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NASA CR-
160770

ADVANCED FLIGHT DESIGN SYSTEMS

SUBSYSTEM PERFORMANCE MODELS

JUNE 1980

CONTRACT NO. NAS9-15793

SAMPLE MODEL

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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.

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LIST OF TABLES

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 CO_2 removal system at Node 2. Cabin make-up Nitrogen and Oxygen are extracted from Source 1 and 2. CO_2 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.

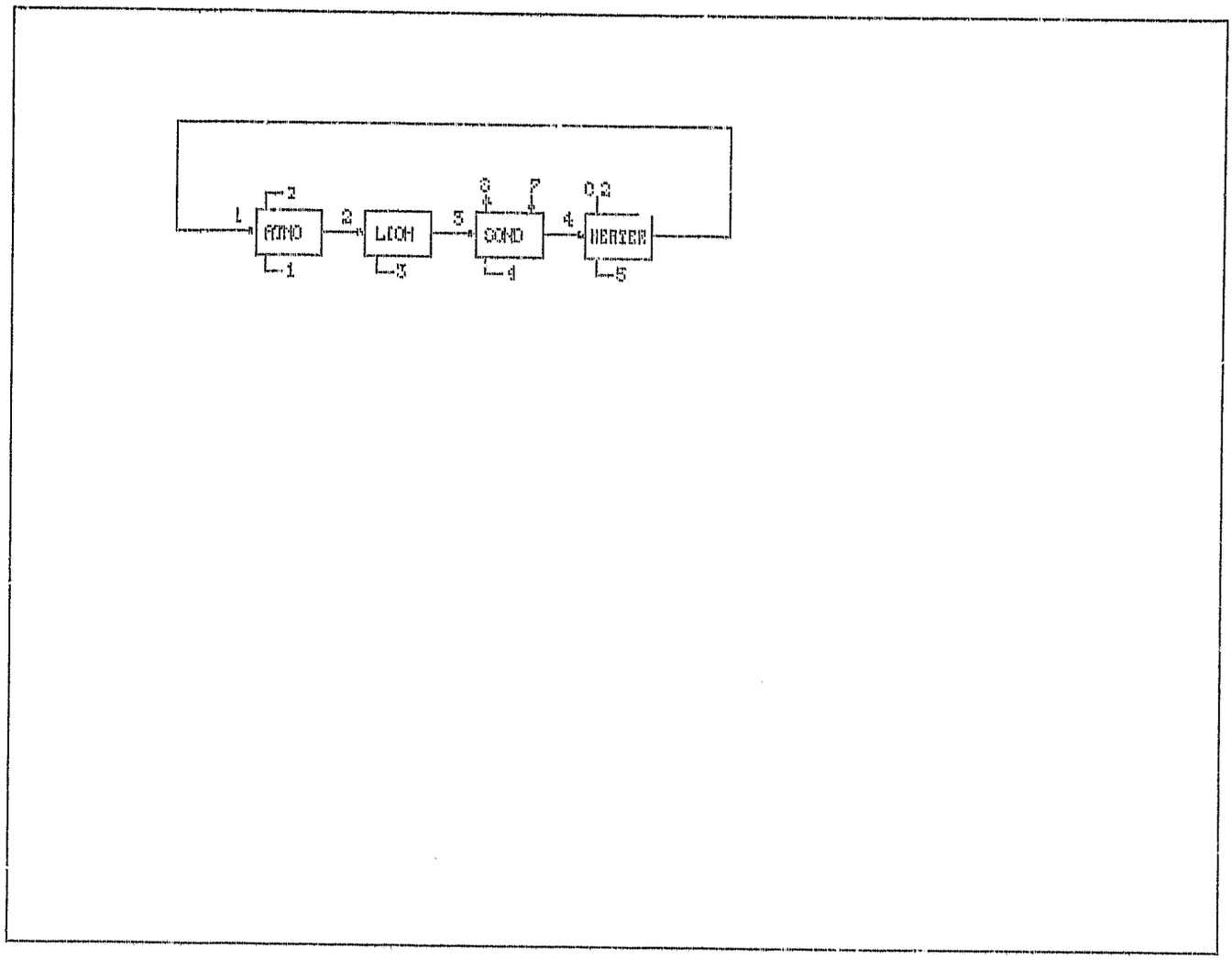

Figure 2.1. Sample Model Schematic

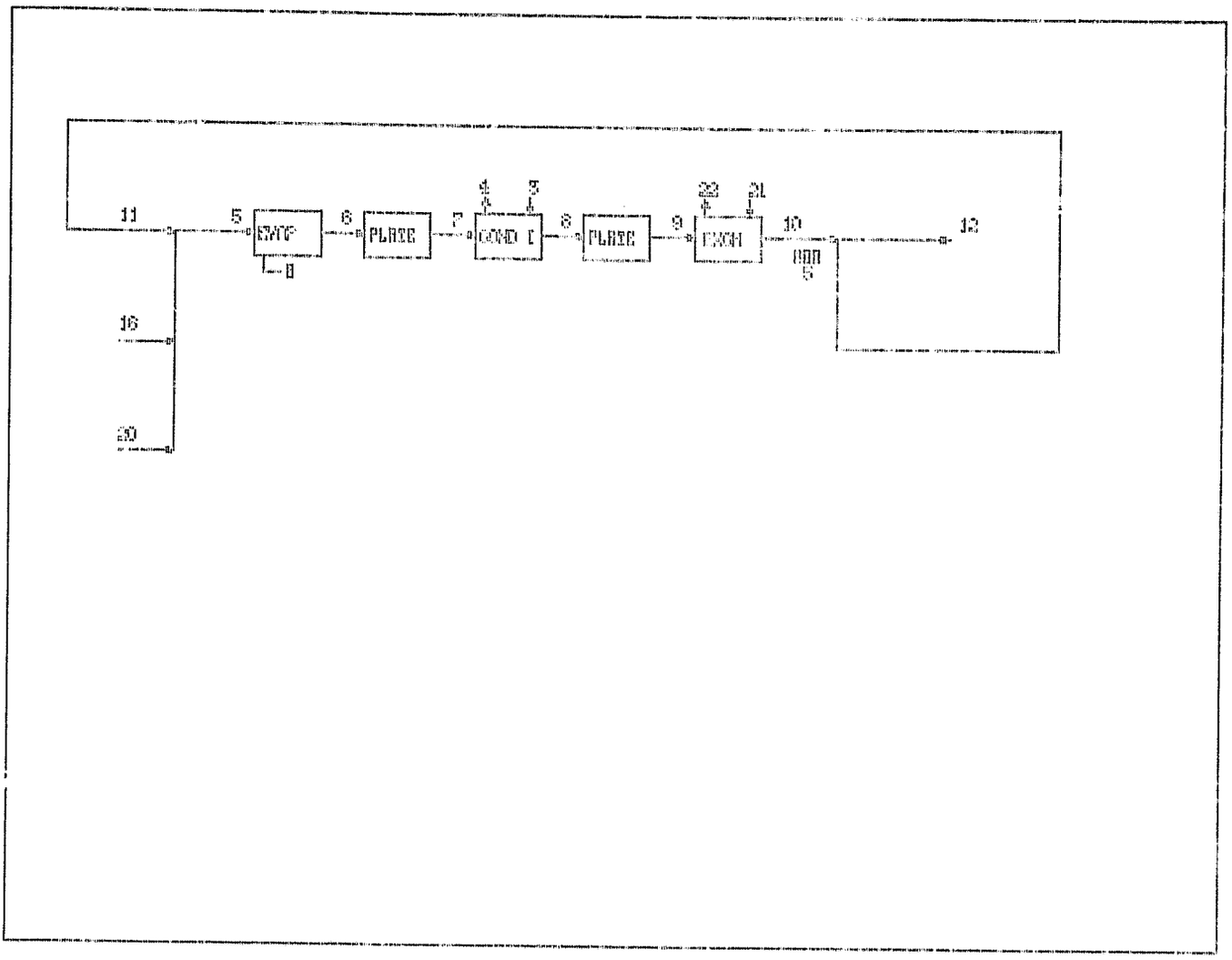

Figure 2.1. Sample Model Schematic (Cont.)

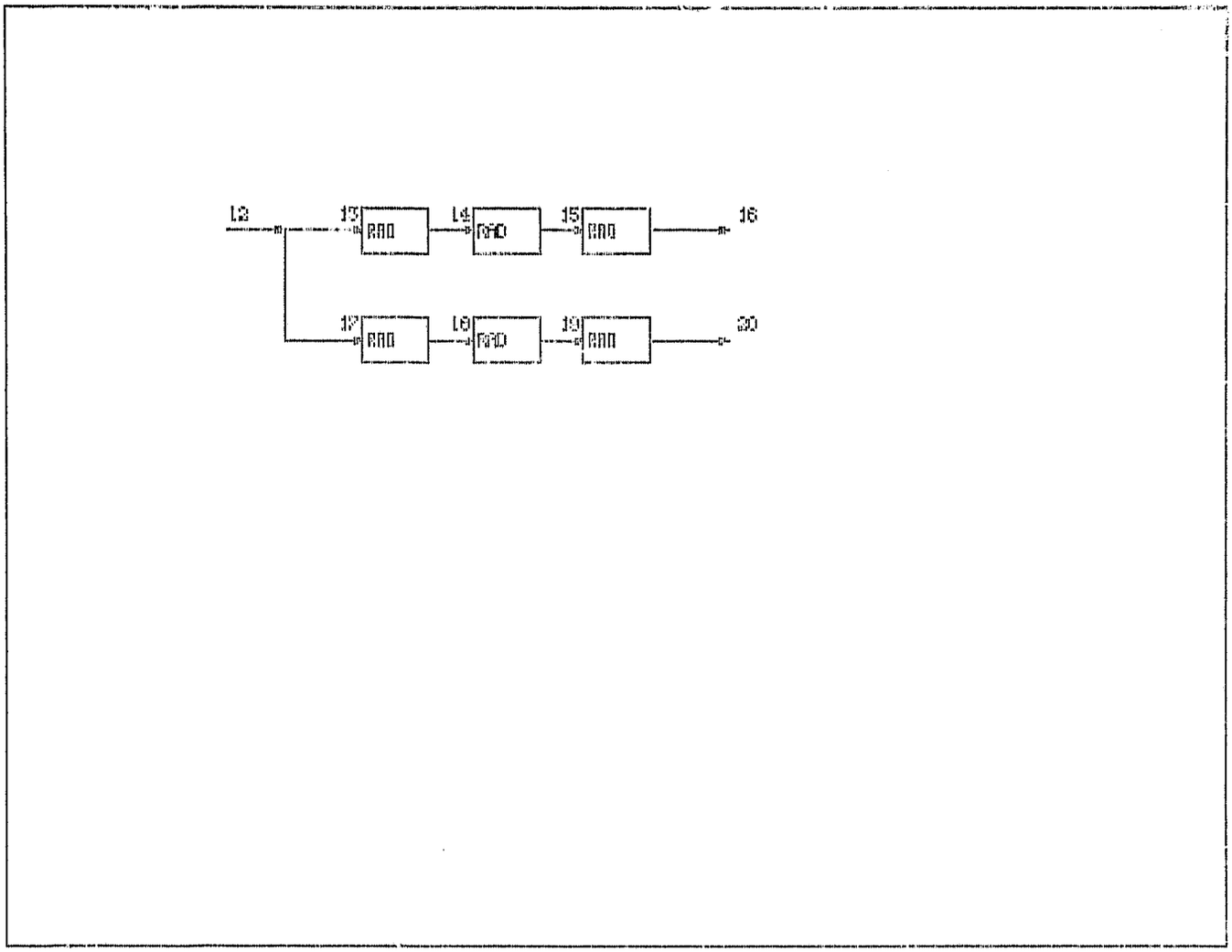

Figure 2.1. Sample Model Schematic (Cont.)

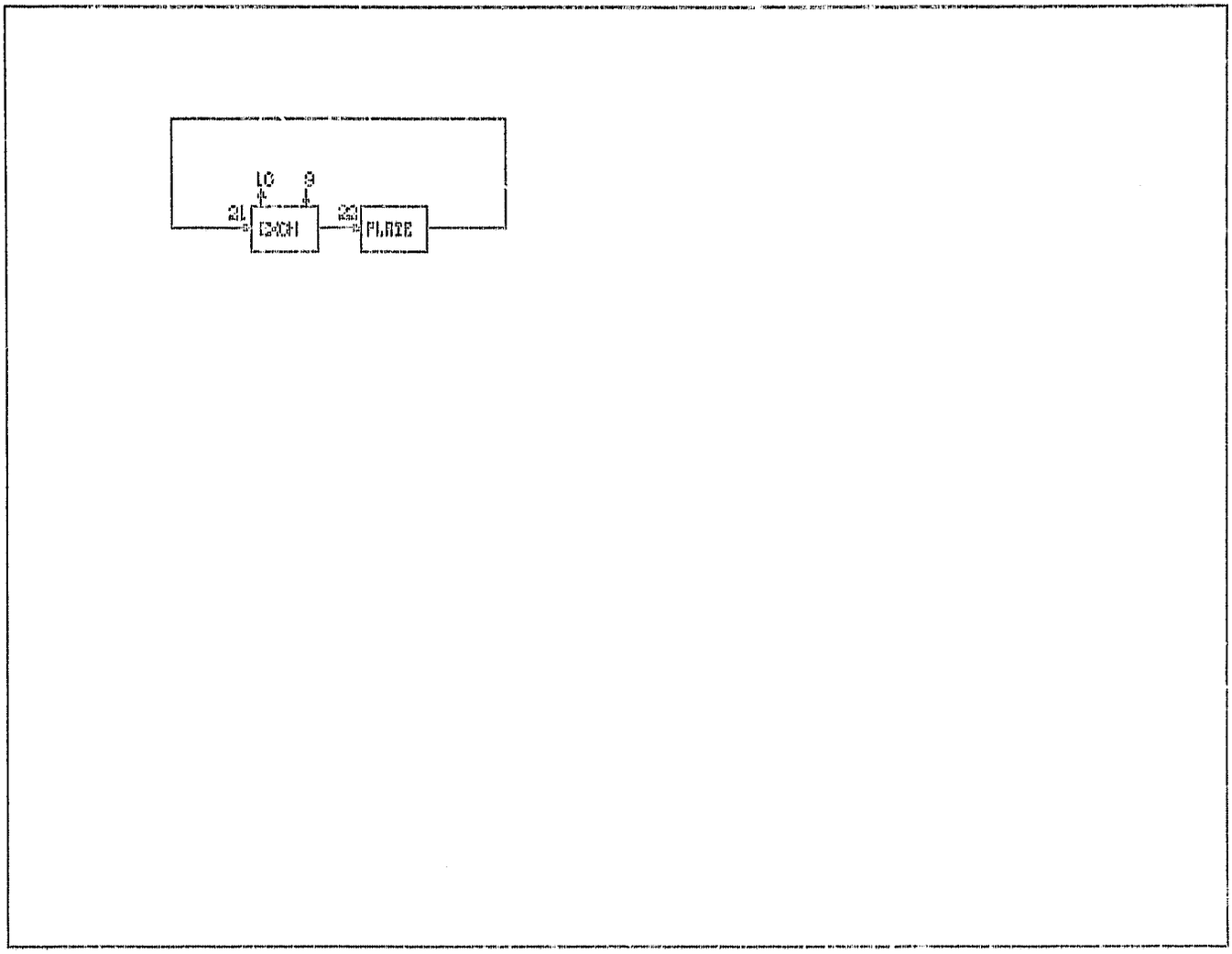

Figure 2.1. Sample Model Schematic (Concl.)

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 componant 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.

```
      1:       COMMON/HEAT/ K,L,TEMP,P(100,2),F(100,2),C(100,20),TC(100,1
     2)
      2:       COMMON/TIMES/DELT,DELTO2,TIME,TSTOP,PRNT
      3:       COMMON/WRITE/ IWRITE,IPRNT,ICNT,IRUN,IFRST
      4:       COMMON/PSST/ NPLTS,IPLT(25),JPLT(25),METFO(25)
      5:       COMMON/TABS/ X(500),Y(500),INTAB(20),INO
      6:       COMMON/LUMP2/ ATITLE(12),BIG(25),WEE(25)
      7:       COMMON/NEW/ NPLPTS,NERG,NOMCRE
      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 /SE0/ NSE0(100),NNODES,MSE0(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 ATMO(1,2)
     25:       CALL LION(2,3)
     26:       CALL CONXG(3,4,7,8)
     27:       CALL HEATER(4,1)
     28:       CALL CONVRG(1,5.,20,$101,$100)
     29:   101 CONTINUE
     30: C                                       LIQUID COOLANT SYSTEM
29:)
```


Table 3.1. Sample Model Driver (Main)

```
**********
 FORTRAN ENVIRONMENTAL
   ANALYSIS ROUTINES
    CONTROL DISPLAY
ENTER RUN MODE (INTEGER)
   NEW START = 0
   RESTART   = 1
ENTER OUTPUT OPTION
   NO RESTART TAPE     = 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	1.000	500.000

TABLE 2

	XX	YY
1	.000	200.000
2	2.500	400.000

NODE 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

NODE 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 NODES	IN	3	OUT	4
INTERFACE SIDE NODES	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.	OUTLET NODE NO.
4	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
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     INITAL 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       OUTLET NODE NUMBER
            5                       6
**************************************************


   **************************************************
                       NODE NUMBER  6
                        COLD PLATE
   ITEM
   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          OUTLET NODE NUMBER
                    6                         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    ATMOSPERIC 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          OUTLET NODE NUMBER
                8                          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                     518.751   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 VALVE
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          1490.484BTU/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
                  LEG NODE      FLOW
           ITEM    NUMBER    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                                          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     EMMISIVITY                                .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     NODE COUPLING                             0    INTEGER
         NO = 0
         YES = 1
15     SHADOW NODE NUMBER                       25    INTEGER
  INLET NODE NUMBER      OUTLET NODE NUMBER
          13                     14
**********************************************************************
```


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

```
**********************************************************************
                        SHADOWING DATA
                        FOR NODE NO. 13
                        SHADOWED BY 25

ITEM
1     SHADOW NODE AREA                                    1.000  SQ FT
2     ANGLE OF INCIDENCE                                   .060  RAD
3     DIHEDRAL ANGLE                                       .000  RAD
4     STAND-OFF VECTOR DATA                                  25  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     EMMISIVITY                                       .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    NODE COUPLING                                        0  INTEGER

        NO = 0
        YES = 1
15    SHADOW NODE NUMBER                                   0  INTEGER
  INLET NODE NUMBER     OUTLET NODE NUMBER
         14                    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     EMMISIVITY                                       .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.                  520.999  DEG
14    NODE COUPLING                                        0  INTEGER

        NO = 0
        YES = 1
15    SHADOW NODE NUMBER                                   0  INTEGER
  INLET NODE NUMBER     OUTLET NODE NUMBER
         15                    16
**********************************************************************
```

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     EMMISIVITY                                      .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     NODE COUPLING                                     0  INTEGER

         NO = 0
         YES = 1
15     SHADOW NODE NUMBER                                0  INTEGER
  INLET NODE NUMBER      OUTLET NODE NUMBER
         17                      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     EMMISIVITY                                      .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     NODE COUPLING                                     0  INTEGER

         NO = 0
         YES = 1
15     SHADOW NODE NUMBER                                0  INTEGER
  INLET NODE NUMBER      OUTLET NODE NUMBER
         18                      19
```


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     EMMISIVITY                                     .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.               520.999   DEG
14     NODE COUPLING                                    0   INTEGER

         NO = 0
         YES = 1
15     SHADOW NODE NUMBER                               0   INTEGER
  INLET NODE NUMBER      OUTLET NODE NUMBER
         19                     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
                      COLD PLATE
ITEM
1       THERMAL CAPACITY                  150.000      BTU/DEG
2       OVERALL HEAT TRANSFER
          COEF.                           300.000      BTU/HR DEG
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      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              OUTLET NODE NUMBER
             22                                  21
**********************************************************
```

```
**********************************************************
            THERMAL COUPLING DATA
              FOR NODE NO.  22
            COUPLED TO 1 NODES
          TYPE OF HEAT TRANSFER AND
 ITEM     COUPLING NODE NUMBER CODE      VALUE
   1                  100                 .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.	COPY OF CONSUMABLE	UNIT	INITIAL LIQU.MS
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 RADII(ER.) 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

PRINT OPTION
DISPLAY

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

FUNCTION MENU

YPE	DESCRIPTION	
1	FLUID TEMP	(DEG/R)
2	COMP TEMP	(DEG/R)
3	FLOW RATE	(LPS/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                                      COMP      FLUID      WCP      HEAT
 NO                                       TEMP      TEMP     BTU/HR    LOAD
                                          DEG       DEG        DEG     BTU/HR
  1   CABIN IN     /HEATER OUT                    519.990    501.000  2001.000
  2   CABIN OUT    /LIOH IN                       510.165    501.000
  3   LIOH OUT     /COND. IN                      512.278    501.000
  4   COND. OUT    /HEATER IN          521.000    500.830    501.000   450.000
  5   EVAP IN      /JUNCTION           495.000    519.979   1490.484
  6   EVAP OUT     /PLATE IN           500.000    498.474   1490.484
  7   PLATE OUT    /INTF IN                       499.715   1490.484  6636.095
  8   INTF OUT     /PLATE IN           521.000    504.167   1490.484
  9   PLATE OUT    /EXCH IN                       518.751   1490.484
 10   EXCH OUT     /DIVERT                        518.891   1490.484
 12   LEG          /BRANCH                        518.891    769.090
 11   LEG          /MIXER                         518.891    721.394
 13   LEG          /RADIN              521.000    518.891    384.545
 17   LEG          /RADIN              521.000    518.891    384.545
 14   RADOUT       /RADIN              521.000    520.957    384.545
 15   RADOUT       /RADIN              521.000    520.999    384.545
 16   RADOUT       /MIXER                         521.000    384.545
 18   RADOUT       /RADIN              521.000    520.957    384.545
 19   RADOUT       /RADIN              521.000    520.999    384.545
 20   RADOUT       /MIXER                         521.000    384.545
 21   EXCH IN      /PLATE OUT                     520.896    100.000
 22   EXCH OUT     /PLATE IN           521.000    518.916    100.000   200.000
**********************************************************************

                              GAS PROPERTIES

TIME =     .000

NODE   SPECIFIC     WATER     NITROGEN     OXYGEN       CO2          TOTAL
 NO      HEAT       PSI         PSI         PSI         PSI           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 =     .000
                 INITIAL          QUANTITY         QUANTITY
      SOURCE     AVAILABLE          USED           REMAINING
         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                                        COMP      FLUID      WCP       HEAT
 NO                                         TEMP      TEMP     BTU/HR      LOAD
                                            DEG       DEG        DEG      BTU/HR
  1    CABIN IN      /HEATER OUT                    500.405    501.000   2001.000
  2    CABIN OUT     /LIOH IN                       505.543    501.000
  3    LIOH OUT      /COND. IN                      506.041    501.000
  4    COND. OUT     /HEATER IN          500.574    496.495    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    498.557   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   1172.202
 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    SPECIFIC      WATER      NITROGEN     OXYGEN        C02          TOTAL
 NO       HEAT         PSI         PSI         PSI          PSI          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
TIME =     1.000
            INITIAL                 QUANTITY              QUANTITY
SOURCE     AVAILABLE                  USED                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

                                        COMP      FLUID       WCP        HEAT
                                        TEMP      TEMP      BTU/HR       LOAD
NODE                                    DEG       DEG         DEG      BTU/HR
 NO
  1    CABIN IN      /HEATER OUT                 497.571     501.000   2001.000
  2    CABIN OUT     /LIOH IN                    502.644     501.000
  3    LIOH 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     495.059    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     453.310       3.726
 15    RADOUT        /RADIN          442.470     446.216       3.726
 16    RADOUT        /MIXER                      442.659       3.726
 18    RADOUT        /RADIN          446.023     453.310       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    200.006
**********************************************************************
**********************************************************************
.
                          GAS PROPERTIES

TIME =    2.000

NODE    SPECIFIC      WATER      NITROGEN      OXYGEN        C02          TOTAL
 NO       HEAT         PSI          PSI          PSI          PSI          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
      TIME =     2.000
                  INITIAL                QUANTITY          QUANTITY
      SOURCE     AVAILABLE                USED            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.)

```
**********************************************************************
      TFEAR
      TEST PLOT OPTION
                              FLUID PROPERTIES
TIME =    3.000

NODE                                        COMP       FLUID       WCP        HEAT
 NO                                         TEMP       TEMP      BTU/HR      LOAD
                                            DEG        DEG         DEG      BTU/HR
  1    CABIN IN      /HEATER OUT                      497.165     501.000   2001.000
  2    CABIN OUT     /LIGH IN                         502.231     501.000
  3    LIGH OUT      /COND. IN                        502.510     501.000
  4    COND. OUT     /HEATER IN          497.215      496.202     501.000    450.000
  5    EVAP IN       /JUNCTION           495.009      497.580    1490.482
  6    EVAP OUT      /PLATE IN           495.350      495.345    1490.482
  7    PLATE OUT     /INTF IN                         495.349    1490.482   3305.164
  8    INTF OUT      /PLATE IN           497.807      497.566    1490.482    300.000
  9    PLATE OUT     /EXCH IN                         497.775    1490.482
 10    EXCH OUT      /DIVERT                          498.214    1490.482
 12    LEG           /BRANCH                          498.214       7.452
 11    LEG           /MIXER                           498.214    1483.029
 13    LEG           /RADIN              425.292      498.214       3.726
 17    LEG           /RADIN              425.292      498.214       3.726
 14    RADOUT        /RADIN              413.539      425.401       3.726
 15    RADOUT        /RADIN              410.168      413.677       3.726
 16    RADOUT        /MIXER                           410.307       3.726
 18    RADOUT        /RADIN              413.540      425.401       3.726
 19    RADOUT        /RADIN              332.595      413.677       3.726
 20    RADOUT        /MIXER                           332.665       3.726
 21    EXCH IN       /PLATE OUT                       504.822     100.000
 22    EXCH OUT      /PLATE IN           505.155      498.295     100.000    400.000
**********************************************************************
**********************************************************************

                              GAS PROPERTIES

TIME =    3.000

NODE    SPECIFIC      WATER     NITROGEN     OXYGEN        C02          TOTAL
 NO       HEAT         PSI         PSI         PSI         PSI           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
             INITIAL          QUANTITY          QUANTITY
SOURCE     AVAILABLE            USED            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.)

```
**********************************************************************
      TREAR
      TEST PLOT OPTION
                              FLUID PROPERTIES
TIME =    4.000
                                        COMP      FLUID      WCP        HEAT
                                        TEMP      TEMP     BTU/HR      LOAD
NODE                                    DEG       DEG        DEG      BTU/HR
 NO
  1    CABIN IN      /HEATER OUT                  497.073    501.000  2001.000
  2    CABIN OUT     /LIOH IN                     492.143    501.000
  3    LIOH OUT      /COND. IN                    487.213    501.000
  4    COND. OUT     /HEATER IN       497.121     486.156    501.000   450.000
  5    EVAP IN       /JUNCTION        495.000     497.100   1498.482
  6    EVAP OUT      /PLATE IN        495.323     496.321   1498.482
  7    PLATE OUT     /INTF IN                     495.323   1498.482  3229.835
  8    INTF OUT      /PLATE IN        497.304     497.496   1498.482   400.000
  9    PLATE OUT     /EXCH IN                     497.762   1498.482
 10    EXCH OUT      /DIVERT                      498.125   1498.482
 12    LEG           /BRANCH                      498.125      7.452
 11    LEG           /MIXER                       498.125   1483.030
 13    LEG           /RADIN           407.406     498.125      3.726      .013
 17    LEG           /RADIN           407.796     498.125      3.726      .013
 14    RADOUT        /RADIN           389.867     497.777      3.726      .013
 15    RADOUT        /RADIN           485.774     389.970      3.726      .013
 16    RADOUT        /MIXER                       385.881      3.726
 18    RADOUT        /RADIN           389.867     497.777      3.726      .013
 19    RADOUT        /RADIN           320.260     385.979      3.726      .013
 20    RADOUT        /MIXER                       320.423      3.726
 21    EXCH IN       /PLATE OUT                   503.586    100.000
 22    EXCH OUT      /PLATE IN        503.063     498.192    100.000   400.000
**********************************************************************
**********************************************************************

                              GAS PROPERTIES

TIME =    4.000

NODE    SPECIFIC      WATER      NITROGEN     OXYGEN        CO2          TOTAL
 NO       HEAT         PSI          PSI         PSI          PSI          PSI
  1        .210         .105       11.600       3.100         .069      14.709
  2        .210         .105       11.600       3.100         .069      14.709
  3        .210         .105       11.600       3.100         .069      14.709
  4        .210         .105       11.600       3.100         .069      14.709
**********************************************************************
PAUSE FOR HARDCOPY. ENTER ANY CHARACTER TO CONTINUE


**********************************************************************
                          CONSUMABLES
                            USAGE
TIME =    4.000
          INITIAL                    QUANTITY              QUANTITY
SOURCE    AVAILABLE                    USED                REMAINING
   1          .000                     6.129                -6.129
   2          .000                     2.261                -2.261
   3          .000                      .000                  .000
   4          .000                     -.577                  .577
   5          .000                   527.855              -527.855
   6          .000                    18.693               -18.693
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                                        COMP      FLUID      WCP       HEAT
 NO                                         TEMP      TEMP     BTU/HR     LOAD
                                            DEG       DEG        DEG     BTU/HR
  1   CABIN IN      /HEATER OUT                      497.041    501.000  2001.000
  2   CABIN OUT     /LIOH IN                         502.106    501.000
  3   LIOH 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              310.490      372.1[illegible]   3.726
 20   RADOUT        /MIXER                           310.5[illegible]   3.726
 21   EXCH IN       /PLATE OUT                       502.91[illegible]  100.000
 22   EXCH OUT      /PLATE IN           503.156      498.170    100.000   400.000
**********************************************************************
**********************************************************************

                              GAS PROPERTIES

TIME =    5.000

NODE   SPECIFIC      WATER      NITROGEN     OXYGEN       C02          TOTAL
 NO      HEAT         PSI         PSI         PSI          PSI          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
            INITIAL                  QUANTITY              QUANTITY
SOURCE     AVAILABLE                   USED                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.)

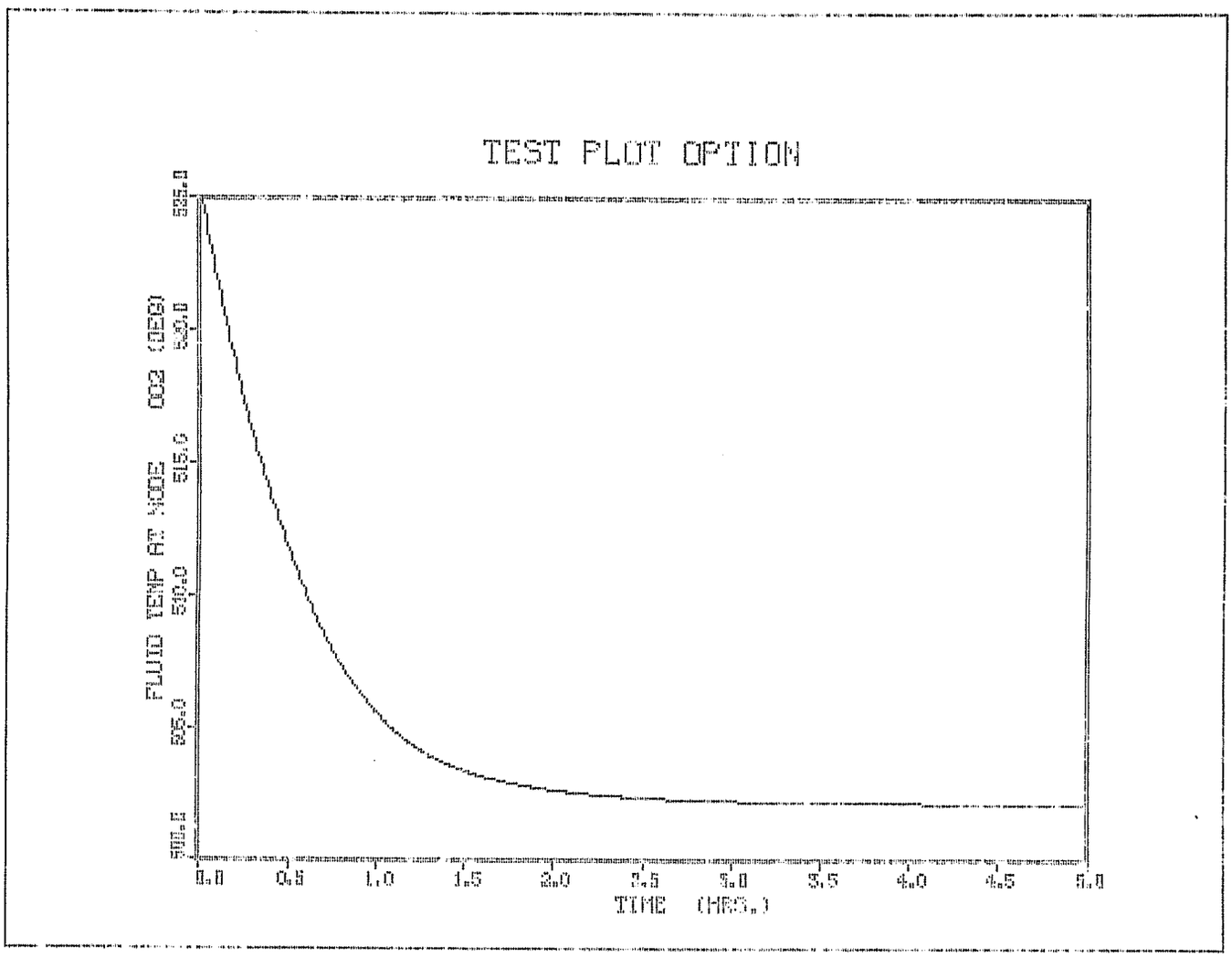

Figure 3.5. Plot Data Output

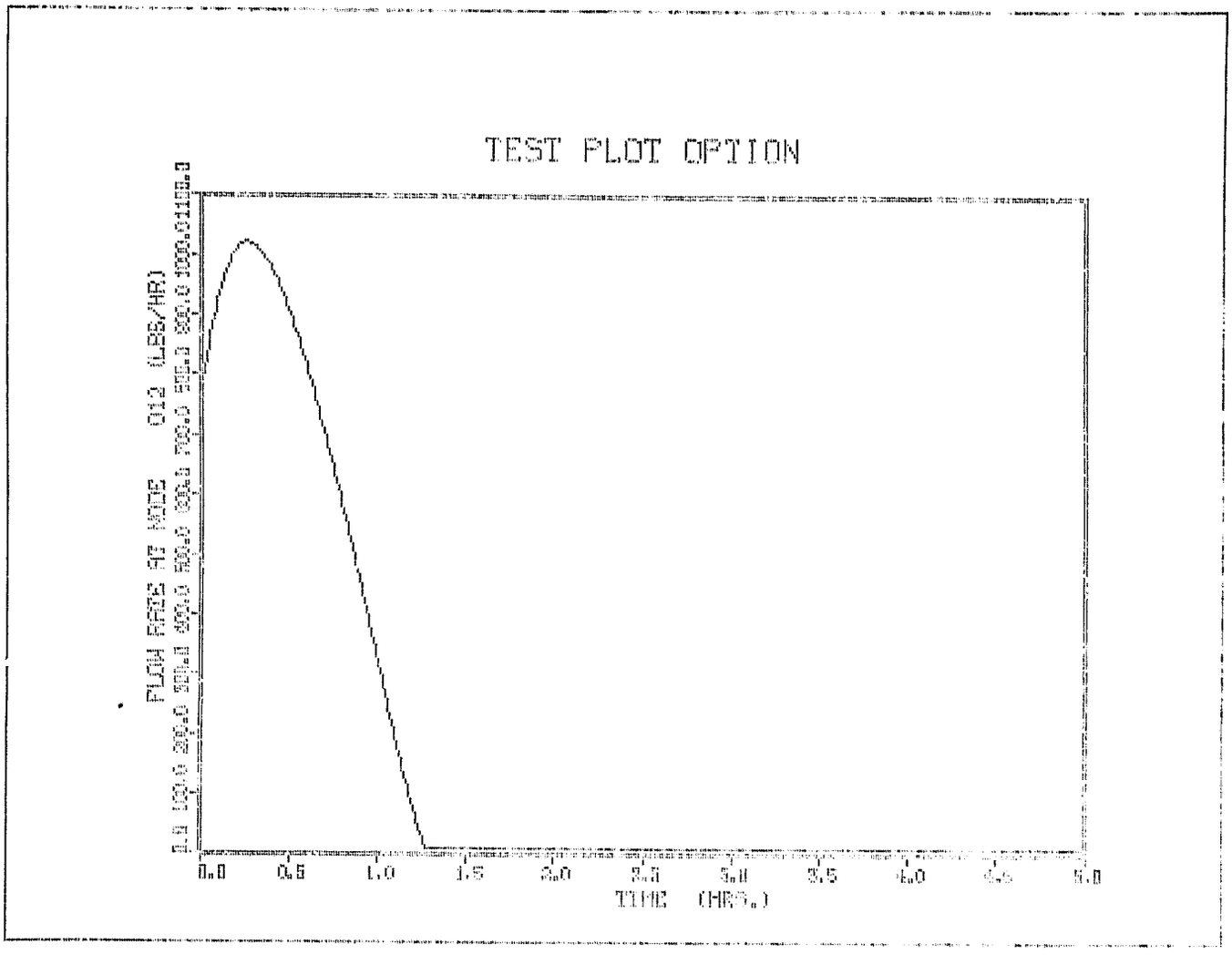

Figure 3.5. Plot Data Output (Cont.)

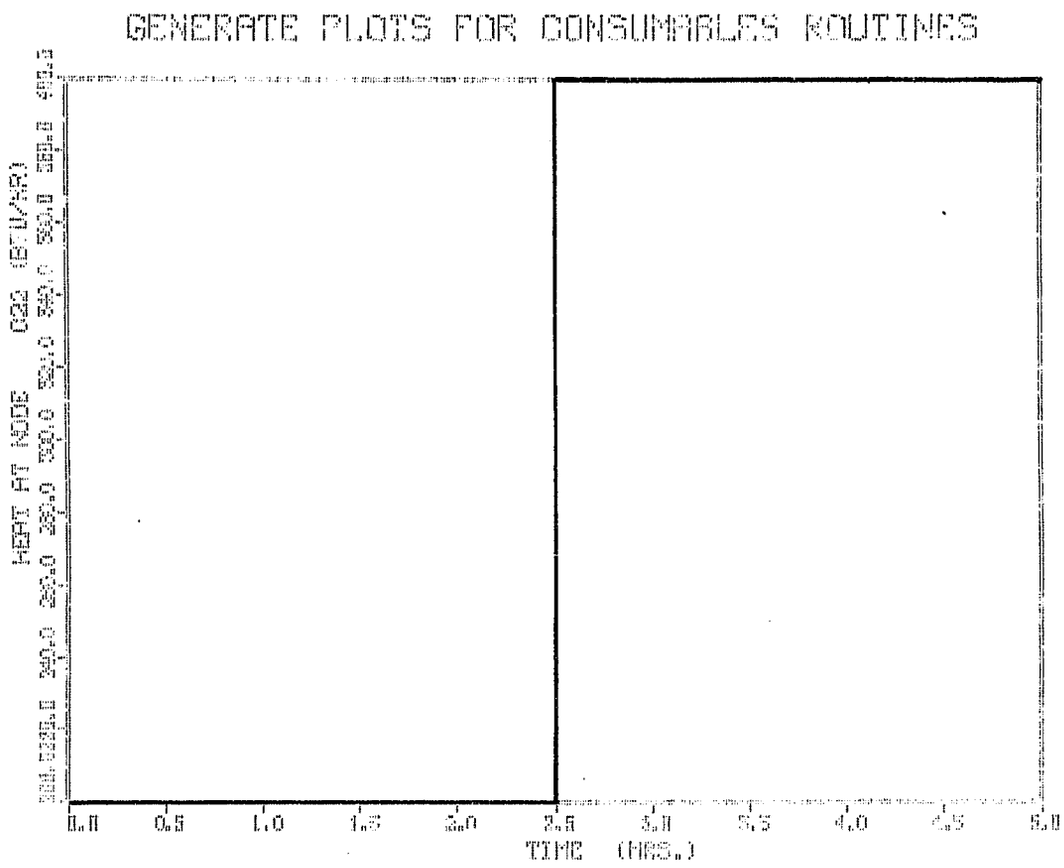

Figure 3.5. Plot Data Output (Concl.)

APPENDIX A

COMPUTER CONTROL INFORMATION

MAP USED TO EXECUTE MAIN20 PROGRAM.

```
        1:SEG MANE
        2:IN FM2-T61867*FEAR.MAIN20
        3:SEG D*,(MANE)
        4:IN FM2-T61867*FEAR.START
        5:SEG P*,(MANE)
        6:IN FM2-T61867*FEAR.LOOP
        7:SEG C*,(MANE)
        8:IN FM2-T61867*FEAR.SPLIT,FM2-T61867*FEAR.PLOTE
        9:SEG D*,(MANE)
       10:IN FM2-T61867*FEAR.MIX,FM2-T61867*FEAR.MOD, FM2-T61867*FEAR.EVNP
       11:SEG E*,(MANE)
       12:IN FM2-T61867*FEAR.CONVRG
       13:SEG F*,(MANE)
       14:IN FM2-T61867*FEAR.PRINT
       15:SEG G*,(MANE)
       16:IN FM2-T61867*FEAR.TABLE/NEW,FM2-T61867*FEAR.STEP/NEW
       17:SEG F1*,(F)
       18:IN FM2-T61867*FEAR.NTANK,FM2-T61867*FEAR.TRAJ,FM2-T61867*FEAR.MT
TAPE
       19:SEG F2*,(F)
       20:IN DPLOOT
       21:SEG F3*,(F)
       22:IN FM2-T61867*FEAR.SCHEN/PLOT
       23:SEG F31*,(F3)
       24:IN ALFMFT,LABTOG
       25:SEG F32*,(F3)
       26:IN CATA,CATB,CATC
       27:SEG F33*,(F3)
       28:IN BARS
       29:SEG F4*,(F)
       30:IN FM2-T61867*FEAR.BASPD,FM2-T61867*FEAR.CONFD,FM2-T61867*F
EPS/NEW
       31:SEG F5*,(F)
       32:IN FM2-T61867*FEAR.PLOOT
       33:EQU IOG*/0227
       34:LIB FM2-T61867*FEAR.
       35:LIB M:D*LOCALLIB.
       36:LIB D:SCPLA*LIB.
       37:LIB F06*MOPSPLT.
EOF:37 SCAN:36
0:>
```

Figure A-1. MAP

```
ENTER USERID/PASSWORD:
>
*DESTROY USERID/PASSWORD ENTRY
*UNIVAC 1100 OPERATING SYSTEM  VER. 38R3A+409-G1(DSI)*
>%RUN 660KPC,FM2/9212,TPW-153091
DATE: 061789        TIME: 145396
>%ASG,A FM2-T61867*FEAR/*/0061.
READY
>%USE ALT.,FM2-T61867*FEAR/L/0061.     PROGRAM FILE
READY
>%ASG,A DATA.
FACILITY REJECTED '000010000000
>%ASG,CP DATA.
READY
>%JSC*CALLUP.TAPES T53091*660KPC.,X11837       RESTART TAPE
REQUEST HAS BEEN ACCEPTED
>%FREE DATA.
READY
>%ASG,A DATA.
READY
>%USE 1.,DATA.              FORTRAN UNIT 1
READY
>%ASG,CP PLOTS,F/400//1000       INTERMEDIATE PLOT FILE
READY
>%FREE PLOTS.
READY
>%ASG,A PLOTS.
READY
>%USE 4.,PLOTS.       FORTRAN UNIT 4
READY
>%ASG,TJ TAPE.,8C,X11837
WAITING ON FACILITY
READY
>%REWIND TAPE.
FURPUR 27R3A       E33 SL73R1 06/17/89 15:05:15
>%COPY TAPE.,DATA.
     3 BLOCKS COPIED.
EOF ENCOUNTERED ON INPUT TAPE
>%REWIND TAPE.
>%FREE TAPE.        DO NOT TIE UP TAPE DRIVES LONGER THAN NECESSARY
READY
>%XQT ALT.TFEAR
*GCS-SIGN-ON TO F6        CONFIRMED*
```


Figure A-2. Computer Control