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160770

ADVANCED FLIGHT DESIGN SYSTEMS SUBSYSTEM PERFORMANCE MODELS

JUNE 1980

CONTRACT NO. NAS9-15793

SAMPLE MODEL ENVIRONMENTAL ANALYSIS ROUTINE LIBRARY

(NASA-CR-160770) ADVANCED FLIGHT DESIGN
SYSTEMS SUBSYSTEM PERFORMANCE MODELS.

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SAMPLE MODEL: ENVIRONMENTAL ANALYSIS

ROUTINE LIBRARY (TRW Defense and Space

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TRW

DEFENSE AND SPACE SYSTEMS GROUP



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PREFACE

Subsystem performance analysis is required in Flight Design to assess the capability of the Environmental Control and Life Support System (ECLSS) to support the flight requirements and define operational procedures under contingency flight conditions. Current ECLSS modeling techniques are limited in the variety of configurations and they employ batch mode computer program execution methods. Future spacecraft will require analysis of both a greater variety and a greater number of ECLSS than for previous spacecraft programs. Improvements in the variety of configurations that can be modeled and a reduction in effort required for modeling and analysis can be accomplished by developing a modular computer library program which operates interactively.

An effort has been conducted to develop a modular interactive ECLSS performance analysis tool. The final reports on the effort are included in an Executive Summary and two Technical Reports. The Technical Reports include a User Guide and a sample model.

The Executive Summary presents an overview of the effort.

The Technical Reports include a User Guide which, due to the modular nature of the Program Library, includes a greater degree of technical detail than one for a conventional program. This Sample Model report supplements the User Guide and illustrates a complete ECLSS model set up and execution.

CONTENTS

| | Page |
|---|----------|
| 1. Introduction | 1.1 |
| 2. Sample ECLSS Model Description | 2.1 |
| 3. Sample ECLSS Model Execution and Output | 3.1 |
| Appendix A Computer Control Information | 3.26 |

LIST OF FIGURES

| | Page |
|--|------|
| 2.1 Sample Model Schematic | 2.2 |
| 3.1 Program Initialization and Control | 3.4 |
| 3.2 Utility Input and Component Data | 3.5 |
| 3.3 Boundary Condition and Print Control | 3.15 |
| 3.4 Performance Data Output | 3.17 |
| 3.5 Plot Data Output | 3.23 |
| A-1 Map | 3.27 |
| A-2 Computer Control | 3.28 |

LIST OF TABLES

| | Page |
|--|------|
| 3.1 Sample Model Driver (MAIN) | 3.2 |

1. INTRODUCTION

This report presents a sample Environmental Control and Life Support (ECLSS) model performance analysis using the Environmental Analysis Routines Library (EARL). This volume supplements the user's Guide to provide an example of a complete model set up and execution. The particular model was synthesized to utilize all of the component performance routines and most of the program options. The subsequent text presents a description of the synthesized ECLSS, the driver Routine (MAIN), and the various displays, in the order they appear in execution. The MAP and Computer Control Statements are given in Appendix A.

2. SAMPLE ECLSS MODEL DESCRIPTION

A schematic of the ECLSS to be analyzed is given on Figure 2.1*. The system consists of an atmospheric loop and a payload loop interfaced to a liquid heat rejection loop.

The atmospheric coolant enters the cabin at Node 1 and exits into a CO₂ removal system at Node 2. Cabin make-up Nitrogen and Oxygen are extracted from Source 1 and 2. CO₂ removal canisters are provided from Source 3. Moisture removal is accomplished between Nodes 3 and 4. The moisture removal system rejects heat to the liquid loop at Nodes 7 and 8 and stores the condensate in Source 4. Cabin temperature is modulated by a heater at Node 4 which controls to a prescribed temperature at the cabin outlet (Node 2). Heater power is extracted from Source 5.

The liquid heat rejection loop mixes the radiator panel outlet and radiator by-pass flow (Nodes 16, 20, and 11) into Node 5 which is a final cooling stage evaporator. The evaporator extracts its expendable media from Source 6. The liquid cools cold plated equipment between Node 6 and 7 prior to interfacing with Nodes 3 and 4 of the atmospheric coolant loop condenser. The liquid then cools a second cold plate prior to interfacing with Nodes 21 and 22 of a payload coolant loop. Radiator panel and by-pass flow are then modulated at Node 10 to control the temperature at Node 5. Node 11 is the by-pass leg. The radiator consists of two parallel sets of three panels each.

The payload loop rejects heat at Node 21 to the liquid loop (Nodes 9 and 10) for cooling of payload equipment at Node 22.

* Figure 2.1 is a program produced schematic prepared from a previous run of the sample model given in this text. It does not appear in the order with respect to other displays had it been part of the sample execution.

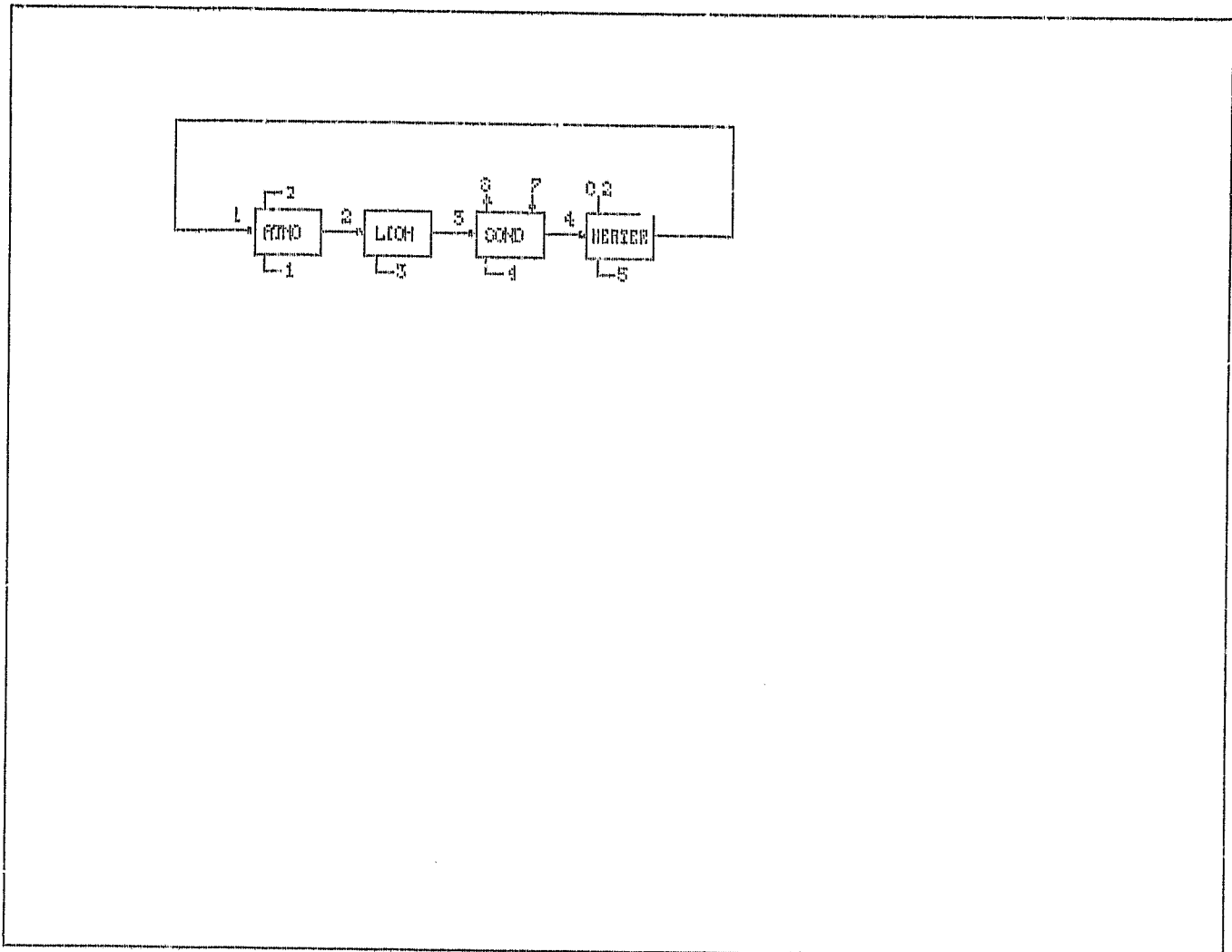


Figure 2.1. Sample Model Schematic

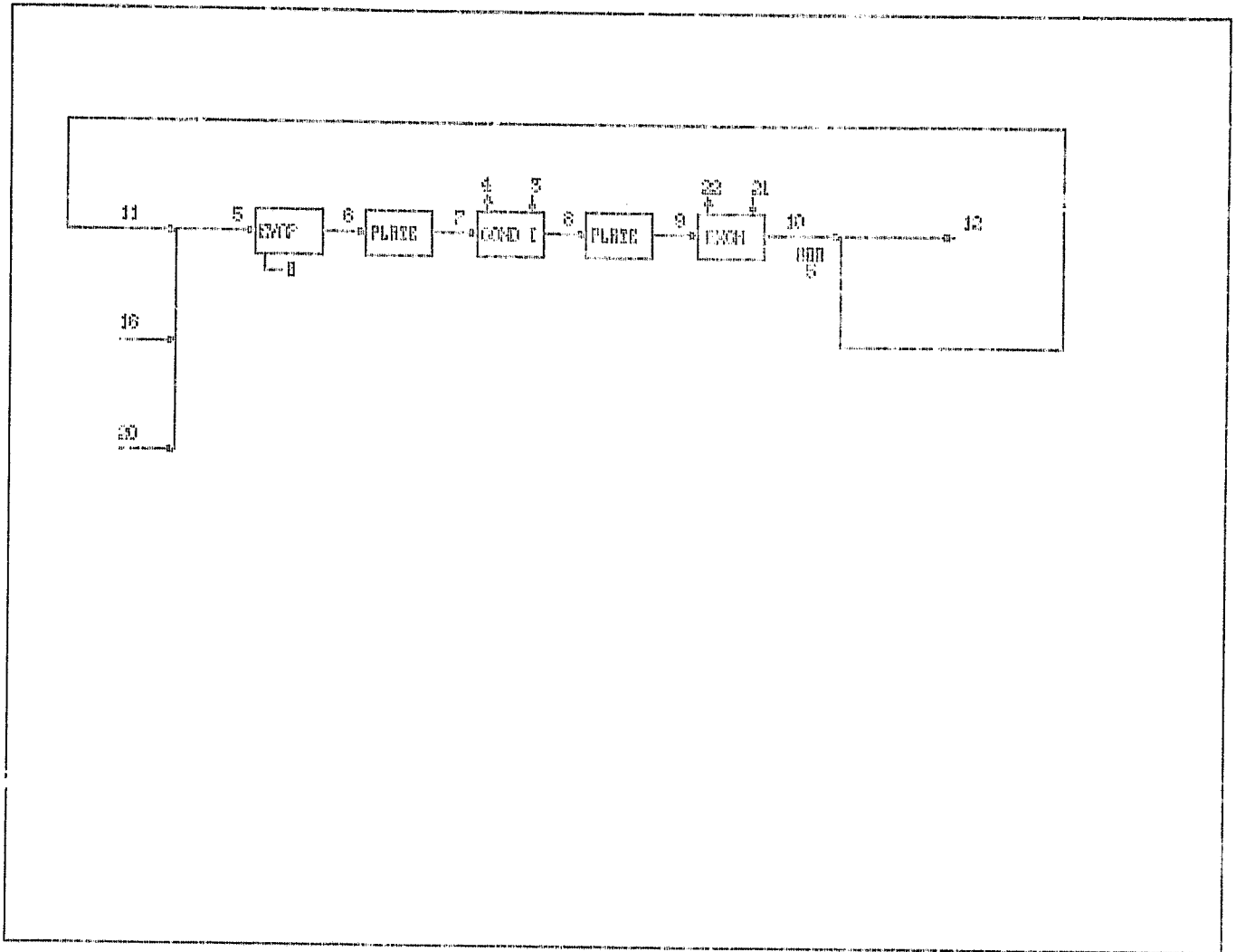


Figure 2.1. Sample Model Schematic (Cont.)

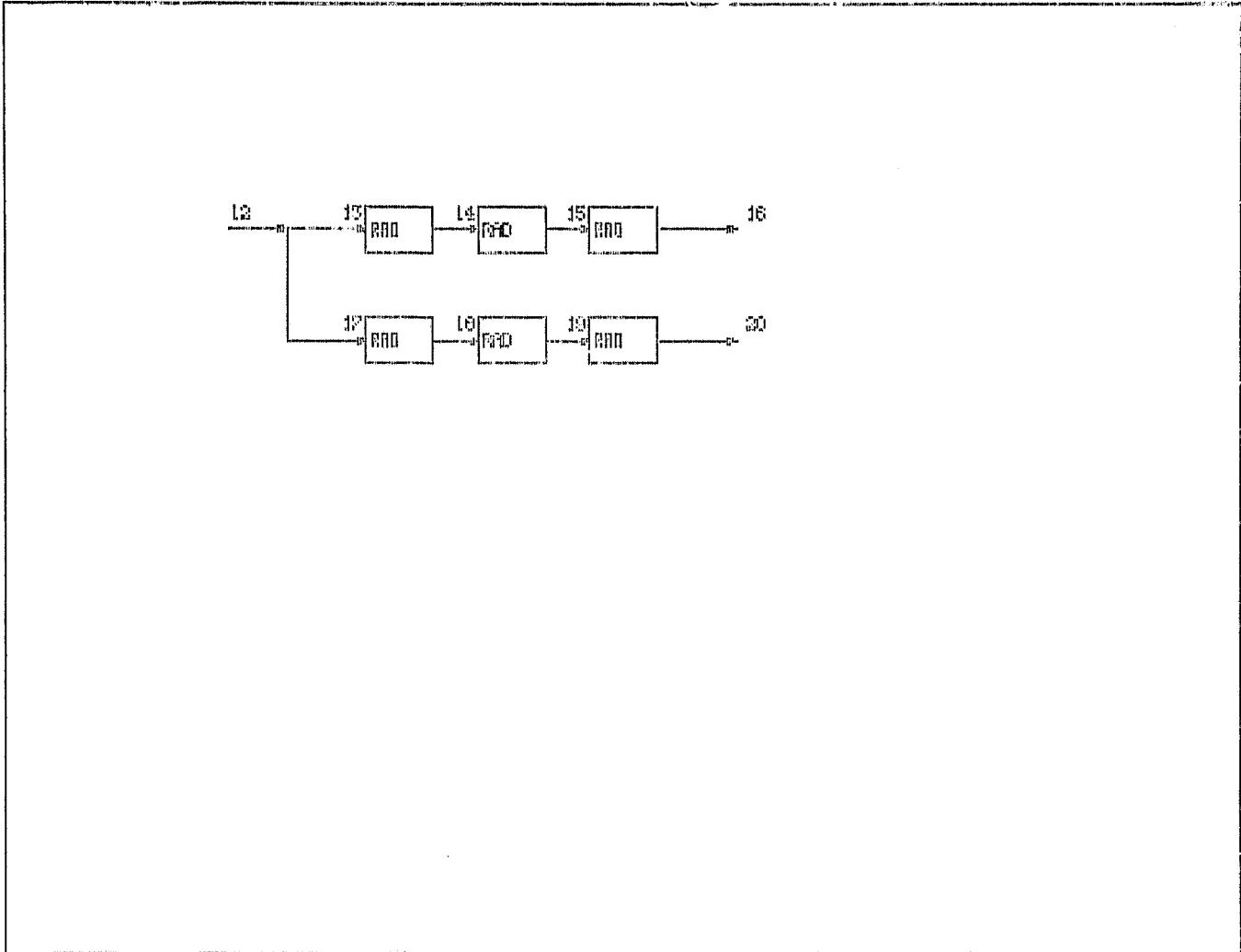


Figure 2.1. Sample Model Schematic (Cont.)

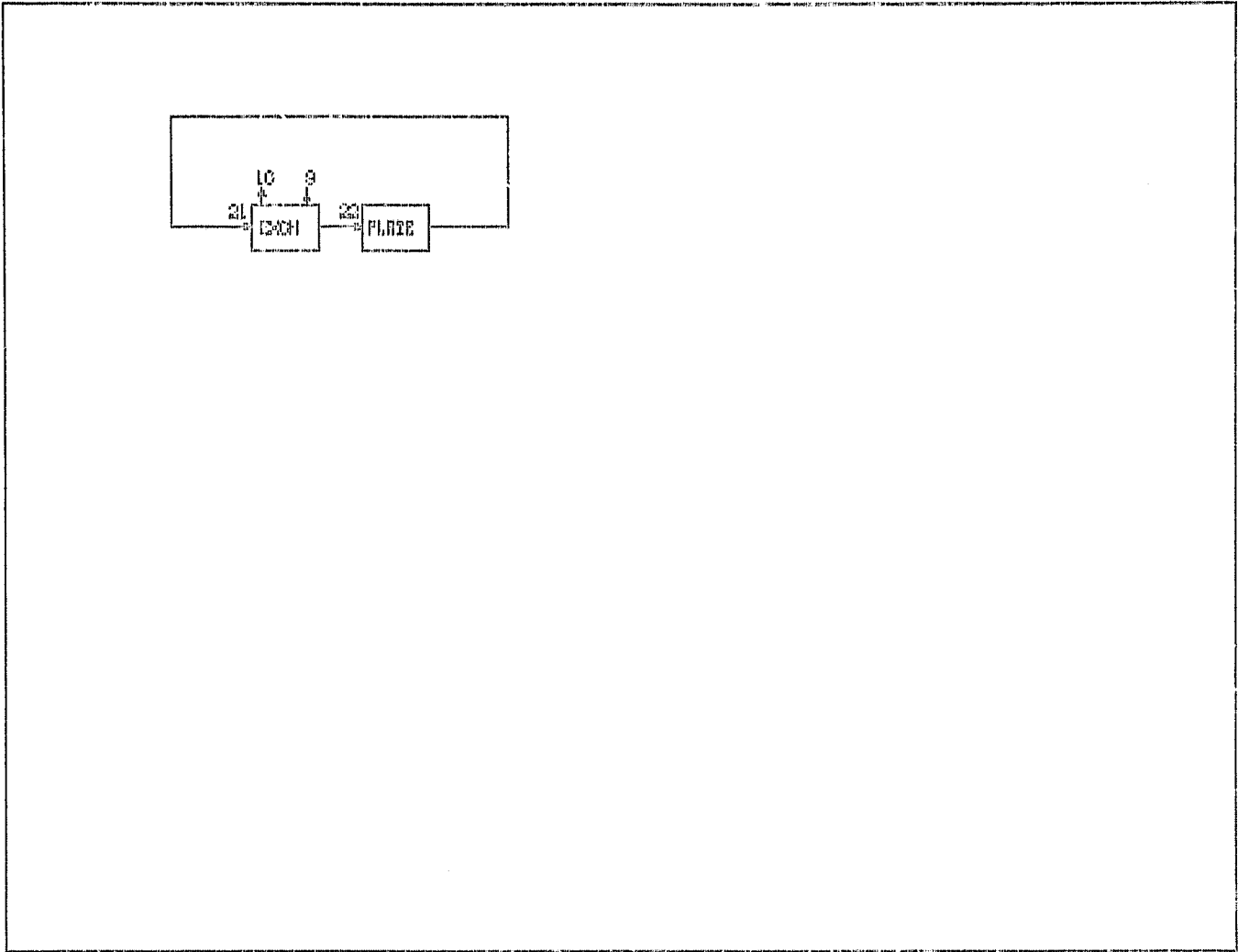


Figure 2.1. Sample Model Schematic (Concl.)

3. SAMPLE ECLSS MODEL EXECUTION

The driver routine (MAIN 20)* for the ECLSS described in the previous section is shown on Table 3.1.

Program Control displays are shown on Figure 3.1. In these, and subsequent displays, only the completed display is illustrated. Utility input and component data displays are shown on Figure 3.2. The Boundary Condition and Print Control information shown on Figure 3.3. These three Figures are part of the active execution. Printed performance and Plot data as output are shown on Figures 3.4 and 3.5 respectively. These latter two Figures are generated as part of the passive execution.

* This model was executed using the MAP given in Appendix A. Several problems related to loss of Common Data have occurred executing with this particular MAP structure. These problems can be avoided by including those common blocks shown for MAIN 20 in all model driver routines.

```

2) 1: COMMON/HEAT/ K,L,TEMP,P(100,2),F(100,2),C(100,20),IC(100,1
2: COMMON/TIMES/DELT,DELTO2,TIME,TSTOP,PRNT
3: COMMON/WRITE/ IWRITE,IPRNT,ICNT,IRUN,IFRST
4: COMMON/PSST/ NPLTS,IPLT(25),JPLT(25),NETFO(25)
5: COMMON/TABS/ X(500),Y(500),INTAB(20),INO
6: COMMON/LUMP2/ ATITLE(12),BIG(25),NEE(25)
7: COMMON/NEP/ NPLPTS,NERG,MOWCRE
8: COMMON/EPS/ NEPS(100),DEPS(100)
9: COMMON /FLAGS/ ISDUM,ISEL,ISCHEM,ITRAJ,IEPS,ISP,IGEN
10: COMMON /ITABLE/ IASST(100,2)
11: COMMON /SEQ/ NSEQ(100),NNODES,NSEAC(100),MNODES
12: DATA IFRST/1/
13:C          INITIALIZATION
14: CALL START
15:C          UPDATE HEAT LOADS
16: 1 CONTINUE
17: C(1,4)= 2001.
18: CALL TABLE(1,TIME,C(8,4))
19: CALL STEP(2,TIME,C(22,4))
20:C          START TIMING LOOP
21:C          ATMOSPHERIC SYSTEM
22: 100 CONTINUE
23: CALL LOOP(1)
24: CALL ATNO(1,2)
25: CALL LION(2,3)
26: CALL COMKG(3,4,7,8)
27: CALL HEATER(4,1)
28: CALL COMVRG(1,5.,20, #101, #100)
29: 101 CONTINUE
30:C          LIQUID COOLANT SYSTEM

```

30:>

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Table 3.1. Sample Model Driver (Main)

```

*****
FORTAN ENVIRONMENTAL
ANALYSIS ROUTINES
CONTROL DISPLAY
ENTER RUN MODE (INTEGER)
NEW START = 0
RESTART = 1
ENTER OUTPUT OPTION
NO RESTART TIME = 0
WRITE BEGINNING RESTART TAPE = 1
WRITE ENDING RESTART TAPE = 2
*****

```

```

*****
INITIALIZATION CONTROL
TFEAR
TEST PLOT OPTION
ITEM:
1 COMP. TIME INCREMENT .010 HR
2 START TIME .000 HR
3 STOP TIME 5.000 HR
4 PRINT INCREMENT 1.000 HR
5 INITIAL SYSTEM TEMP 521.000 DEG
*****

```

Figure 3.1. Program Initialization and Control


```

*****
TABLE 1
XX YY
1 .000 .000
2 .000 500.000
*****

```

```

*****
TABLE 2
XX YY
1 .000 200.000
2 2.500 400.000
*****

```

```

*****
MODE 1
ATMOSPHERIC COMPARTMENT

```

| ITEM | | VALUE | UNIT |
|------|------------------------------------|----------|------------|
| 1 | COMPARTMENT VOLUME | 1000.000 | CUBIC FT |
| 2 | LEAKAGE RATE | 2.000 | LB/HR |
| 3 | COOLANT FLOW RATE | 501.000 | BTU/HR DEG |
| 4 | HEAT LOAD | 2001.000 | BTU/HR |
| 5 | SPECIFIC HEAT OF GAS | .210 | BTU/LB DEG |
| 6 | PARTIAL PRESSURE OF WATER | .130 | PSI |
| 7 | PARTIAL PRESSURE OF NITROGEN | 11.600 | PSI |
| 8 | PARTIAL PRESSURE OF OXYGEN | 3.100 | PSI |
| 9 | PARTIAL PRESSURE OF CARBON DIOXIDE | .093 | PSI |
| 10 | TOTAL PRESSURE | 14.700 | PSI |
| 11 | NITROGEN TANK | 1 | INTEGER |
| 12 | OXYGEN TANK | 2 | INTEGER |
| 13 | INLET GAS TEMPERATURE | 505.100 | DEG |

```

*****
CREW MEMBER
METABOLIC RATES

```

```

MODE NO. 1

```

| ITEM | METABOLIC RATE | UNIT |
|------|----------------|--------|
| 1 | .000 | BTU/HR |
| 2 | .000 | BTU/HR |
| 3 | .000 | BTU/HR |
| 4 | 600.000 | BTU/HR |
| 5 | .000 | BTU/HR |
| 6 | .000 | BTU/HR |

Figure 3.2. Utility Input and Component Data

 NODE NO. 2

LITHIUM HYDROXIDE
 CANISTER

| ITEM | | VALUE | UNITS |
|------|------------------------------|---------|------------|
| 1 | CANISTER MASS | 1.000 | LBS |
| 2 | GAS FLOW RATE | 501.000 | BTU/HR DEG |
| 3 | CANISTER PRESSURE CHANGE | .150 | PSI |
| 4 | SPECIFIC HEAT OF GAS | .210 | BTU/LB DEG |
| 5 | PARTIAL PRESSURE OF WATER | .130 | PSI |
| 6 | PARTIAL PRESSURE OF NITROGEN | 11.600 | PSI |
| 7 | OXYGEN | 3.100 | PSI |
| 8 | CARBON | .093 | PSI |
| | DIOXIDE | | |
| 9 | TOTAL PRESSURE | 14.700 | PSI |
| 10 | INITIAL ABSORBED QUANTITY | .000 | FRACTION |
| 11 | CANISTER SOURCE | 3 | INTEGER |
| 12 | INLET GAS TEMPERATURE | 510.165 | DEG |

 NODE NO. 3
 CONDENSING HEAT EXCHANGER
 ATMOSPHERIC SIDE

| ITEM | | VALUE | UNIT |
|------|--------------------------------|----------|------------|
| | *** CALLING SIDE *** | | |
| 1 | CONDENSING HEAT TRANSFER COEF. | 2000.000 | BTU/HR DEG |
| 2 | DRY HEAT TRANSFER COEF. | 1000.000 | BTU/HR DEG |
| 3 | COOLANT FLOW RATE | 501.000 | BTU/HR DEG |
| 4 | FLUID INLET TEMP | 512.278 | DEG |
| 5 | CONDENSATE TANK NO. | 4 | INTEGER |
| | *** INTERFACE SIDE *** | | |
| 6 | COOLANT FLOW RATE | 1490.484 | BTU/HR DEG |
| 7 | FLUID INLET TEMP | 499.000 | DEG |
| | CALLING SIDE MODES | IN 3 | OUT 4 |
| | INTERFACE SIDE MODES | IN 7 | OUT 8 |

Figure 3.2. Utility Input and Component Data (Cont.)

```

*****
ATMOSPHERIC COOLANT
PROPERTIES FOR
NODE NUMBER 3
INFORMATION ONLY
NOT EDITABLE
PARTIAL PRESSURE OF WATER .133 PSIA
PARTIAL PRESSURE OF NITROGEN 11.600 PSIA
PARTIAL PRESSURE OF OXYGEN 3.100 PSIA
PARTIAL PRESSURE OF CARBON
DIOXIDE .090 PSIA
ATMOSPHERIC PRESSURE 14.700 PSIA
*****

```

```

*****
NODE NUMBER 4

```

HEATER

| ITEM | | VALUE | UNIT |
|------|-------------------------------|----------|-------------|
| 1 | THERMAL CAPACITY | 200.000 | BTU/DEG |
| 2 | OVERALL HEAT TRANSFER COEF. | 1500.000 | BTU/HR DEG |
| 3 | COOLANT FLOW RATE | 501.000 | BTU/HR DEG |
| 4 | INITIAL COMPONENT TEMPERATURE | 521.000 | DEG. |
| 5 | INITIAL INLET TEMPERATURE | 500.830 | DEG. |
| 6 | HEATER POWER | 450.000 | BTU/HR DEG. |
| 7 | CONTROL NODE NUMBER | 2 | INTEGER |
| 8 | CONTROL TEMPERATURE | 532.000 | DEG. |
| 9 | DEAD BAND | 2.000 | DEG. |
| 10 | INITIAL TEMP AT CONTROL NODE | 510.165 | DEG |
| 11 | ATMOSPHERIC COOLANT | 1 | INTEGER |
| | 0 = NO 1 = YES | | |
| 12 | THERMAL COUPLING | 0 | INTEGER |
| | 0 = NO 1 = YES | | |
| 13 | POWER SOURCE | 5 | INTEGER |
| | INLET NODE NO. | 4 | |
| | OUTLET NODE NO. | 1 | |

```

*****

```

```

*****
ATMOSPHERIC COOLANT
PROPERTIES FOR
NODE NUMBER 4
INFORMATION ONLY
NOT EDITABLE
PARTIAL PRESSURE OF WATER .126 PSIA
PARTIAL PRESSURE OF NITROGEN 11.600 PSIA
PARTIAL PRESSURE OF OXYGEN 3.100 PSIA
PARTIAL PRESSURE OF CARBON
DIOXIDE .090 PSIA
ATMOSPHERIC PRESSURE 14.700 PSIA
*****

```

Figure 3.2. Utility Input and Component Data (Cont.)

NODE NUMBER 5
-EVAPORATOR

| ITEM | | VALUE | UNIT |
|------|-----------------------------|----------|-----------------|
| 1 | HEAT OF VAPORAZATION | 1060.000 | BTU/LB |
| 2 | OVERALL HEAT TRANSFER COEF. | 3000.000 | BTU/HR DEG |
| 3 | COOLANT FLOW RATE | 1490.484 | BTU/HR DEG |
| 4 | SATURATION TEMP | 495.000 | DEG |
| 5 | INITIAL FLUID INLET TEMP | 521.000 | DEG |
| 6 | CONSUMABLE | 1 | INTEGER .LE. 10 |
| | 1 = POTABLE WATER | | |
| | 2 = WATER | | |
| | 3 = AMMONIA | | |
| | 4 = OTHER | | |
| 7 | TANK ASSIGNMENT | 6 | INTEGER .LE. 20 |
| | INLET NODE NUMBER | 5 | |
| | OUTLET NODE NUMBER | 6 | |

NODE NUMBER 6
COLD PLATE

| ITEM | | VALUE | UNIT |
|------|-----------------------------|----------|------------|
| 1 | THERMAL CAPACITY | 150.000 | BTU/DEG |
| 2 | OVERALL HEAT TRANSFER COEF. | 2500.000 | BTU/HR DEG |
| 3 | COOLANT FLOW RATE | 1490.484 | BTU/HR DEG |
| 4 | INITIAL COMPONENT TEMP. | 500.000 | DEG |
| 5 | INITIAL COOLANT INLET TEMP. | 498.474 | DEG |
| 6 | ATMOSPHERIC COOLANT | 0 | INTEGER |
| | 0 = NO | | |
| | 1 = YES | | |
| 7 | EPS DATA ASSIGNMENT | 0 | INTEGER |
| | 0 = NO | | |
| | 1 = YES | | |
| 8 | THERMAL COUPLING | 0 | INTEGER |
| | 0 = NO | | |
| | 1 = YES | | |
| | INLET NODE NUMBER | 6 | |
| | OUTLET NODE NUMBER | 7 | |

NODE NO. 7
CONDENSING HEAT EXCHANGER
INTERFACE SIDE

| ITEM | | VALUE | UNIT |
|--------------------------|------------------------|------------|------------|
| *** CALLING SIDE *** | | | |
| 1 | COOLANT FLOW RATE | 1490.404 | BTU/HR DEG |
| 2 | FLUID INLET TEMP. | 499.715 | DEG |
| 3 | ATMOSPHERIC COOLANT | 0 | INTEGER |
| | NO = 0 | | |
| | YES = 1 | | |
| *** ATMOSPHERIC SIDE *** | | | |
| 4 | COOLANT FLOW RATE | 501.000 | BTU/HR DEG |
| 5 | FLUID INLET TEMP | 512.278 | DEG |
| | CALLING SIDE NODES | IN 7 OUT 8 | |
| | ATMOSPHERIC SIDE NODES | IN 3 OUT 4 | |

Figure 3.2. Utility Input and Component Data (Cont.)

NODE NUMBER 8
COLD PLATE

| ITEM | | | |
|------|-----------------------------|----------|--------------------|
| 1 | THERMAL CAPACITY | 200.000 | BTU/DEG |
| 2 | OVERALL HEAT TRANSFER COEF. | 3000.000 | BTU/HR DEG |
| 3 | COOLANT FLOW RATE | 1490.484 | BTU/HR DEG |
| 4 | INITIAL COMPONENT TEMP. | 521.000 | DEG |
| 5 | INITIAL COOLANT INLET TEMP. | 504.167 | DEG |
| 6 | ATMOSPHERIC COOLANT | 0 | INTEGER |
| | 0 = NO | | |
| | 1 = YES | | |
| 7 | EPS DATA ASSIGNMENT | 0 | INTEGER |
| | 0 = NO | | |
| | 1 = YES | | |
| 8 | THERMAL COUPLING | 1 | INTEGER |
| | 0 = NO | | |
| | 1 = YES | | |
| | INLET NODE NUMBER | 8 | OUTLET NODE NUMBER |
| | | | 9 |

THERMAL COUPLING DATA
FOR NODE NO. 8
COUPLED TO 1 NODES
TYPE OF HEAT TRANSFER AND
ITEM COUPLING NODE NUMBER CODE VALUE
1 122 .500
VALUES ARE:
BTU/HR FOR SERIES 100 COUPLING
BTU/HR DEG**4 FOR SERIES 200 COUPLING

NODE NO. 9

HEAT EXCHANGER

| ITEM | | VALUE | UNIT |
|------|--------------------------------------|----------|------------|
| | *** CALLING SIDE *** | | |
| 1 | HEAT TRANSFER COEF. | 3000.000 | BTU/HR DEG |
| 2 | COOLANT FLOW RATE | 1490.484 | BTU/HR DEG |
| 3 | FLUID INLET TEMPERATURE | 519.751 | DEG |
| 4 | TYPE | 0 | INTEGER |
| | COUNTERFLOW = 0 PARALLEL FLOW = 1 | | |
| 5 | ATMOSPHERIC COOLANT | 0 | INTEGER |
| | NO = 0 YES = 1 | | |
| | *** INTERFACE SIDE *** | | |
| 6 | HEAT TRANSFER COEF. | 300.000 | BTU/HR DEG |
| 7 | COOLANT FLOW RATE | 100.000 | BTU/HR DEG |
| 8 | FLUID INLET TEMPERATURE | 521.000 | DEG |

Figure 3.2. Utility Input and Component Data (Cont.)

 NODE NUMBER 10
 MODULATION VALUE

| ITEM | DESCRIPTION | VALUE | UNIT |
|------|------------------------------|----------|--------------|
| 1* | LEG 1 NODE NUMBER | 12 | INTEGER |
| 2* | LEG 2 NODE NUMBER | 11 | INTEGER |
| 3* | CONTROL NODE NUMBER | 5 | INTEGER |
| 4 | CONTROL TEMP | 505.000 | DEG |
| 5 | INITIAL TEMP AT CONTROL NODE | 521.000 | DEG |
| 6 | PROPORTIONAL GAINS | .001 | FRACTION/DEG |
| 7 | MAX HARD OVER | 1.000 | FRACTION |
| 8 | MIN HARD OVER | .000 | FRACTION |
| 9 | INITIAL TEMP AT MOD NODE | 518.891 | DEG |
| 10 | COOLANT FLOW AT MOD NODE | 1490.489 | BTU/HR. DEG. |
| 11 | ATMOSPHERIC COOLANT | 0 | INTEGER |

0 = NO
 1 = YES
 * MUST BE DEFINED BEFORE YOU EXIT DISPLAY

| NODE NO. 12 | | BRANCH | |
|-------------------|---------------------|---------|------------|
| SPLIT INTO | | 2 LEGS | |
| ITEM | LEG NODE NUMBER | FLOW | PROPORTION |
| 1 | 13 | .500 | |
| 2 | 17 | .500 | |
| 3 | ATMOSPHERIC COOLANT | 0 | INTEGER |
| 0 = NO 1 = YES | | | |
| 4 | COOLANT FLOW RATE | 769.090 | BTU/HR DEG |
| 5 | COOLANT INLET TEMP | 518.891 | DEG |

 NODE NUMBER 13
 RADIATOR PANEL

| ITEM | DESCRIPTION | VALUE | UNIT |
|-------------------|-----------------------------|----------|------------|
| 1 | THERMAL CAPACITANCE | 25.000 | BTU/DEG |
| 2 | OVERALL HEAT TRANSFER COEF. | 1500.000 | BTU/HR DEG |
| 3 | COOLANT FLOW RATE | 384.545 | BTU/HR DEG |
| 4 | SOLAR ABSORBIVITY | .100 | FRACTION |
| 5 | EMISSIVITY | .900 | FRACTION |
| 6 | RIGHT FIN EFFECTIVENESS | .800 | FRACTION |
| 7 | LEFT FIN EFFECTIVENESS | .800 | FRACTION |
| 8 | RIGHT FIN AREA | 10.000 | SQ FT |
| 9 | LEFT FIN AREA | 10.000 | SQ FT |
| 10 | ANGLE OF INCIDENCE | .000 | RAD |
| 11 | DIHEDRAL ANGLE | .000 | RAD |
| 12 | INITIAL FIN TEMP | 521.000 | DEG |
| 13 | INITIAL COOLANT INLET TEMP. | 518.891 | DEG |
| 14 | NODE COUPLING | 0 | INTEGER |
| NO = 0 YES = 1 | | | |
| 15 | SHADOW NODE NUMBER | 25 | INTEGER |
| | INLET NODE NUMBER | 13 | |
| | OUTLET NODE NUMBER | 14 | |

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Figure 3.2. Utility Input and Component Data (Cont.)

SHADOWING DATA
FOR NODE NO. 13
SHADOWED BY 25

| ITEM | | VALUE | UNIT |
|------|-------------------------------------|-------|---------|
| 1 | SHADOW NODE AREA | 1.000 | SQ FT |
| 2 | ANGLE OF INCIDENCE | .000 | RAD |
| 3 | DIHEDRAL ANGLE | .000 | RAD |
| 4 | STAND-OFF VECTOR DATA | 26 | INTEGER |
| 5 | STAND-OFF DISTANCE | 2.000 | FT |
| 6 | EQUIV. STAND-OFF ANGLE OF INCIDENCE | .000 | RAD |
| 7 | EQUIV. STAND-OFF DIHEDRAL ANGLE | .000 | RAD |

NODE NUMBER 14
RADIATOR PANEL

| ITEM | | VALUE | UNIT |
|------|-----------------------------|----------|------------|
| 1 | THERMAL CAPACITANCE | 25.000 | BTU/DEG |
| 2 | OVERALL HEAT TRANSFER COEF. | 1500.000 | BTU/HR DEG |
| 3 | COOLANT FLOW RATE | 384.545 | BTU/HR DEG |
| 4 | SOLAR ABSORBIVITY | .100 | FRACTION |
| 5 | EMISSIVITY | .900 | FRACTION |
| 6 | RIGHT FIN EFFECTIVENESS | .800 | FRACTION |
| 7 | LEFT FIN EFFECTIVENESS | .800 | FRACTION |
| 8 | RIGHT FIN AREA | 10.000 | SQ FT |
| 9 | LEFT FIN AREA | 10.000 | SQ FT |
| 10 | ANGLE OF INCIDENCE | .000 | RAD |
| 11 | DIHEDRAL ANGLE | .000 | RAD |
| 12 | INITIAL FIN TEMP | 521.000 | DEG |
| 13 | INITIAL COOLANT INLET TEMP. | 520.957 | DEG |
| 14 | NODE COUPLING | 0 | INTEGER |

NO = 0
YES = 1

| | | | |
|----|--------------------|----|---------|
| 15 | SHADOW NODE NUMBER | 0 | INTEGER |
| | INLET NODE NUMBER | 14 | |
| | OUTLET NODE NUMBER | 15 | |

NODE NUMBER 15
RADIATOR PANEL

| ITEM | | VALUE | UNIT |
|------|-----------------------------|----------|------------|
| 1 | THERMAL CAPACITANCE | 25.000 | BTU/DEG |
| 2 | OVERALL HEAT TRANSFER COEF. | 1500.000 | BTU/HR DEG |
| 3 | COOLANT FLOW RATE | 384.545 | BTU/HR DEG |
| 4 | SOLAR ABSORBIVITY | .100 | FRACTION |
| 5 | EMISSIVITY | .900 | FRACTION |
| 6 | RIGHT FIN EFFECTIVENESS | .800 | FRACTION |
| 7 | LEFT FIN EFFECTIVENESS | .800 | FRACTION |
| 8 | RIGHT FIN AREA | 10.000 | SQ FT |
| 9 | LEFT FIN AREA | 10.000 | SQ FT |
| 10 | ANGLE OF INCIDENCE | .000 | RAD |
| 11 | DIHEDRAL ANGLE | .000 | RAD |
| 12 | INITIAL FIN TEMP | 521.000 | DEG |
| 13 | INITIAL COOLANT INLET TEMP. | 520.999 | DEG |
| 14 | NODE COUPLING | 0 | INTEGER |

NO = 0
YES = 1

| | | | |
|----|--------------------|----|---------|
| 15 | SHADOW NODE NUMBER | 0 | INTEGER |
| | INLET NODE NUMBER | 15 | |
| | OUTLET NODE NUMBER | 15 | |

Figure 3.2. Utility Input and Component Data (Cont.)

 NODE NUMBER 17
 RADIATOR PANEL

| ITEM | | VALUE | UNIT |
|------|-----------------------------|----------|------------|
| 1 | THERMAL CAPACITANCE | 25.000 | BTU/DEG |
| 2 | OVERALL HEAT TRANSFER COEF. | 1500.000 | BTU/HR DEG |
| 3 | COOLANT FLOW RATE | 384.545 | BTU/HR DEG |
| 4 | SOLAR ABSORBIVITY | .100 | FRACTION |
| 5 | EMMISSIVITY | .900 | FRACTION |
| 6 | RIGHT FIN EFFECTIVENESS | .800 | FRACTION |
| 7 | LEFT FIN EFFECTIVENESS | .800 | FRACTION |
| 8 | RIGHT FIN AREA | 10.000 | SQ FT |
| 9 | LEFT FIN AREA | 10.000 | SQ FT |
| 10 | ANGLE OF INCIDENCE | .000 | RAD |
| 11 | DIHEDERIAL ANGLE | .000 | RAD |
| 12 | INITIAL FIN TEMP | 521.000 | DEG |
| 13 | INITIAL COOLANT INLET TEMP. | 518.891 | DEG |
| 14 | NOSE COUPLING | 0 | INTEGER |
| | NO = 0 | | |
| | YES = 1 | | |
| 15 | SHADOW NODE NUMBER | 0 | INTEGER |
| | INLET NODE NUMBER | 17 | |
| | OUTLET NODE NUMBER | 18 | |

 NODE NUMBER 18
 RADIATOR PANEL

| ITEM | | VALUE | UNIT |
|------|-----------------------------|----------|------------|
| 1 | THERMAL CAPACITANCE | 25.000 | BTU/DEG |
| 2 | OVERALL HEAT TRANSFER COEF. | 1500.000 | BTU/HR DEG |
| 3 | COOLANT FLOW RATE | 384.545 | BTU/HR DEG |
| 4 | SOLAR ABSORBIVITY | .100 | FRACTION |
| 5 | EMMISSIVITY | .900 | FRACTION |
| 6 | RIGHT FIN EFFECTIVENESS | .800 | FRACTION |
| 7 | LEFT FIN EFFECTIVENESS | .800 | FRACTION |
| 8 | RIGHT FIN AREA | 10.000 | SQ FT |
| 9 | LEFT FIN AREA | 10.000 | SQ FT |
| 10 | ANGLE OF INCIDENCE | .000 | RAD |
| 11 | DIHEDERIAL ANGLE | .000 | RAD |
| 12 | INITIAL FIN TEMP | 521.000 | DEG |
| 13 | INITIAL COOLANT INLET TEMP. | 520.957 | DEG |
| 14 | NOSE COUPLING | 0 | INTEGER |
| | NO = 0 | | |
| | YES = 1 | | |
| 15 | SHADOW NODE NUMBER | 0 | INTEGER |
| | INLET NODE NUMBER | 18 | |
| | OUTLET NODE NUMBER | 19 | |

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Figure 3.2. Utility Input and Component Data (Cont.)

NODE NUMBER 19
RADIATOR PANEL

| ITEM | | VALUE | UNIT |
|------|-----------------------------|----------|------------|
| 1 | THERMAL CAPACITANCE | .250 | BTU/DEG |
| 2 | OVERALL HEAT TRANSFER COEF. | 1500.000 | BTU/HR DEG |
| 3 | COOLANT FLOW RATE | 384.545 | BTU/HR DEG |
| 4 | SOLAR ABSORBIVITY | .100 | FRACTION |
| 5 | EMMISSIVITY | .900 | FRACTION |
| 6 | RIGHT FIN EFFECTIVENESS | .800 | FRACTION |
| 7 | LEFT FIN EFFECTIVENESS | .800 | FRACTION |
| 8 | RIGHT FIN AREA | 10.000 | SQ FT |
| 9 | LEFT FIN AREA | 10.000 | SQ FT |
| 10 | ANGLE OF INCIDENCE | .000 | RAD |
| 11 | DIHEDRAL ANGLE | .000 | RAD |
| 12 | INITIAL FIN TEMP | 521.000 | DEG |
| 13 | INITIAL COOLANT INLET TEMP. | 520.999 | DEG |
| 14 | NODE COUPLING | 0 | INTEGER |
| | NO = 0 | | |
| | YES = 1 | | |
| 15 | SHADOW NODE NUMBER | 0 | INTEGER |
| | INLET NODE NUMBER | 19 | |
| | OUTLET NODE NUMBER | 20 | |

NODE NO. 5
JUNCTION
MIXING 3 NODES
MIXED NODE

| ITEM | NUMBER | UNIT |
|------|---------------------|-----------|
| 1 | 11 | INTEGER |
| 2 | 16 | INTEGER |
| 3 | 20 | INTEGER |
| 4 | ATMOSPHERIC COOLANT | 0 INTEGER |
| | 0 = NO | |
| | 1 = YES | |

NODE NO. 21

HEAT EXCHANGER

| ITEM | | VALUE | UNIT |
|------|-------------------------|----------|------------|
| | *** CALLING SIDE *** | | |
| 1 | HEAT TRANSFER COEF. | 300.000 | BTU/HR DEG |
| 2 | COOLANT FLOW RATE | 100.000 | BTU/HR DEG |
| 3 | FLUID INLET TEMPERATURE | 521.000 | DEG |
| 4 | TYPE | 0 | INTEGER |
| | COUNTERFLOW = 0 | | |
| | PARALLEL FLOW = 1 | | |
| 5 | ATMOSPHERIC COOLANT | 0 | INTEGER |
| | NO = 0 | | |
| | YES = 1 | | |
| | *** INTERFACE SIDE *** | | |
| 6 | HEAT TRANSFER COEF. | 3000.000 | BTU/HR DEG |
| 7 | COOLANT FLOW RATE | 1490.484 | BTU/HR DEG |
| 8 | FLUID INLET TEMPERATURE | 518.751 | DEG |

Figure 3.2. Utility Input and Component Data (Cont.)

```

*****
                                NODE NUMBER 22
                                GOLD PLATE
ITEM  THERMAL CAPACITY          150.000      BTU/DEG
1
2  OVERALL HEAT TRANSFER     300.000      BTU/HR DEG
   COEF.
3  COOLANT FLOW RATE         100.000      BTU/HR DEG
4  INITIAL COMPONENT
   TEMP.                      521.000      DEG
5  INITIAL COOLANT
   INLET TEMP.                518.916      DEG
6  ATMOSPHERIC COOLANT      0
   0 = NO
   1 = YES
7  EPS DATA ASSIGNMENT      0      INTEGER
   0 = NO
   1 = YES
8  THERMAL COUPLING          1      INTEGER
   0 = NO
   1 = YES
   INLET NODE NUMBER          22      OUTLET NODE NUMBER
                                   21
*****

```

```

*****
                                THERMAL COUPLING DATA
                                FOR NODE NO. 22
                                COUPLED TO 1 NODES
                                TYPE OF HEAT TRANSFER AND
ITEM  COUPLING NODE NUMBER CODE  VALUE
1      108                      .500
VALUES ARE:
      BTU/HR FOR SERIES 100 COUPLING
      BTU/HR DEG**4 FOR SERIES 200 COUPLING
*****

```

Figure 3.2. Utility Input and Component Data (Concl.)

```

*****
CONSUMABLES
SOURCES

```

| ITEM | SOURCE NO. | TYPE OF CONSUMABLE | UNIT | INITIAL QUANTITY |
|------|------------|--------------------|----------|------------------|
| 1 | 1 | NITROGEN | LBS. | 000 |
| 2 | 2 | OXYGEN | LBS. | 000 |
| 3 | 3 | LITHIUM HYDROXIDE | LBS. | 000 |
| 4 | 4 | WATER | LBS. | 000 |
| 5 | 5 | ELECTRIC POWER | WATT HRS | 000 |
| 6 | 6 | POTABLE WATER | LBS. | 000 |

```

*****

```

```

*****
ORBITAL HEATING
CONTROL PARAMETERS

```

| ITEM | VALUE | UNIT |
|--|-------|---------|
| 1 CONTROL INDICATOR 1 = READ TAPE 2 = CALCULATE TRAJECTORY | 2 | INTEGER |
| 2 UNIT CONVERSION FOR TAPE 1 = EARTH RADIUS () 2 = KILOMETERS (KM.) | 1 | INTEGER |

```

*****

```

```

*****
ORBITAL PARAMETERS

```

| ITEM | VALUE | UNIT |
|---|--------------|---------|
| 1 COMP FREQUENCY | 1 | INTEGER |
| 2 ATTITUDE HOLD KEY 1 = INERTIAL 2 = LOCAL VERTICAL | 1 | INTEGER |
| 3 SUN COORDINATE X | 2.3466000+04 | ER. |
| 4 Y | 0.0000000 | ER. |
| 5 Z | 0.0000000 | ER. |
| 6 EULER ANGLE ABOUT Z | .000 | RAD. |
| 7 Y | .000 | RAD. |
| 8 X | .000 | RAD. |
| 9 ORBIT SEMIMAJOR AXIS | 1.029 | ER. |
| 10 ORBIT ECCENTRICITY | .000 | N/D |
| 11 ORBIT INCLINATION | .000 | RAD. |
| 12 RIGHT ASCENSION | .000 | RAD. |
| 13 ARGUMENT OF PERIGEE | .000 | RAD. |
| 14 TIME OF PERIGEE PASSAGE | .000 | ER. |

```

*****

```

Figure 3.3. Boundary Condition and Print Control

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```

*****
PRINT OPTION
  DISPLAY
ITEM  OPTION  FLAG
 1    SELECT  STATUS
 2    NODES   0
 3    PLOTS   1
     SCHEMATIC 0
*****

```

```

*****
FUNCTION MENU
DESCRIPTION
TYPE 1 FLUID TEMP (DEG/R)
     2 COMP TEMP (DEG/R)
     3 FLOW RATE (LBS/HR)
     4 HEAT (BTU/HR)
     5 ACC CONSUM (LBS)
     6 HEATER PWR (BTU/HR)
     7 PRT PRES H2O (PSI)
     8 PRT PRES N2 (PSI)
     9 PRT PRES O2 (PSI)
    10 PRT PRES CO2 (MMHG)
    11 HTR ENERGY (BTU)
*****

```

```

*****
PLOT CONTROL
TEM  NODE NO  TYPE  MAX  MIN
 1    2    FLUID TEMP  .000  .000
 2   12    FLOW RATE  .000  .000
 3   22    HEAT  .000  .000
*****

```

Figure 3.3. Boundary Condition and Print Control (Concl.)

TFEAR
TEST PLOT OPTION

FLUID PROPERTIES

TIME = .000

| NODE NO | | COMP TEMP DEG | FLUID TEMP DEG | WCP BTU/HR DEG | HEAT LOAD BTU/HR |
|---------|-----------|---------------|----------------|----------------|------------------|
| 1 | CABIN IN | | 519.990 | 501.000 | 2001.000 |
| 2 | CABIN OUT | | 510.165 | 501.000 | |
| 3 | LIOH OUT | | 512.278 | 501.000 | |
| 4 | COND. OUT | 521.000 | 500.830 | 501.000 | 450.000 |
| 5 | EVAP IN | 495.000 | 519.970 | 1490.484 | |
| 6 | EVAP OUT | 500.000 | 498.474 | 1490.484 | |
| 7 | PLATE OUT | | 499.715 | 1490.484 | 6636.095 |
| 8 | INTF OUT | | 504.167 | 1490.484 | |
| 9 | PLATE OUT | 521.000 | 518.751 | 1490.484 | |
| 10 | EXCH OUT | | 518.891 | 1490.484 | |
| 12 | LEG | | 518.891 | 769.090 | |
| 11 | LEG | | 518.891 | 721.394 | |
| 13 | LEG | 521.000 | 518.891 | 384.545 | |
| 17 | LEG | 521.000 | 518.891 | 384.545 | |
| 14 | RADOUT | 521.000 | 520.957 | 384.545 | |
| 15 | RADOUT | 521.000 | 520.999 | 384.545 | |
| 16 | RADOUT | | 521.000 | 384.545 | |
| 18 | RADOUT | 521.000 | 520.957 | 384.545 | |
| 19 | RADOUT | 521.000 | 520.999 | 384.545 | |
| 20 | RADOUT | | 521.000 | 384.545 | |
| 21 | EXCH IN | | 520.896 | 100.000 | |
| 22 | EXCH OUT | 521.000 | 518.916 | 100.000 | 200.000 |

GAS PROPERTIES

TIME = .000

| NODE NO | SPECIFIC HEAT | WATER PSI | NITROGEN PSI | OXYGEN PSI | CO2 PSI | TOTAL PSI |
|---------|---------------|-----------|--------------|------------|---------|-----------|
| 1 | .210 | .126 | 11.600 | 3.100 | .090 | 14.700 |
| 2 | .210 | .130 | 11.600 | 3.100 | .093 | 14.700 |
| 3 | .210 | .133 | 11.600 | 3.100 | .090 | 14.700 |
| 4 | .210 | .126 | 11.600 | 3.100 | .090 | 14.700 |

PAUSE FOR HARDCOPY. ENTER ANY CHARACTER TO CONTINUE

CONSUMABLES
USAGE

| TIME = | INITIAL AVAILABLE | QUANTITY USED | QUANTITY REMAINING |
|--------|-------------------|---------------|--------------------|
| SOURCE | | | |
| 1 | .000 | .000 | .000 |
| 2 | .000 | .000 | .000 |
| 3 | .000 | .000 | .000 |
| 4 | .000 | .000 | .000 |
| 5 | .000 | .000 | .000 |
| 6 | .000 | .000 | .000 |

PAUSE FOR HARDCOPY. ENTER ANY CHARACTER TO CONTINUE

Figure 3.4. Performance Data Output

 TFEAR
 TEST PLOT OPTION

FLUID PROPERTIES

TIME = 1.000

| NODE NO | | | COMP TEMP DEG | FLUID TEMP DEG | WCP BTU/HR DEG | HEAT LOAD BTU/HR |
|---------|-----------|-------------|---------------|----------------|----------------|------------------|
| 1 | CABIN IN | /HEATER OUT | | 500.465 | 501.000 | 2001.000 |
| 2 | CABIN OUT | /LIQH IN | | 505.543 | 501.000 | |
| 3 | LIQH OUT | /COND. IN | | 506.041 | 501.000 | |
| 4 | COND. OUT | /HEATER IN | 500.574 | 436.495 | 501.000 | 450.000 |
| 5 | EVAP IN | /JUNCTION | 495.000 | 496.417 | 1490.484 | |
| 6 | EVAP OUT | /PLATE IN | 495.220 | 495.187 | 1490.484 | |
| 7 | PLATE OUT | /INTF IN | | 495.215 | 1490.484 | 4981.428 |
| 8 | INTF OUT | /PLATE IN | 499.234 | 499.557 | 1490.484 | 100.000 |
| 9 | PLATE OUT | /EXCH IN | | 499.161 | 1490.484 | |
| 10 | EXCH OUT | /DIVERT | | 500.071 | 1490.484 | |
| 12 | LEG | /BRANCH | | 500.071 | 318.282 | |
| 11 | LEG | /MIXER | | 500.071 | 1172.292 | |
| 13 | LEG | /RADIN | 493.701 | 500.071 | 159.141 | |
| 17 | LEG | /RADIN | 493.701 | 500.071 | 159.141 | |
| 14 | RADOUT | /RADIN | 488.900 | 493.798 | 159.141 | |
| 15 | RADOUT | /RADIN | 485.021 | 489.034 | 159.141 | |
| 16 | RADOUT | /MIXER | | 485.175 | 159.141 | |
| 18 | RADOUT | /RADIN | 488.900 | 493.798 | 159.141 | |
| 19 | RADOUT | /RADIN | 480.461 | 489.034 | 159.141 | |
| 20 | RADOUT | /MIXER | | 480.741 | 159.141 | |
| 21 | EXCH IN | /PLATE OUT | | 513.737 | 100.000 | |
| 22 | EXCH OUT | /PLATE IN | 514.404 | 500.275 | 100.000 | 200.000 |

GAS PROPERTIES

TIME = 1.000

| NODE NO | SPECIFIC HEAT | WATER PSI | NITROGEN PSI | OXYGEN PSI | CO2 PSI | TOTAL PSI |
|---------|---------------|-----------|--------------|------------|---------|-----------|
| 1 | .210 | .106 | 11.600 | 3.100 | .077 | 14.700 |
| 2 | .210 | .107 | 11.600 | 3.100 | .077 | 14.700 |
| 3 | .210 | .108 | 11.600 | 3.100 | .077 | 14.700 |
| 4 | .210 | .106 | 11.600 | 3.100 | .077 | 14.700 |

 PAUSE FOR HARDCOPY. ENTER ANY CHARACTER TO CONTINUE

CONSUMABLES USAGE

| SOURCE | INITIAL AVAILABLE | QUANTITY USED | QUANTITY REMAINING |
|--------|-------------------|---------------|--------------------|
| 1 | .000 | 1.532 | -1.532 |
| 2 | .000 | .565 | -.565 |
| 3 | .000 | .000 | .000 |
| 4 | .000 | -.263 | .263 |
| 5 | .000 | 131.965 | -131.965 |
| 6 | .000 | 8.498 | -8.498 |

PAUSE FOR HARDCOPY. ENTER ANY CHARACTER TO CONTINUE

Figure 3.4. Performance Data Output (Cont.)

 TFEAR
 TEST PLOT OPTION

FLUID PROPERTIES

TIME = 2.000

| NODE NO | | | COMP TEMP DEG | FLUID TEMP DEG | MCP BTU/HR DEG | HEAT LOAD BTU/HR |
|---------|-----------|-------------|---------------|----------------|----------------|------------------|
| 1 | CABIN IN | /HEATER OUT | | 497.571 | 501.000 | 2001.000 |
| 2 | CABIN OUT | /LYOH IN | | 502.644 | 501.000 | |
| 3 | LYOH OUT | /COND. IN | | 503.005 | 501.000 | |
| 4 | COND. OUT | /HEATER IN | 497.632 | 496.320 | 501.000 | 450.000 |
| 5 | EVAP IN | /JUNCTION | 495.000 | 498.059 | 1490.482 | |
| 6 | EVAP OUT | /PLATE IN | 495.424 | 495.410 | 1490.482 | |
| 7 | PLATE OUT | /INTF IN | | 495.421 | 1490.482 | 3497.986 |
| 8 | INTF OUT | /PLATE IN | 497.990 | 497.768 | 1490.482 | 200.000 |
| 9 | PLATE OUT | /EXCH IN | | 497.962 | 1490.482 | |
| 10 | EXCH OUT | /DIVERT | | 498.574 | 1490.482 | |
| 12 | LEG | /BRANCH | | 498.574 | 7.452 | |
| 11 | LEG | /MIXER | | 498.574 | 1483.030 | |
| 13 | LEG | /RADIN | 453.141 | 498.574 | 3.726 | |
| 17 | LEG | /RADIN | 453.141 | 498.574 | 3.726 | |
| 14 | RADOUT | /RADIN | 446.023 | 453.318 | 3.726 | |
| 15 | RADOUT | /RADIN | 442.470 | 446.216 | 3.726 | |
| 16 | RADOUT | /MIXER | | 442.059 | 3.726 | |
| 18 | RADOUT | /RADIN | 446.023 | 453.318 | 3.726 | |
| 19 | RADOUT | /RADIN | 348.510 | 446.216 | 3.726 | |
| 20 | RADOUT | /MIXER | | 348.601 | 3.726 | |
| 21 | EXCH IN | /PLATE OUT | | 507.758 | 100.000 | |
| 22 | EXCH OUT | /PLATE IN | 508.209 | 498.691 | 100.000 | 200.000 |

GAS PROPERTIES

TIME = 2.000

| NODE NO | SPECIFIC HEAT | WATER PSI | NITROGEN PSI | OXYGEN PSI | CO2 PSI | TOTAL PSI |
|---------|---------------|-----------|--------------|------------|---------|-----------|
| 1 | .210 | .105 | 11.600 | 3.100 | .070 | 14.700 |
| 2 | .210 | .106 | 11.600 | 3.100 | .071 | 14.700 |
| 3 | .210 | .106 | 11.600 | 3.100 | .070 | 14.700 |
| 4 | .210 | .105 | 11.600 | 3.100 | .070 | 14.700 |

 PAUSE FOR HARDCOPY. ENTER ANY CHARACTER TO CONTINUE

 CONSUMABLES USAGE

| SOURCE | INITIAL AVAILABLE | QUANTITY USED | QUANTITY REMAINING |
|--------|-------------------|---------------|--------------------|
| 1 | .000 | 3.065 | -3.065 |
| 2 | .000 | 1.131 | -1.131 |
| 3 | .000 | .000 | .000 |
| 4 | .000 | -383 | 383 |
| 5 | .000 | 263.929 | -263.929 |
| 6 | .000 | 12.292 | -12.292 |

PAUSE FOR HARDCOPY. ENTER ANY CHARACTER TO CONTINUE

Figure 3.4. Performance Data Output (Cont.)

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TFEAR
TEST PLOT OPTION

FLUID PROPERTIES

TIME = 3.000

| NODE NO | | COMP TEMP DEG | FLUID TEMP DEG | WCP BTU/HR DEG | HEAT LOAD BTU/HR |
|---------|-----------|---------------|----------------|----------------|------------------|
| 1 | CABIN IN | | 497.165 | 501.000 | 2001.000 |
| 2 | CABIN OUT | | 502.231 | 501.000 | |
| 3 | LIGH OUT | | 502.510 | 501.000 | |
| 4 | COND. OUT | | 497.215 | 501.000 | 450.000 |
| 5 | EVAP IN | 495.000 | 497.580 | 1490.482 | |
| 6 | EVAP OUT | 495.350 | 495.345 | 1490.482 | |
| 7 | PLATE OUT | | 495.349 | 1490.482 | 3305.164 |
| 8 | INTF OUT | | 497.566 | 1490.482 | 300.000 |
| 9 | PLATE OUT | 497.807 | 497.775 | 1490.482 | |
| 10 | EXCH OUT | | 498.214 | 1490.482 | |
| 12 | LEG | | 498.214 | 7.452 | |
| 11 | LEG | | 498.214 | 1483.029 | |
| 13 | LEG | 425.292 | 498.214 | 3.726 | |
| 17 | LEG | 425.292 | 498.214 | 3.726 | |
| 14 | RADOUT | 413.539 | 425.401 | 3.726 | |
| 15 | RADOUT | 410.168 | 413.677 | 3.726 | |
| 16 | RADOUT | | 410.307 | 3.726 | |
| 18 | RADOUT | 413.540 | 425.401 | 3.726 | |
| 19 | RADOUT | 332.595 | 413.677 | 3.726 | |
| 20 | RADOUT | | 332.665 | 3.726 | |
| 21 | EXCH IN | | 504.822 | 100.000 | |
| 22 | EXCH OUT | 505.155 | 498.295 | 100.000 | 400.000 |

GAS PROPERTIES

TIME = 3.000

| NODE NO | SPECIFIC HEAT | WATER PSI | NITROGEN PSI | OXYGEN PSI | CO2 PSI | TOTAL PSI |
|---------|---------------|-----------|--------------|------------|---------|-----------|
| 1 | .210 | .105 | 11.600 | 3.100 | .068 | 14.700 |
| 2 | .210 | .105 | 11.600 | 3.100 | .069 | 14.700 |
| 3 | .210 | .106 | 11.600 | 3.100 | .068 | 14.700 |
| 4 | .210 | .105 | 11.600 | 3.100 | .068 | 14.700 |

PAUSE FOR HARDCOPY. ENTER ANY CHARACTER TO CONTINUE

CONSUMABLES
USAGE

TIME = 3.000

| SOURCE | INITIAL AVAILABLE | QUANTITY USED | QUANTITY REMAINING |
|--------|-------------------|---------------|--------------------|
| 1 | .000 | 4.597 | -4.597 |
| 2 | .000 | 1.696 | -1.696 |
| 3 | .000 | .000 | .000 |
| 4 | .000 | .486 | -.486 |
| 5 | .000 | 395.894 | -395.894 |
| 6 | .000 | 15.672 | -15.672 |

PAUSE FOR HARDCOPY. ENTER ANY CHARACTER TO CONTINUE

Figure 3.4. Performance Data Output (Cont.)

TEBAR
TEST PLOT OPTION

FLUID PROPERTIES

TIME = 4.000

| NODE NO | | | COMP TEMP DEG | FLUID TEMP DEG | WCF BTU/HR DEG | HEAT LOAD BTU/HR |
|---------|-----------|------------|---------------|----------------|----------------|------------------|
| 1 | CABIN IN | HEATER OUT | | 497.073 | 501.000 | 2001.000 |
| 2 | CABIN OUT | LITR IN | | 502.138 | 501.000 | |
| 3 | LITR OUT | COND. IN | | 502.363 | 501.000 | |
| 4 | COND. OUT | HEATER IN | 497.121 | 496.166 | 501.000 | 450.000 |
| 5 | EVAP IN | THROT IN | 496.000 | 497.000 | 1490.482 | |
| 6 | EVAP OUT | PLATE IN | 496.323 | 496.321 | 1490.482 | |
| 7 | PLATE OUT | INTF IN | | 496.323 | 1490.482 | 3229.835 |
| 8 | INTF OUT | PLATE IN | 497.304 | 497.426 | 1490.482 | 400.000 |
| 9 | PLATE OUT | EXCH IN | | 497.767 | 1490.482 | |
| 10 | EXCH OUT | DYVERT | | 498.125 | 1490.482 | |
| 12 | LEG | BRANCH | | 498.125 | 7.452 | |
| 11 | LEG | MIXER | | 498.125 | 1453.079 | |
| 13 | LEG | RADIN | 407.706 | 498.125 | 3.726 | .013 |
| 17 | LEG | RADIN | 407.706 | 498.125 | 3.726 | .013 |
| 14 | RADOUT | RADIN | 389.867 | 407.776 | 3.726 | .013 |
| 15 | RADOUT | RADIN | 389.774 | 389.979 | 3.726 | .013 |
| 16 | RADOUT | MIXER | | 389.881 | 3.726 | |
| 18 | RADOUT | RADIN | 389.867 | 407.777 | 3.726 | .013 |
| 19 | RADOUT | RADIN | 320.268 | 389.979 | 3.726 | .013 |
| 20 | RADOUT | MIXER | | 320.323 | 3.726 | |
| 21 | EXCH IN | PLATE OUT | | 503.506 | 100.000 | |
| 22 | EXCH OUT | PLATE IN | 503.063 | 498.197 | 100.000 | 400.000 |

GAS PROPERTIES

TIME = 4.000

| NODE NO | SPECIFIC HEAT | WATER PSI | NITROGEN PSI | OXYGEN PSI | CO2 PSI | TOTAL PSI |
|---------|---------------|-----------|--------------|------------|---------|-----------|
| 1 | .210 | .105 | 11.600 | 3.100 | .069 | 14.700 |
| 2 | .210 | .105 | 11.600 | 3.100 | .069 | 14.700 |
| 3 | .210 | .105 | 11.600 | 3.100 | .069 | 14.700 |
| 4 | .210 | .105 | 11.600 | 3.100 | .069 | 14.700 |

PAUSE FOR HARDCOPY. ENTER ANY CHARACTER TO CONTINUE

CONSUMABLES
USAGE

| SOURCE | TIME = 4.000 | INITIAL AVAILABLE | QUANTITY USED | QUANTITY REMAINING |
|--------|--------------|-------------------|---------------|--------------------|
| 1 | | .000 | 6.129 | -6.129 |
| 2 | | .000 | 2.261 | -2.261 |
| 3 | | .000 | .000 | .000 |
| 4 | | .000 | .577 | -.577 |
| 5 | | .000 | 527.858 | -527.858 |
| 6 | | .000 | 19.693 | -19.693 |

PAUSE FOR HARDCOPY. ENTER ANY CHARACTER TO CONTINUE

Figure 3.4. Performance Data Output (Cont.)

TFEAR
TEST PLOT OPTION

FLUID PROPERTIES

TIME = 5.000

| NODE NO | | | COMP TEMP DEG | FLUID TEMP DEG | WCP BTU/HR DEG | HEAT LOAD BTU/HR |
|---------|-----------|-------------|---------------|----------------|----------------|------------------|
| 1 | CABIN IN | /HEATER OUT | | 497.041 | 501.000 | 2001.000 |
| 2 | CABIN OUT | /LIQH IN | | 502.106 | 501.000 | |
| 3 | LIQH OUT | /COND. IN | | 502.291 | 501.000 | |
| 4 | COND. OUT | /HEATER IN | 497.089 | 496.131 | 501.000 | 450.000 |
| 5 | EVAP IN | /JUNCTION | 495.000 | 497.314 | 1490.482 | |
| 6 | EVAP OUT | /PLATE IN | 495.310 | 495.309 | 1490.482 | |
| 7 | PLATE OUT | /INTF IN | | 495.310 | 1490.482 | 3203.921 |
| 8 | INTF OUT | /PLATE IN | 497.844 | 497.460 | 1490.482 | 500.000 |
| 9 | PLATE OUT | /EXCH IN | | 497.793 | 1490.482 | |
| 10 | EXCH OUT | /DIVERT | | 498.111 | 1490.482 | |
| 12 | LEG | /BRANCH | | 498.111 | 7.452 | |
| 11 | LEG | /MIXER | | 498.111 | 1483.029 | |
| 13 | LEG | /RADIN | 396.171 | 498.111 | 3.726 | |
| 17 | LEG | /RADIN | 396.172 | 498.111 | 3.726 | |
| 14 | RADOUT | /RADIN | 372.059 | 396.218 | 3.726 | |
| 15 | RADOUT | /RADIN | 366.563 | 372.136 | 3.726 | |
| 16 | RADOUT | /MIXER | | 366.649 | 3.726 | |
| 18 | RADOUT | /RADIN | 372.059 | 396.219 | 3.726 | |
| 19 | RADOUT | /RADIN | 310.480 | 372.172 | 3.726 | |
| 20 | RADOUT | /MIXER | | 310.51 | 3.726 | |
| 21 | EXCH IN | /PLATE OUT | | 502.910 | 100.000 | |
| 22 | EXCH OUT | /PLATE IN | 503.156 | 498.170 | 100.000 | 400.000 |

GAS PROPERTIES

TIME = 5.000

| NODE NO | SPECIFIC HEAT | WATER PSI | NITROGEN PSI | OXYGEN PSI | CO2 PSI | TOTAL PSI |
|---------|---------------|-----------|--------------|------------|---------|-----------|
| 1 | .210 | .104 | 11.600 | 3.100 | .071 | 14.700 |
| 2 | .210 | .105 | 11.600 | 3.100 | .072 | 14.700 |
| 3 | .210 | .105 | 11.600 | 3.100 | .071 | 14.700 |
| 4 | .210 | .104 | 11.600 | 3.100 | .071 | 14.700 |

PAUSE FOR HARDCOPY. ENTER ANY CHARACTER TO CONTINUE

CONSUMABLES
USAGE

TIME = 5.000

| SOURCE | INITIAL AVAILABLE | QUANTITY USED | QUANTITY REMAINING |
|--------|-------------------|---------------|--------------------|
| 1 | .000 | 7.661 | -7.661 |
| 2 | .000 | 2.827 | -2.827 |
| 3 | .000 | .000 | .000 |
| 4 | .000 | -.661 | .661 |
| 5 | .000 | 659.823 | -659.823 |
| 6 | .000 | 21.559 | -21.559 |

PAUSE FOR HARDCOPY. ENTER ANY CHARACTER TO CONTINUE

Figure 3.4. Performance Data Output (Concl.)

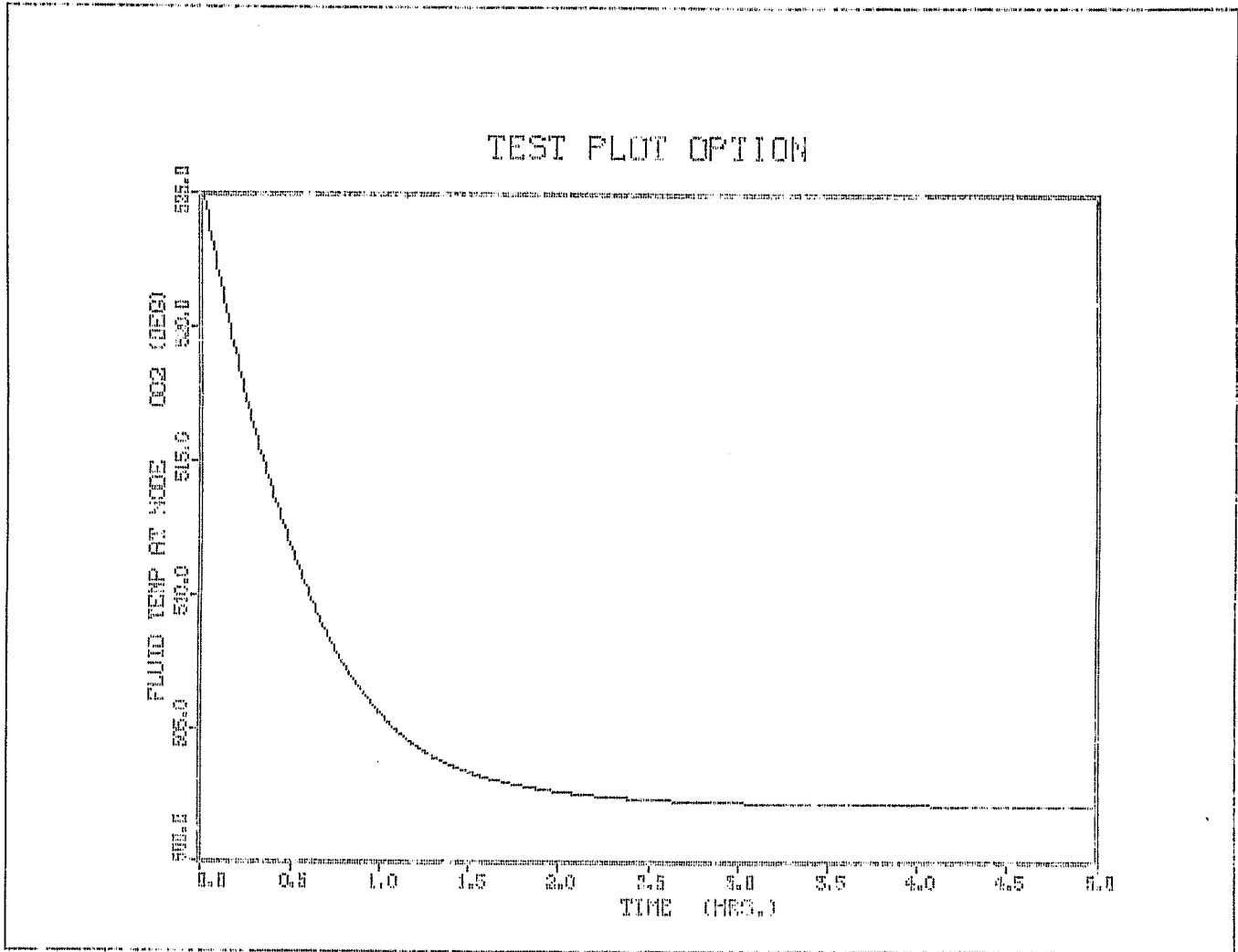


Figure 3.5. Plot Data Output

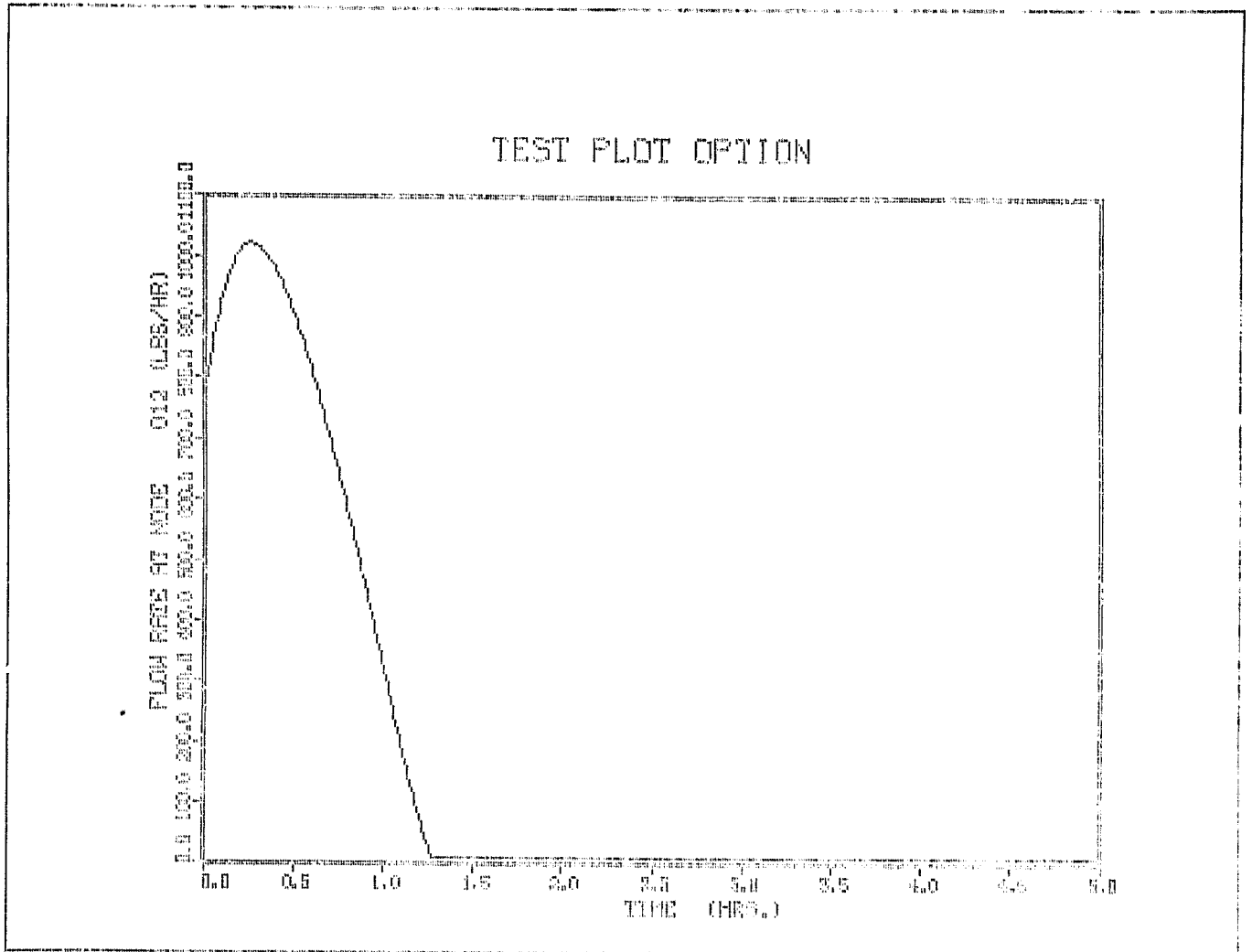
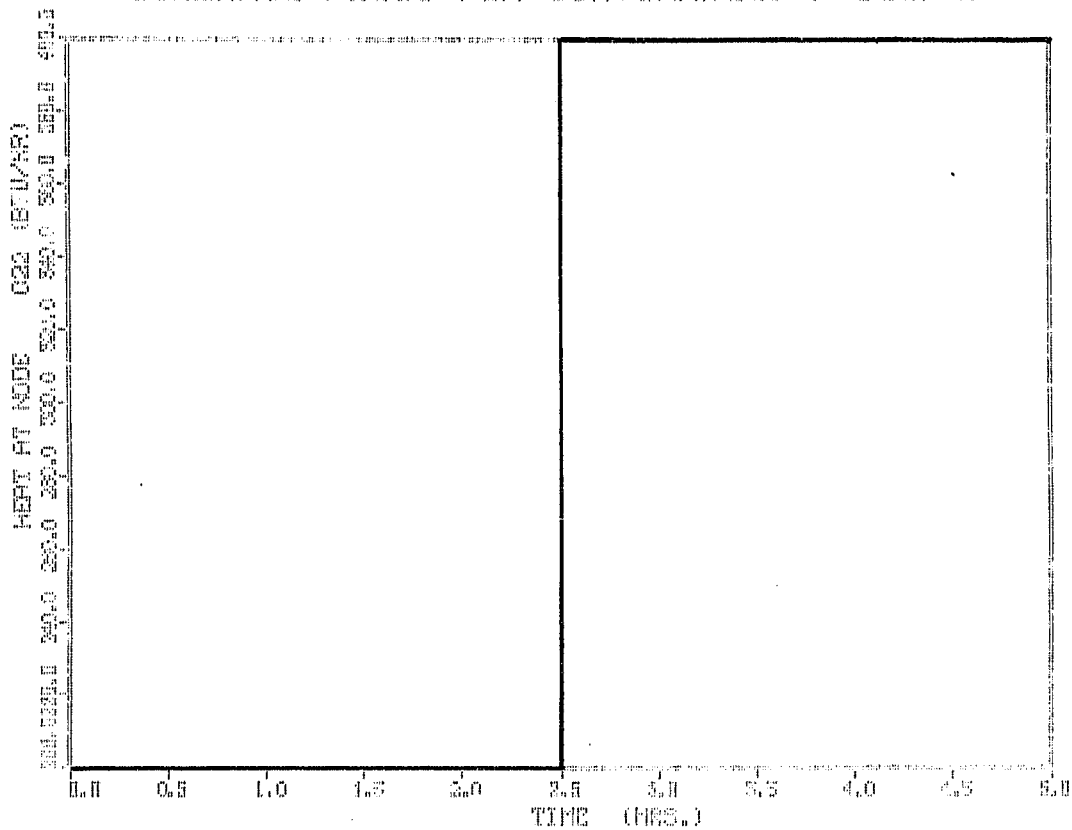


Figure 3.5. Plot Data Output (Cont.)

GENERATE PLOTS FOR CONSUMABLES ROUTINES



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Figure 3.5. Plot Data Output (Concl.)

APPENDIX A
COMPUTER CONTROL INFORMATION

MAP USED TO EXECUTE MAINED PROGRAM.

```
1:SEG MAIN
2:IN FM2-T61867*FEAR.MAIN20
3:SEG A*,(NAME)
4:IN FM2-T61867*FEAR.START
5:SEG B*,(NAME)
6:IN FM2-T61867*FEAR.LOOP
7:SEG C*,(NAME)
8:IN FM2-T61867*FEAR.SPLIT,FM2-T61867*FEAR.PLOTE
9:SEG D*,(NAME)
10:IN FM2-T61867*FEAR.MIN,FM2-T61867*FEAR.MOD, FM2-T61867*FEAR.EVNT
11:SEG E*,(NAME)
12:IN FM2-T61867*FEAR.CONVERG
13:SEG F*,(NAME)
14:IN FM2-T61867*FEAR.PRINT
15:SEG G*,(NAME)
16:IN FM2-T61867*FEAR.TABLE/NEW,FM2-T61867*FEAR.STEP/NEW
17:SEG F1*,(F)
18:IN FM2-T61867*FEAR.DTANK,FM2-T61867*FEAR.TRAJ,FM2-T61867*FEAR.PT
TAPE
19:SEG F2*,(F)
20:IN DPLOOT
21:SEG F3*,(F)
22:IN FM2-T61867*FEAR.SCHEN/PL0T
23:SEG F31*,(F3)
24:IN ALFACT,CARTOG
25:SEG F32*,(F3)
26:IN DATA,CATB,CATC
27:SEG F33*,(F3)
28:IN BARS
29:SEG F4*,(F)
30:IN FM2-T61867*FEAR.GASPR,FM2-T61867*FEAR.COMPR,FM2-T61867*FEAR.E
EPS/NEW
31:SEG F5*,(F)
32:IN FM2-T61867*FEAR.PLOOT
33:EQI 105*/0227
34:LIB FM2-T61867*FEAR.
35:LIB MSC*LOCALIB.
36:LIB DISPLA*LIB.
37:LIB FD6*MOPSPLT.
EOF:37 SCAM:36
0:>
```

Figure A-1. MAP

```

ENTER USERID/PASSWORD:
>
*DESTROY USERID/PASSWORD ENTRY
*UNIVAC 1100 OPERATING SYSTEM VER. 3CR30#A09-G1(CSI)*
>WRIN 660KPC,FM2#9212,TRM-153091
DATE: 061780 TIME: 145306
>WASB,A FM2-T61867#FEAR#0061.
READY
>WSE ALT.,FM2-T61867#FEAR#L#0061. PROGRAM FILE
READY
>WASB,A DATA.
FACILITY REJECTED 400010000000
>WASE,CP DATA.
READY
>WISC#CALLUP TAPES 153091#660KPC.,X11837 RESTART TAPE
REQUEST HAS BEEN ACCEPTED
>WFREE DATA.
READY
>WASB,A DATA.
READY
>WSE 1.,DATA. FORTRAN UNIT 1
READY
>WASB,CP PLOTS,F#400#1000 INTERMEDIATE PLOT FILE
READY
>WFREE PLOTS.
READY
>WASB,A PLOTS.
READY
>WSE 4.,PLOTS. FORTRAN UNIT 4
READY
>WASB,TJ TAPE.,8C,X11837
WAITING ON FACILITY
READY
>WREIND TAPE.
PURPLR 27R30 E33 5L73R1 06/17/80 15:05:15
>WCOPY TAPE.,DATA.
3 BLOCKS COPIED.
EOF ENCOUNTERED ON INPUT TAPE
>WREIND TAPE.
>WFREE TAPE. DO NOT TIE UP TAPE DRIVES LONGER THAN NECESSARY
READY
>WOT ALT.TFEAR.
*BCS-SIGN-ON TO F6 CONFIRMED*

```

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Figure A-2. Computer Control