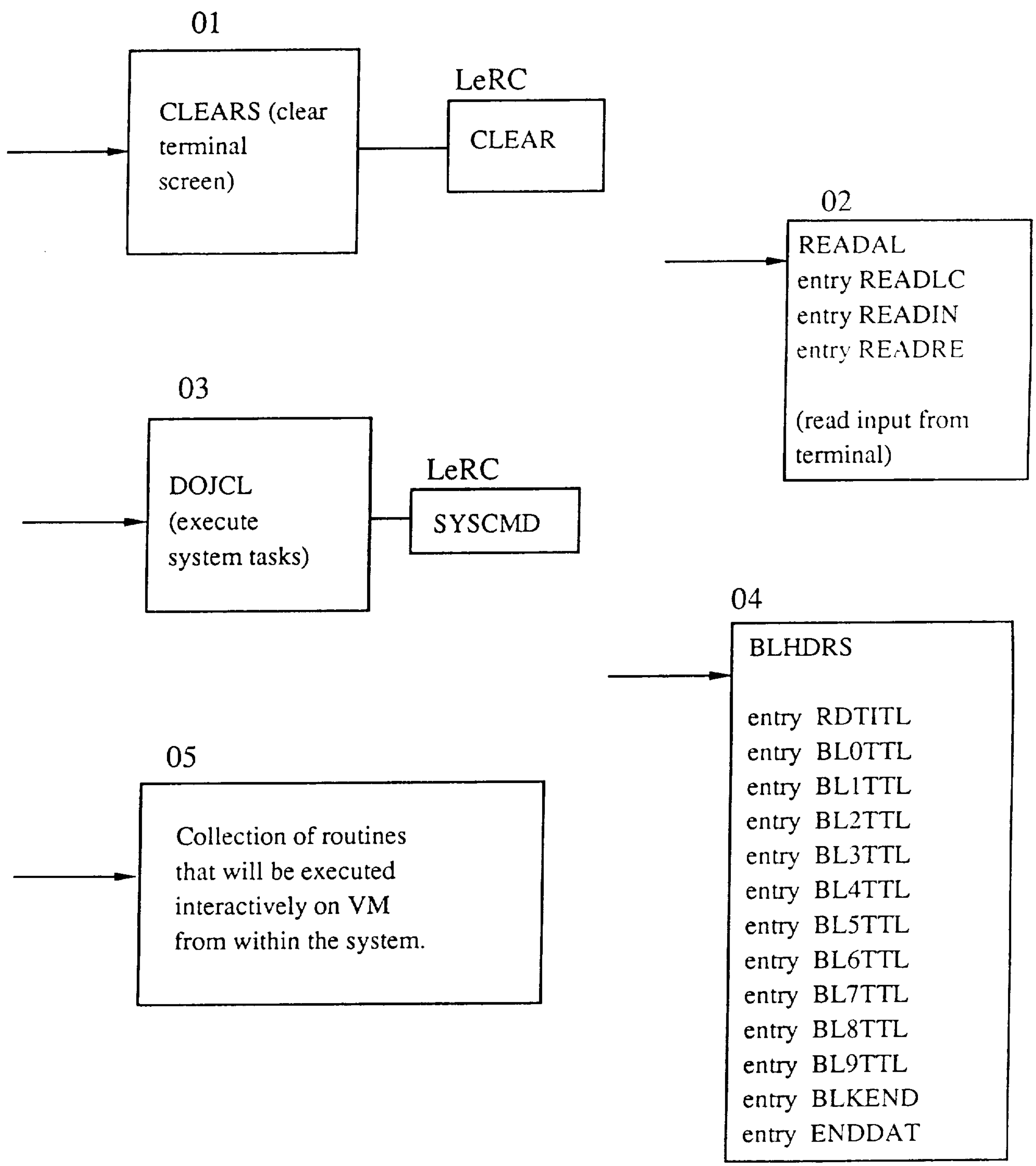


FIGURE 9-6

NASA
National Aeronautics and Space Administration

Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
NASA TM-102468		

4. Title and Subtitle
CryoTran User's Manual
Version 1.0

5. Report Date
December 1989

6. Performing Organization Code

7. Author(s)
Glenn R. Cowgill, David J. Chato, and Ehab Saad

8. Performing Organization Report No.
E-5256

10. Work Unit No.
591-23

9. Performing Organization Name and Address
National Aeronautics and Space Administration
Lewis Research Center
Cleveland, Ohio 44135-3191

11. Contract or Grant No.

13. Type of Report and Period Covered
Technical Memorandum

12. Sponsoring Agency Name and Address
National Aeronautics and Space Administration
Washington, D.C. 20546-0001

14. Sponsoring Agency Code

15. Supplementary Notes
Glenn R. Cowgill, Analex Corporation, NASA Lewis Research Center, Cleveland, Ohio 44135; David J. Chato, NASA Lewis Research Center; and Ehab Saab, Analex Corporation, NASA Lewis Research Center.

16. Abstract
The development of cryogenic fluid management systems for space operation is a major portion of the efforts of the Cryogenic Fluids Technology Office (CFTO) at the NASA Lewis Research Center. Analytical models are a necessary part of experimental programs which are used to verify the results of experiments and are also used as a predictor for parametric studies. The CryoTran computer program is a bridge to obtain analytical results. The object of CryoTran is to coordinate these separate analyses into an integrated framework with a user-friendly interface and a common cryogenic property database. CryoTran is an integrated software system designed to help solve a diverse set of problems involving cryogenic fluid storage and transfer in both ground and low-g environments.

17. Key Words (Suggested by Author(s))	18. Distribution Statement
Integrated computer model Cryogenic fluid management Heat transfer	Unclassified – Unlimited Subject Category 61

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of pages	22. Price*
Unclassified	Unclassified	326	A15

*For sale by the National Technical Information Service, Springfield, Virginia 22161

National Aeronautics and
Space Administration

Lewis Research Center
ICOMP (M.S. 5-3)
Cleveland, Ohio 44135

Official Business
Penalty for Private Use $300

FOURTH CLASS MAIL

ADDRESS CORRECTION REQUESTED

U.S.MAIL

Postage and Fees Paid
National Aeronautics and
Space Administration
NASA 451

NASA

JAN 0 3 1990 E-5256 RP

NASA SCIENTIFIC AND TECHNICAL DOCUMENT AVAILABILITY AUTHORIZATION (DAA)

To be initiated by the responsible NASA Project Officer, Technical Monitor, or other appropriate NASA official for all presentations, reports, papers, and proceedings that contain scientific and technical information. Explanations are on the back of this form and are presented in greater detail in NMI 2230.1B, "NASA Scientific and Technical Document Availability Authorization."

☒ Original ☐ Modified

(Facility Use Only) Control No. ______ Date ______

I. DOCUMENT/PROJECT IDENTIFICATION

Title: Cryotran User Manual

Author(s): G. Cowgill, D. Chato, E. Saad

Originating NASA Organization: Lewis Research Center

Performing Organization (If different): ______

Contract/Grant/Interagency/Project Number(s): 591-23 Document Date: ______

Document Number(s): TM102468

For externally published documents or presentations, enter appropriate information on the intended publication such as name, place, and date of conference, periodical or journal title, or book title and publisher: ______

II. AVAILABILITY CATEGORY

IN-61
256146
326P

Check the appropriate category(ies):

Security Classification: ☐ Secret ☐ Secret RD ☐ Confidential ☐ Confidential RD ☒ Unclassified

Export Controlled Document - Documents marked in this block must be routed to NASA Headquarters (International Affairs Division) for approval.

☐ ITAR ☐ EAR

NASA Restricted Distribution Document

☐ FEDD ☐ Limited Distribution ☐ Other - See Section III

Document disclosing an invention

☐ Documents marked in this block must be withheld from release until six months have elapsed after submission of this form, unless a different release date established by the appropriate counsel. (See Section IX).

Publicly Available Document

☒ Publicly available documents must be unclassified and may not be export-controlled nor restricted distribution documents.

III. SPECIAL CONDITIONS

Check one or more of the applicable boxes as the basis for special restricted distribution if the "Other" box under NASA Restricted Distribution Document in Section II is checked. Guidelines are provided on reverse side of form. This document contains:

☐ Foreign government information ☐ Preliminary information

☐ Commercial product test or evaluation results ☐ Information subject to special contract provision

Check one of the following limitations as appropriate:

☐ U.S. Government agencies and U.S. Government agency contractors only ☐ NASA personnel and NASA contractors only

☐ NASA contractors and U.S. Government agencies only ☐ NASA personnel only

☐ U.S. Government agencies only ☐ Available only with approval of issuing office

IV. BLANKET RELEASE (OPTIONAL)

All documents issued under the following contract/grant/project number ______ may be processed as checked in Sections II and III.

The blanket release authorization granted ______ (Date) is:

☐ Rescinded - Future documents must have individual availability authorizations.

☐ Modified - Limitations for all documents processed in the STI system under the blanket release should be changed to conform to blocks as checked in Section II.

V. PROJECT OFFICER/TECHNICAL MONITOR

X Joseph D. Gaby, Jr. — Typed Name of Project Office/Technical Monitor

6210 — Office Code

Joseph D. Gaby Jr. — Signature

12-19-89 — Date Signed

VI. PROGRAM OFFICE REVIEW

☒ Approved ☐ Not Approved

MARIA LOPEZ-TELLADO — Typed Name of Program Officer

CODE RR. — Program Office and Code

Signature

1/9/90 — Date

VII. INTERNATIONAL AFFAIRS DIVISION REVIEW

☐ Foreign publication/presentation approved. ☐ Export controlled limitation is approved. ☐ Export controlled limitation is not applicable.

☐ The following Export controlled limitation (ITAR/EAR) is assigned to this document: ______

NAME & TITLE

VIII. EXPIRATION OF REVIEW TIME

The document is being released in accordance with the availability category and limitations checked in Section II since no objection was received from the Program Office within 15 days of submission, as specified by NMI 2230.1B.

Name & Title ______ Office Code ______ Date ______

Note: This release procedure cannot be used with documents designated as Export Controlled Documents or prepared for foreign presentation.

IX. DOCUMENTS DISCLOSING AN INVENTION

a. This document may be released on ______ DATE

Installation Patent or Intellectual Property Counsel ______ DATE

b. The document was processed on ______ DATE in accordance with Section II.

NASA STI Facility ______ DATE

X. DISPOSITION

Forms not approved are to be returned to Project Officer or Technical Monitor listed in Section V.

Completed forms should be forwarded to the NASA Scientific and Technical Information Facility, P.O. Box 8757, B.W.I. Airport, Maryland 21240, with either (check box):

☐ Printed or reproducible copy of document enclosed.

☐ Abstract or standard bibliographic page enclosed. The issuing activity should provide a copy of the document, when completed, to the NASA Scientific and Technical Information Facility at the above listed address.