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1 OCTOBER 1976
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<td>--------</td>
<td>------------</td>
<td>-------</td>
</tr>
<tr>
<td>A</td>
<td>Area</td>
<td>in²</td>
</tr>
<tr>
<td>BTU</td>
<td>British Thermal Unit</td>
<td></td>
</tr>
<tr>
<td>C or MCₚ</td>
<td>Thermal capacitance</td>
<td>BTU/°R</td>
</tr>
<tr>
<td>°F</td>
<td>Degrees Fahrenheit</td>
<td></td>
</tr>
<tr>
<td>ft³</td>
<td>Cubic feet</td>
<td></td>
</tr>
<tr>
<td>g.e.t.</td>
<td>Ground Elapsed time</td>
<td></td>
</tr>
<tr>
<td>gpm</td>
<td>Gallons per minute</td>
<td></td>
</tr>
<tr>
<td>hp</td>
<td>Horsepower</td>
<td></td>
</tr>
<tr>
<td>hr</td>
<td>Hour</td>
<td></td>
</tr>
<tr>
<td>lbm</td>
<td>Pounds mass</td>
<td></td>
</tr>
<tr>
<td>N₂H₄</td>
<td>Hydrazine</td>
<td></td>
</tr>
<tr>
<td>psia</td>
<td>Pounds per square inch</td>
<td></td>
</tr>
<tr>
<td>Q</td>
<td>Heat rate or heat load</td>
<td>BTU/hr</td>
</tr>
<tr>
<td>°R</td>
<td>Degrees Rankine</td>
<td></td>
</tr>
<tr>
<td>UA</td>
<td>Heat transfer coefficient</td>
<td>BTU/hr-°R</td>
</tr>
<tr>
<td>WCₚ</td>
<td>Dynamic thermal capacitance</td>
<td>lbm-BTU/hr-lbm-°R</td>
</tr>
<tr>
<td>σ</td>
<td>Stephan-Boltzmann</td>
<td></td>
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<tr>
<td>ε</td>
<td>Surface emissivity</td>
<td>BTU/hr-ft²-°R⁸</td>
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1.0 SUMMARY

This volume of the Thermal APU/Hydraulics Analysis Program (TAHAP) documentation contains all the User's Guide information plus program description necessary to run and have a general understanding of the program. This information consists of general descriptions of the APU/Hydraulic System and the TAHAP model, input and output data descriptions, and specific subroutine requirements. Deck set-ups and input data formats are included in Appendix A while Appendices B thru E have other necessary and/or helpful information for using TAHAP. Volume II of the TAHAP documentation consists of the math model descriptions for the driver program and each of its supporting subroutines.
2.0 INTRODUCTION

McDonnell-Douglas Technical Services Co. (MDTSCO) under the Space Shuttle Engineering and Operations Support (SSEOS) contract is responsible for providing support to the Consumables Analysis Section (CAS) of the Mission Planning and Analysis Division of NASA/JSC. The Consumables Analysis Section is responsible for providing consumables budgets for the electrical, mechanical (Auxiliary Power Unit (APU)/Hydraulics), and environmental control systems of the Space Shuttle Orbiter. The MDTSCO support of CAS in this effort includes determining APU subsystem fuel (hydrazine) and APU/Hydraulic water consumables requirements, and performing various studies to assess the APU and Hydraulic system mission requirements compatibility with system operational and performance constraints. This support is partially accomplished through the use of the Thermal APU/Hydraulic Analysis Program (TAHAP). The TAHAP documentation has been divided into two volumes. This document is the User's Guide and Programmer's Manual for TAHAP. The math model descriptions of the driver program and the supporting subroutines are presented in Vol. II.
3.0 PROGRAM DESCRIPTION

The thermal APU/Hydraulics Analysis Program (TAHAP) is a dynamic simulation of the Auxiliary Power Unit/Hydraulic (APU/Hyd) System thermal performance. In the following sections there is a general description of the APU/Hyd system itself and the TAHAP model along with some background information on the model. A description of the basic program structure including reference to the routines and special variables which control the progress of the program is contained in Sec. 3.1.4 followed by a brief description of each of the TAHAP supporting subroutines.

3.1 General Description

The following sections contain a general description of the APU/Hyd system and briefly describe the way TAHAP simulates it. The purpose and capabilities of the model are also discussed along with some background information concerning the model's origin and evaluation.

3.1.1 Purpose and Capabilities of TAHAP

TAHAP is designed to simulate the APU/Hydraulic system to the level of detail required to adequately determine mission timeline-dependent consumption rates for both N₂H₄ for APU power and water for APU and Hyd system heat rejection. Its primary purpose is to compute these APU/Hydraulics consumables requirements. A secondary purpose of TAHAP is to evaluate the compatibility of system performance constraints with mission requirements. Two versions of
TAHAP were developed to run mission consumables analyses for both Approach and Landing Test (ALT) and Orbital Flight Test (OFT) missions.

3.1.2 General Description of the APU/Hydraulic system and its simulation

The Orbiter hydraulic subsystem is comprised of three essentially parallel fluid circuits which supply hydraulic power to the Flight Control surfaces, Space Shuttle Main Engine (SSME) controls, SSME, Thrust Vector Control (TVC), landing gear and other utility actuators. Each hydraulic circuit is powered by a constant pressure, variable displacement, main pump which is driven by one of three APU's in the APU subsystem. Each APU consists of a 2-stage turbine which drives the main hydraulic pump through a speed reduction gear box, roughly 19 to 1. The turbine is powered by the catalytic decomposition of liquid hydrazine (N$_2$H$_4$) supplied to a gas generator from a fuel pump-augmented blowdown supply system. A lubrication oil circulation system powered by the APU gearbox is used to provide active thermal control for each APU.

Heat rejection for each APU lube oil and hydraulic oil loop is provided by one of three water boilers for OV-101 and one of three water spray boilers for OV-102. Separate heat exchangers are provided for each of the fluid loops running through each water (spray) boiler.
The OV-101 and OV-102 APU/Hydraulic system fluid loops simulated by TAHAP are illustrated in Figures 3-1 and 3-2 respectively. These fluid loops are simulated as follows:

The individual instantaneous actuator flowrate demands are used for determining the heat loads on the hydraulic system and the main pump power input requirements. APU performance data, normalized to main pump input power, is used to compute fuel requirements directly. The water consumption rates are determined by computing the heat loads on the water boiler. This is accomplished by computing the thermal mass response to hydraulic heating at nodes for each actuator in the fluid circuit and computing the main pump and APU gearbox waste heat rejection. The heat sink performance of the water boiler is computed using predicted heat exchanger effectiveness for the environmental conditions and the fluid conditions at the inlet.

3.1.3 FEAR Documentation

TAHAP is an application of the FORTRAN Environmental Analysis Routines (FEAR, Ref. 1) developed by the TRW Systems Division and modified as required. The routines in FEAR were originally written as utility support for Environmental Control and Life Support Systems (ECLSS) consumables analyses models. A driver program was written for the APU/Hydraulics consumables analyses using FEAR. Consequently many of the subroutines have lines of code or large portions of arrays utilized in ECLSS applications only. These
Figure 3-1

GV-101
HYDRAULIC SYSTEM FLUID LOOP DIAGRAM
SYSTEM 1

ORIGINAL PAGE IS
OF POOR QUALITY

FOLDOUT FRAME 1
Figure 3-1 contd.

OV-101
HYDRAULIC SYSTEM FLUID LOOP DIAGRAM
SYSTEM 2

FLUID FLOW

ORIGINAL PAGE IS
OF POOR QUALITY

FOLDOUT FRAME
re 3-1 contd.

V-101
FLUID LOOP DIAGRAM
STEM 2

LEGEND

XXXX NODE NUMBER DESIGNATION
XXXX LINE NUMBER DESIGNATION
F F F F F F F F F F F F F F F F F
PRESSURE REFERENCE
CHECK VALVE
CAPPED LINE
PUMP
ACTIVE HEAT DEVICE
PARTIALLY DEDICATED DEVICE
PASSIVE DEVICE
HEAT EXCHANGER

SWITCHING VALVE COMMON

I. ACTIVE PORT
II. 1ST STANDBY PORT
III. 2ND STANDBY PORT

NODES NOT SHOWN:
150 TURBINE 2
153 WATER STORAGE TANK 2
260 AFT FUSELAGE BOUNDARY
252 LEFT WING BOUNDARY
253 RIGHT WING BOUNDARY
263 MID FUSELAGE BOUNDARY
265 VERTICAL STABILIZER BOUNDARY
256 BODY FLAP AREA BOUNDARY
257 RIGHT WHEEL MOUNT BOUNDARY
258 LEFT WHEEL MOUNT BOUNDARY
259 FORWARDS FUSELAGE BOUNDARY
260 ROSE WHEEL MOUNT BOUNDARY
262 AMBREUIL AIR BOUNDARY
276 FUEL AND ENERGY TRACKING

ALL NODE AND LINE THERMAL COUPLING IS SHOWN IN APPENDIX E.
Figure 3-1 contd.

HYDRAULIC SYSTEM 3 LOOP DIAGRAM

1. FLUID FLOW
2. PUMP
3. ACCUM Cyl Valve
4. MAIN FILTER
5. CASE DRAIN
6. MAIN PUMP
7. ACCUM CYL VALVE
8. GEARBOX
9. RESERVOIR
10. DUMP ACCUMULATOR

NOTES:
- SEE SYSTEM 1 FOR RETURN ROUTING

ORIGINAL PAGE IS OF POOR QUALITY
Figure 3-1 contd.

SYSTEM FLUID LOOP DIAGRAM
SYSTEM 3

---

LEGEND

---

SWITCHING VALVE CONTROL:

063 ACTIVE PORT
061 1st STANDBY PORT
062 2nd STANDBY PORT

NADKS NOT SHOWN:

200 TURBINE 3
203 WATER STORAGE TANK 3
205 AFT FUSELAGE BOUNDARY
202 LEFT WING BOUNDARY
204 RIGHT WING BOUNDARY
205 VEHICLE STABILIZER BOUNDARY
206 BODY FLAP AREA BOUNDARY
207 RIGHT WHEEL WELL BOUNDARY
208 LEFT WHEEL WELL BOUNDARY
209 FORWARD FUSELAGE BOUNDARY
210 NOSE WHEEL WELL BOUNDARY
212 AUXILIARY AIR BOUNDARY
217 FUEL AND ENERGY TRACKING

ALL NODE AND LINE THERMAL COUPLING IS SHOWN IN APPENDIX C.
Figure 3-2

OV-102

HYDRAULIC SYSTEM FLUID LOOP DIAGRAM SYSTEM 1

FLUID FLOW

RESERVOIR

ACCUMULATOR

COOLING BOILER

FILTER

FLUID FLOW

GSE

APU GLANIG

NOTES:

1. FLUID FLOW

FOLDOUT FRAME

ORIGINAL PAGE IS OF POOR QUALITY
Figure 3-Z

OV-102

HYDRAULIC SYSTEM FLUID LOOP DIAGRAM

SYSTEM 1

FLUID FLOW

- LEGEND
  
  (A) NODE NUMBER DESIGNATION
  (B) CYCLE NUMBER DESIGNATION
  # FITTING
  --- LINE CONNECTION
  --- INTEGRAL PATH
  | PRESSURE REFERENCE
  --- NO FLOW
  | CHECK VALVE
  C CAPPED LINE
  — PUMP
  ▲ ACTIVE HEAT DEVICE
  ◼ PASSIVE DEVICE
  △ HEAT EXCHANGER

SWITCHING VALVE CONTROL:
- ACTIVE PORT
- STAND OFF PORT
- STAND BY PORT

NOTES NOT SHOWN:
- TURBINE
- WATER STORAGE TANK
- AFF FUSELAGE BOUNDARY
- EXHAUST AREA BOUNDARY
- LEFT VIGG BOUNDARY
- RIGHT VIGG BOUNDARY
- MIDDLE FUSELAGE BOUNDARY
- VERTICAL STABILIZER BOUNDARY
- BODY F/J I.A. BOUNDARY
- RIGHT KNEE AREA BOUNDARY
- LEFT KNEE AREA BOUNDARY
- TRIMMABLE AIR BOUNDARY
- FUEL AND ENERGY TRACKING

FLOW DIRECTION AFTER LOG DEPLOY
FLOW DIRECTION DURING CIRCULATION AND LOG RETRACT OPERATIONS
Figure 3-2 contd.

OV-102

FLUID LOOP DIAGRAM
SYSTEM 2

LEGEND

NODE NUMBER DESIGNATION
XXXX LINE DESIGNATION
PITTING LINE JUNCTION
CAPPED LINE
PUMP
ACTIVE HEAT DEVICE
PARTIALLY DEDICATED DEVICE
PASSIVE DEVICE
HEAT EXCHANGER

SWITCHING VALVE CONTROL:
(A) ACTIVE PORT
(S) SIM Standby PORT
(T) STANDBY PORT

NODES NOT SHOWN:

150 TURBINE 2
153 WATER STORAGE TANK 2
200 AFT FUSELAGE BOUNDARY
251 EXIST ASIA BOUNDARY
252 LEFT WING BOUNDARY
253 RIGHT WING BOUNDARY
254 MID FUSELAGE BOUNDARY
255 VERTICAL STABILIZER BOUNDARY
256 BODY FLAP AREA BOUNDARY
257 FLIGHT VICEI KILL BOUNDARY
258 LEFT VICEI KILL BOUNDARY
259 FULL YOKE BOUNDARY
260 NOSEWheel BOUNDARY
261 ASENT AIR BOUNDARY
276 FUEL AND ENERGY TRACKING
Figure 3-2 contd.

OV-102

SYSTEM FLUID LOOP DIAGRAM

SYSTEM 3

FLUID FLOW

LEGEND

- BLUE JOURNAL DESIGNATION
- LICE NOZZLE DESIGNATION
- FITTING
- LINE ADJACENCY
- INTERNAL PATH
- PRESSURE REFERENCE
- NO FLOW
- CHECK VALVE
- CAPPED LINE
- PUMP
- ACTIVE NOZZLE DEVICE
- PARTIALLY DEDICATED DEVICE
- PASSIVE DEVICE
- HEAT EXCHANGER

SWITCHING VALVE CONTROL:
- (A) ACTIVE PORT
- (S1) 1ST STANDBY PORT
- (S2) 2ND STANDBY PORT

NODES NOT SHOWN:
- 200 TURBINE 3
- 201 WATER STORAGE TANK 3
- 202 AFT FUSELAGE BOUNDARY
- 203 ENGINE AREA BOUNDARY
- 204 LEFT VING BOUNDARY
- 205 RIGHT VING BOUNDARY
- 206 AFT FUSELAGE BOUNDARY
- 207 VERTICAL TAIL BOUNDARY
- 208 BODY FLAP AREA BOUNDARY
- 209 LEFT WHEEL TIRE 1
- 210 RIGHT WHEEL TIRE 1
- 211 FORWARD FUSELAGE BOUNDARY
- 212 NOSE WHEEL BOUNDARY
- 213 ANTHRACITE AIR BOUNDARY
- 214 FUEL AND ENERGY BOUNDARY

FOLDOUT FRAME 2
areas have been left in the coding on a non-interference basis in order to keep from unnecessarily deviating from the general FEAR application techniques and FEAR documentation. The effort required to remove such sections has not been justified since they are essentially transparent to the user. Careful deletion of those sections, however, should not effect the running of TAHAP. These sections are not addressed in the write-up except in defining storage allocation. (Appendix D)

3.1.4 Program Structure and Control

The structure of the Thermal APU/Hydraulics Analysis Program (TAHAP) is shown in the diagrams in Figures 3-3 and 3-4. As shown, the program control is handled primarily by DRIVER, "MAIN" and DRAW. Because of its size the program needs to be overlaid. The logical place to divide the program is at the end of a mission when "MAIN" calls DRAW, which controls the use of the Cal Comp plot package. The routine, DRIVER, merely manages the switch from the first layer which has "MAIN" and all the consumables calculations, to the second layer which contains DRAW and its supporting subroutines. "MAIN", which is consequently a subroutine, functions as the main routine of the first layer and is referred to as the main routine.

Essential to the program control are the routines START, PRINT, and PLOOT. The model is initialized by a call to START which is called only once as one of the first executable statements of
*These routines are contained in the utility library RANDIO package.

**This routine and its supporting routines are on the CALCOMP FASTRAND file.
*These routines are contained in the utility library RANDIO package

**This routine and its supporting routines are on the Calcomp FASTRAND file.
"MAIN": START zeroes blank common, reads in the input data, and sets up the computation and print intervals for the program. Once the run has been initialized by START and the hydraulic system line data tape has been read in (for ALT only) it is driven by a mission timeline which is input on tape. This timeline input includes time, total system flowrates, actuator flowrates, a configuration flag, vehicle load factor, and APU speed flag. For each time on the tape the distribution of actuators among the three systems is determined from the value of the configuration flag in conjunction with the loss management matrix which is input on cards.

PRINT, which is called each computation cycle, manages the print frequency and format while the routine, PLOOT, stores the desired parameters for plotting on magnetic drum to be retrieved later by the DRAM layer.

The input/output flow is presented in Fig 3-5.

The timing sequence is set up to use the data on a particular record until the time stored in UPTIME, the first word of each record, is reached. The present input tape being received gives the time at which the rest of the data on the tape record becomes applicable. Consequently some logic was developed for saving all the values on the tape except UPTIME until the next UPTIME has been read in. The timeline data is further processed in order to average the data over the computation cycle.
Figure 3-5  Input/Output Program Flow Schematic for TAHAP

PCF Tape

Hydraulic System Line Data Tape (Alt Only)

Mission Timeline Data Tape

System Configuration Data

Plot Requirements

Node Initialization Data

Node Coupling Coefficients

Miscellaneous Program Control Data

Thermal APU/Hydraulics Analysis Program (TAHAP)

Tabular Data Printout
- Input Data Printout
- Node Thermal Data and Accumulated Consumables at Specified Interval Throughout Mission
- Summary Table at End of Mission

Magnetic Drum Data for Plotting Specified Parameters

Calcomp Plots
Plots of Specified Parameters vs. Mission Time.
Frequency of data on the input tape often varies due to its origin i.e. the difference between input data created from simulator output tapes, trajectory tapes or just estimates of the way a mission may be run. The averaging and tape record cycling process allows the input data to be totally asynchronous with the computation cycle. Tape record frequencies greater or less than the computation cycle can be processed. The logic is, however, limited to accepting a maximum of 25 data records within one computation cycle.

Since a particular set of data will be used until the value for UPTIME is reached it is desirable to keep the program from running at its constant computation cycle during the on-orbit periods when the APU/Hyd system is shutdown on long missions (i.e. ≥ 163 hours on Baseline Reference Missions 1 & 2.) The program control designed for this situation involves the subroutine RSTART and the variable, FUDGE. A mission can be reinitialized at a pre-selected time by utilizing one of two options available in RSTART. The component and fluid temperatures are reinitialized just before deorbit by either reading in a new set of temperature initialization cards or defining all nodes to a predetermined constant. The time value read in from tape is scaled by the variable, FUDGE. Example: If Pre-deorbit checkout begins at 163.46 hrs. insert an "IF" statement that will start subtracting FUDGE
with a value of 163. hrs from UPTIME at .4 hrs. This will allow a sufficient number of on-orbit solutions to bring the system to equilibrium and the time values on the plots can be easily altered to reflect the true mission time.

The value for FUDGE is input on the Summary Table control card described in Appendix A.1. For all other missions, FUDGE will default to zero.

Also integral to the basic program structure are several of the variables in the blank common block. Due to the time dependence of the component and fluid temperatures, P and F, storage locations are provided for both current and previous values through the timing indices, K and L. Until the beginning of the thermal loop, "K" refers to the most recent values of P and F. During the thermal loop "L" is filled with the present solution and "K" retains the previous. At the end of each cycle through the thermal loop "L" is filled with the present solution and "K" retains the previous. At the end of each cycle through the thermal loop the subroutine FLIP is called which exchanges the values.

Specific requirements for the control subroutines mentioned are discussed in Sec 6. Timeline input data is listed and described in detail in Sec 4.2 and general storage allocation for blank common is given in Appendix D.
3.2 OV-101 (ALT) and OV-102 (OFT) Functional Flowcharts

Due to differences between the OV-101 and OV-102 vehicles and the kind of mission involved, the model is split into two versions. The primary differences involve heat sink devices (water boiler for ALT, water spray boiler for OFT), and the difference in flight environment between ALT and OFT. The OV-101 vehicle is subject to atmospheric flight throughout the entire mission, while OFT missions involve relatively short operating periods in the tenuous atmosphere. Several subroutines are included in the ALT version for modeling the hydraulic lines in greater detail than is done in the OFT version. The lack of insulation on the OV-101 lines and the atmospheric environment requires that different methods for computing heat transfer be employed for OV-101 than those used for OV-102 on orbital missions.

BOILP, the subroutine used to model the OV-101 water boiler is used to model the pool mode of the spray boiler on the OV-102 vehicle. The spray mode is modeled by the subroutine, SPRAY, along with several flag checks in the main routine and in MOD. All the present modeling of the spray boiler is preliminary and should be changed as soon as spray boiler design information is available.

Most of the differences are reflected in the "MAIN" routines. Functional Flowcharts for MAINI (ALT) and MAIN2 (OFT) are shown in Figures 3-8 and 3-9 respectively.
FIGURE 3-6 FUNCTIONAL FLOWCHART OF MAIN1

MAIN1

CALL START
READ IN DATA CARDS,
DEFINE PRINT FREQUENCY

CALL LILOAD
READ IN LINE DATA FROM TAPE

INITIALIZE NECESSARY ARRAYS, SAVE
INITIAL VALUES, TINIT, IWAT, G(X,I)

READ IN FIRST TIME POINT, SET INITIAL
FLAGS

A

BEGIN TIMING
SEQUENCE

INITIALIZE TEMPORARY STORAGE VARIABLES
T(I), TFLW(I), FLW(I)

CHECK TO SEE IF DATA
BEING USED IS
APPLICABLE TO CURRENT
TIMESTEP

YES

TIME + DELT ≤ UPTIME?

NO

INTEGRATE TOTAL SYSTEM FLOWRATES AND
ACTUATOR FLOWRATES OVER COMP CYCLE

READ IN NEXT RECORD ON TAPE
UPTIME, TFL, FL, OFTACT, SKIP, IFLAG1
ISPD1, GRAY, ALT2

B
AVERAGE TOTAL SYSTEM AND ACTUATOR FLOWS OVER Timestep

IF END OF MISSION, ZERO SPECIFIED PARAMETERS, TFLAW, TFLW, POWER FLAW, FLW

CALL HYDACT
BUILD ARRAY OF ACTUATORS FOR EACH SYSTEM DEPENDING ON SYSTEM CONFIGURATION. SUM HEAD LOADS AND THERMAL CAPACITANCE PER SYSTEM

CALL ZIPIT
ZERO PARAMETERS FOR LINE CALCULATIONS

DO I = 1, NTURB

CALL FLOPHR
COMPUTE PUMP EFFICIENCY, POWER AND CASE DRAIN FLOWRATES CONSIDERING SYSTEM CONFIGURATION, APU OPERATING SPEED, AND PUMP INLET TEMPERATURE

CALL LINFLO
COMPUTE THE FLOWRATES IN THE HYDRAULIC LINES

STORE POWER FOR PLOTTING.
G(\alpha, 7) = POWER
IS APU ON?

YES

SET TURBINE TO RUNNING TEMPERATURE

CALL LUOIL

COMPUTE SPECIFIC HEAT AND DENSITY OF LUBE OIL, HEAT LOAD ON GEARBOX AND HEAT TRANSFER COEFFICIENT FOR LUBE OIL HEAT EXCHANGER

SET FLAG FOR TRANSFER VALVE

IS TRANSFER VALVE CLOSED?

COMPUTE LEVEL OF WATER IN BOILER BH2O AND THERMAL CAPACITANCE OF WATER BOILER

COMPUTE LEVEL OF WATER CONSIDERING AMOUNT USED SINCE LAST TRANSFER

DETERMINE AMOUNT OF WATER TRANSFERRED THIS TIMESTEP, DWTRAN, AND TOTAL TRANSFERRED SINCE OPENING OF VALVE, BH2OF

ORIGINAL PAGE IS OF POOR QUALITY
COMPUTE BOILER TEMPERATURE CONSIDERING ADDITION OF COLD WATER TRANSFERRED

RECOMPUTE WATER LEVEL, BH2O, ON BASIS OF WATER TRANSFER THIS Timestep

COMPUTE THERMAL CAPACITANCE OF BOILER AND WATER LEVEL

CALL BOUNDT
Determine ambient air temperature.
Compute orbiter structure temperature and vehicle compartment air temperature for each of the boundary nodes.

Interpolate for altitude, ALT.
Compute ambient air pressure, T2
DO I = 1, NTURBN

IS APU (I) ON?

CALL PASS (TURBINE I)
COMPUTE TURBINE COOLDOWN

CALL LOOP (GEARBOX I)
DEFINE STARTING NODE FOR LUBE OIL LOOP

CALL PLATEC (GEARBOX I)
SOLVE HEAT TRANSFER BETWEEN GEARBOX AND LUBE OIL, GEARBOX AND PUMP, AND GEARBOX AND BOUNDARY NODE.

CALL LOOP (PUMP I)
DEFINE STARTING NODE FOR HYDRAULIC LOOP

CALL PLATEC (PUMP I)
SOLVE HEAT TRANSFER BETWEEN HYDRAULIC PUMP AND HYDRAULIC FLUID, PUMP AND GEARBOX, AND PUMP AND BOUNDARY NODE

IS PUMP DISCHARGE FLOW RATE > 0?

YES

NO

I

J

SOLVE THERMAL LOOP

GEAR BOX LOOP

HYDRAULIC SYSTEM LOOP
Calculate case drain and discharge temperatures

Call Thermp

Compute heat rejection distribution between discharge and case drain.

Determine number, JK, and check array, NHYD of actuators to be solved for system I

Determine actuator inlet temperatures. Printout results.

Compute heat transfer to boundary nodes for the lines from pump to the actuators servicing system I. Determine actuator inlet temperatures. Printout results.

Determine number, JK, and check array, NHYD of actuators to be solved for system I

Solve for hydraulic heating, heat transfer from fluid to actuator, and actuator to boundary node

Compute heat transfer to boundary nodes for the hydraulic return lines from the actuators to the mixing point for fluid from actuators and case drain. Determine return line mixing point temperatures. Printout results.

Mix hydraulic fluid returning from actuators with SYS I case drain to determine water boiler inlet flow rate and temperature

Call Mix

Compute heat transfer to boundary nodes for the hydraulic return lines from actuators to the mixing point for fluid from actuators and case drain. Determine return line mixing point temperatures. Printout results.

Do $j = 1$, JK

Call PLATOC (j)

Compute heat transfer to boundary nodes for the hydraulic return lines from the actuators to the mixing point for fluid from actuators and case drain. Determine return line mixing point temperatures. Printout results.

Determine heat rejection distribution between discharge and case drain.
IS PUMP DISCHARGE FLOWRATE > 0?

YES

IS WATER BOILER INLET FLOWRATE GREATER THAN 21 GPM?

YES

SEND 21 GPM THRU HYDRAULIC HEAT EXCHANGER AND REMAINDER OF FLOW THRU WATER BOILER BYPASS

DEFINE TEMPERATURE OF FLUID IN HEAT EXCHANGER AND BYPASS EQUAL TO THE WATER BOILER INLET FLUID TEMPERATURE

CALL HYDFLD

COMPUTE SPECIFIC HEAT AND DENSITY OF HYDRAULIC FLUID AND HEAT TRANSFER COEFFICIENT FOR HYDRAULIC HEAT EXCHANGER

CALL BOILP

DETERMINE WHETHER OR NOT WATER IS BOILING. IF BOILING, COMPUTE WATER USED. IF NOT, CALCULATE SENSIBLE HEAT TRANSFER ONLY. PREPARE WATER USAGE VALUES FOR SUMMARY TABLE.
CALL MIX
MIX HYDRAULIC FLUID FROM HEAT EXCHANGER AND BYPASS TO DETERMINE RESERVOIR INLET FLOWRATE & TEMP

CALL TRANS (PUMP TO SPLIT NODE)
(PUMP TO BYPASS NODE)
(PUMP TO BOILER INLET)
DEFINE TEMP AND FLOWRATE OF EACH NODE UP TO THE BOILER EQUAL TO PUMP TEMP & FLOWRATE

CALL HYDFLD
COMPUTE SPECIFIC HEAT AND DENSITY OF HYDRAULIC FLUID AND HEAT TRANSFER COEFFICIENT OF HYDRAULIC HEAT EXCHANGER

CALL BOILP
SOLVE FOR HEAT TRANSFER BETWEEN FLUID AND WATER IN BOILER. IF BOILING, COMPUTE WATER CONSUMED. IF NOT, COMPUTE SENSIBLE HEAT TRANSFER ONLY.

CALL TRANS (PUMP I TO RESERVOIR I)
DEFINE INLET FLUID TEMP AND FLOWRATE OF RESERVOIR EQUAL TO PUMP TEMP AND FLOWRATE

CALL PASS (WATER STORAGE TANK I)
COMPUTE HEAT TRANSFER FROM WATER STORAGE TANK TO WATER BOILER TO BOUNDARY NODE
CALL PLATEC (RESERVOIR I)
SOLVE HEAT TRANSFER BETWEEN RESERVOIR AND HYDRAULIC FLUID AND RESERVOIR AND BOUNDARY NODE

CALL TRANS (RESERVOIR I TO PUMP I)
DEFINE FLUID TEMP AT PUMP EQUAL TO TEMPERATURE OUT OF RESERVOIR

CALL FUEL
CALCULATE FUEL AND ENERGY CONSUMED CONSIDERING APU SPEED AND POWER. PREPARE FUEL USAGE VALUES FOR SUMMARY TABLE.

CALL QBAL
CALCULATE TOTAL SYS HEAT INPUT, AMOUNT OF HEAT STORED AND AMOUNT OF HEAT DISSIPATED FOR THE TOTAL OF THE THREE SYSTEMS

CALL PLOOT
PUT APPLICABLE DATA FROM PRESENT COMP CYCLE ONTO HIGH SPEED DRUM FOR EACH PLOT DESIGNATED BY PLOT INPUT CARDS TO BE RETRIEVED BY DRAW AT END OF MISSION

CALL SELECT (ENTRY TO PRINT)
IF PRINT COUNTER SATISFIED, PRINTOUT RESULTING NODE DATA AND ACCUMULATED CONSUMABLES IN SPECIFIED FORMAT. INCREMENT TIME.
CALL FLIP
REVERSE INDICES REPRESENTING PRESENT AND
PAST VALUES OF COMPONENT AND FLUID TEMPERATURE

WILL PRINT COUNTER BE SATISFIED ON NEXT
COMP CYCLE?

PRINTOUT NAMELIST

IS CURRENT TIME GREATER THAN STOP TIME?
TIME > TSTOP

CALL PRRTAB
PRINTOUT SUMMARY TABLE

RETURN
CALL START
READ IN DATA CARDS.
DEFINE PRINT FREQUENCY.

INITIALIZE NECESSARY ARRAYS, SAVE INITIAL VALUES, TINIT, IWAT, G(X, I)

READ IN FIRST TIMEPOINT,
SET INITIAL FLAGS

BEGIN TIMING SEQUENCE

CHECK TO SEE IF DATA BEING USED IS APPLICABLE TO CURRENT TIMESTEP

IS
TIME + DELT < UPTIME?

INTEGRATE TOTAL SYSTEM FLOWRATES AND ACTUATOR FLOWRATES OVER COMP CYCLE

READ IN NEXT RECORD ON TAPE, UPTIME, TFL, FL, OFTACT, SKIP, IFLAG1, ISPD1, GRAV, ALT2

CALL RSTART IF LONG MISSION AND REINITIALIZATION REQUIRED, SUBTRACT FUDGE FROM UPTIME TO SKIP LONG INACTIVE PERIOD

A

B
AVERAGE TOTAL FLOW AND ACTUATOR FLOWS
OVER TIME STEP

IF END OF MISSION, ZERO SPECIFIED PARAMETERS.
TFLAW, TFLW, POWER, FLAW, FLW

CALL HYDACT
BUILD ARRAY OF ACTUATORS FOR EACH SYSTEM
DEPENDING ON SYSTEM CONFIGURATION, SUM
HEAT LOADS AND THERMAL CAPACITANCE PER
SYSTEM

DO I = 1, NTURBN

CALL FLOPWR
COMPUTE PUMP EFFICIENCY, POWER AND CASE
DRAIN FLOW RATES CONSIDERING SYSTEM
CONFIGURATION, APU OPERATING SPEED AND
PUMP INLET TEMPERATURE.

STORE POWER FOR PLOTTING. G(X, 9) = POWER (I)

IS APU (I) ON?

ZERO HEAD LOAD AND
FLOWRATE PARAMETERS

SET TURBINE TO
RUNNING TEMPERATURE

CALL LUBOIL
COMPUTE SPECIFIC HEAT AND DENSITY OF LUBE
OIL, HEAT LOAD ON GEARBOX AND HEAT TRANSFER
COEFFICIENT FOR LUBE OIL HEAT EXCHANGER

E
DETERMINE THERMAL CAPACITANCE OF SPRAY BOILER ON BASIS OF AMOUNT OF WATER IN BOILER

INTERPOLATE FOR ALTITUDE AND COMPUTE AMBIENT AIR PRESSURE, ALT, P2

DO I = 1, NTURBN

IS APU (I) ON?

YES

CALL PASS (TURBINE)
compute TURBINE COOL DOWN

CALL LOOP (GEARBOX 1)
DEFINE STARTING NODE FOR LUBE OIL LOOP

CALL PLATEC (GEARBOX I)
SOLVE HEAT TRANSFER BETWEEN GEARBOX AND LUBE OIL, GEARBOX AND PUMP, AND GEARBOX AND BOUNDARY NODE

HYDRAULIC SYSTEM LOOP

CALL LOOP (PUMP I)
DEFINE STARTING NODE FOR HYDRAULIC SYSTEM LOOP

CALL PLATEC (PUMP I)
SOLVE HEAT TRANSFER BETWEEN HYDRAULIC PUMP AND HYDRAULIC FLUID, PUMP AND GEARBOX, AND PUMP AND BOUNDARY NODE

NO

CALL PASS (TURBINE)
compute TURBINE COOL DOWN

GEARBOX LOOP

SOLVE THERMAL LOOP
CALL MIX
MIX HYDRAULIC FLUID FROM EACH OF THE
ACTUATORS- ON SYSTEM I

CALL MIX
MIX RETURNING HYDRAULIC FLUID WITH SYS I
CASE DRAIN FLUID

IS
PUMP DISCHARGE
FLOWRATE > 0?

NO

YES

DETERMINE PUMP HEAT REJECTION DISTRIBUTION
BETWEEN PUMP OUTLET AND CASE DRAIN,
CALCULATE CASE DRAIN AND DISCHARGE
TEMPERATURES

DETERMINE NUMBER, JK, AND ARRAY, NHYD,
OF ACTUATORS TO BE SOLVED FOR SYSTEM I

DO J = 1, JK

CALL PLATOC(J)

SOLVE FOR HYDRAULIC HEATING, HEAT TRANSFER
FROM FLUID TO ACTUATOR AND ACTUATOR TO
BOUNDARY NODE

CALL MIX
MIX HYDRAULIC FLUID FROM EACH OF THE
ACTUATORS ON SYSTEM I

CALL MIX
MIX RETURNING HYDRAULIC FLUID WITH SYS I
CASE DRAIN FLUID

IS
PUMP DISCHARGE
FLOWRATE > 0?

NO

YES
MAT

E

5 of 8

IS

CALL MOD

DETERMINE HOW MUCH FLOW GOES
THRU BYPASS AND HOW MUCH THRU
BOILER

CALL HYDFLD

COMPUTE SPECIFIC HEAT AND DENSITY
OF HYDRAULIC FLUID AND HEAT TRANS-
FER COEFFICIENT FOR HYDRAULIC HEAT
EXCHANGER

CALL BOILP

DETERMINE WHETHER OR NOT WATER
IS BOILING. IF BOILING, CALCULATE
WATER CONSUMABLES. IF NOT, CALCULATE
SENSIBLE HEAT TRANSFER ONLY. PREPARE
WATER USAGE VALUES FOR SUMMARY TABLE

CALL MIX

MIX FLUID FROM BYPASS AND FROM BOILER

CALL TRANS

DEFINE TEMPERATURE AND FLOWRATE
INTO BOILER EQUAL TO THAT JUST MIXED
FROM HYDRAULIC ACTUATOR AND CASE DRAIN

CALL SPRAY

DETERMINE AMOUNT OF WATER USED TO COOL
FLUID DOWN TO CONTROL TEMPERATURE

CALL TRANS (PUMP TO SPLIT NODE)
(PUMP TO BYPASS)
(PUMP TO BOILER INLET)
DEFINE TEMPERATURE AND FLOWRATE OF EACH
NODE UP TO BOILER EQUAL TO PUMP TEMPER-
ATURE AND FLOWRATE
CALL HYDFLD
COMPUTE SPECIFIC HEAT AND DENSITY OF HYDRAULIC FLUID AND HEAT TRANSFER COEFFICIENT OF HYDRAULIC HEAT EXCHANGER

CALL BOILP
SOLVE HEAT TRANSFER BETWEEN FLUID AND WATER, IF WATER BOILING COMPUTE WATER USED. IF NOT, CALCULATE SENSIBLE HEAT TRANSFER ONLY.

CALL TRANS (PUMP TO RESERVOIR)
DEFINE TEMPERATURE AND FLOWRATE INTO RESERVOIR EQUAL TO PUMP TEMP AND FLOWRATE

CALL PASS (WATER STORAGE TANK)
COMPUTE HEAT TRANSFER FROM WATER STORAGE TANK TO WATER BOILER TO BOUNDARY NODE

CALL PLATEC (RESERVOIR)
SOLVE HEAT TRANSFER BETWEEN RESERVOIR AND HYDRAULIC FLUID, AND RESERVOIR AND BOUNDARY NODE

CALL TRANS (RESERVOIR TO PUMP)
DEFINE FLUID TEMP INTO PUMP EQUAL TO FLUID TEMP OUT OF RESERVOIR

CALL FUEL
CALCULATE FUEL AND ENERGY CONSUMED CONSIDERING APU SPEED AND POWER, PREPARE ACCUMULATED VALUES FOR SUMMARY TABLE.
CALL QBAL
CALCULATE TOTAL SYSTEM HEAT INPUT, AMOUNT OF HEAT STORED AND AMOUNT OF HEAT DISSIPATED FOR THE TOTAL OF THE THREE SYSTEMS

CALL PLOOT
PUT APPLICABLE DATA FROM PRESENT COMP CYCLE ONTO HIGH SPEED DRUM FOR EACH PLOT DESIGNATED BY PLOT INPUT CARDS TO BE RETRIEVED BY DRAW AT END OF MISSION

CALL SELECT (ENTRY POINT TO PRINT)
IF PRINT COUNTER SATISFIED, PRINTOUT RESULTING NODE DATA AND ACCUMULATED CONSUMABLES IN SPECIFIED FORMAT. INCREMENT TIME

CALL FLIP
REVERSE INDICES REPRESENTING PRESENT AND PAST VALUES OF COMPONENT AND FLUID TEMPERATURES

WILL PRINT COUNTER BE SATISFIED NEXT COMP CYCLE?

PRINTOUT NAMELIST

L

M
M

IS
CURRENT TIME
GREATER THAN STOP
TIME?
TIME > STOP?

YES

CALL PRRTAB
PRINTOUT SUMMARY TABLE

RETURN

NO

A
3.3 General Description of Subroutines

The following is a brief description of each of the subroutines called from either the ALT or OFT versions of the Thermal APU/Hydraulics Analysis Program (TAHAP).

BOILP - Determines sensible and evaporative heat sink performance of water boiler, computes and integrates consumption rates.

DRAW - Retrieves data to be plotted from high speed drum, prepares it and calls the CALCOMP routines.

FLIP - Reverses timing indices.

FLOPWR - Computes pump efficiency, shaft horsepower, and case drain flowrate, converts flowrate units.

FUEL - Calculates fuel rates, fuel and energy consumed and accumulates consumables preparing accumulated values for summary table.

FUNC - Function subprogram which outputs value of polynomial curve fit evaluated at a given X.

HYDACT - Uses system configuration flag and loss management matrix to build array of actuator system assignments.

HYDFLD - Solves equations for specific heat and density of hydraulic fluid, computes heat transfer coefficient for water boiler hydraulic heat exchanger.

ICNVRT - Converts node numbers to hollerith characters for plot titles.
LILOAD - Reads in line data and constructs necessary arrays.
   (ALT model only)
LINFLO - Defines the flowrates in the hydraulic lines. (ALT model only)
LOOP - Defines current temperature of starting node of thermal loop equal to that node's most recent temperature solution.
LUBOIL - Solves equations for specific heat and density of lubrication oil, computes heat transfer coefficient for lube oil heat exchanger.
MIX - Determines resulting flow and fluid temperature from mixing of flow from several branches.
MOD - Solves general equations to proportion flow split between two branches in response to prescribed temperature control location and proportional gains.
PASS - Solves heat transfer equations for a passive (external to fluid loop) component.
PLATE - Determines diffusion node heating.
PLATO - Determines hydraulic and diffusion node heating. (Entry point to PLATE)
PLATEC - Determines diffusion node heating for components thermally coupled to other components or boundary nodes.
PLATOC - Determines hydraulic and diffusion node heating for components thermally coupled to other diffusion and/or boundary nodes. (Entry point to PLATEC)
PLOOT - Puts data for requested CALCOMP plots onto high speed drum.

PRINT (SELECT) - Provides print-out in specified format and updates time.

QBAL - Performs a heat balance by computing the total heat in, total heat out, and total heat stored in the system for the purpose of error detection, and numerical error magnitude assessment.

RSTART - Reinitializes node data for long missions. (OFT model only)

SCAL - Performs scaling for CALCOMP plots, used by DRAW.

START - Reads input data in specified formats and sets up coupling data.

SPRAY - Presently used for simulating spray boiler and computing water consumed. Should be replaced as soon as spray boiler design data is available. (OFT model only)

THERMP - Computes the heat loss in the hydraulic pressure lines from the pump to the actuators due to conduction, radiation, and convection coupling, determines actuator inlet fluid temperatures, and prints out line data. (ALT model only)

THERMR - Computes the heat loss in the hydraulic return lines from the actuators due to conduction, radiation, and convection coupling, computes fluid branch mixing temperatures, and prints out line data. (ALT Model only)
TRANS - Transfers fluid temperature and flowrates from one node to another.

ZIPIT - zeroes several arrays for line data calculations. (ALT only)
4.0 INPUT DATA DESCRIPTION

The thermal APU/Hydraulics Program (TAHAP) requires that several types of data be input. The data consists of systems data and mission timeline data, the specific data required is described in the following sections along with a note as to the mode of input (card or tape.) The format and units required for each data item as well as the input deck setup is described in Appendix A.

4.1 Systems Data

The systems data described here consisting of node thermal data, node coupling data, and the loss management and system configuration matrices must be input on cards. The hydraulic line data described in this section is input on tape and is for the ALT model only. In section 4.1.6 boundary conditions data which can be input is discussed briefly. The format and sequence of these cards are described in Appendix A.1.

4.1.1 Node Thermal Data

There are six thermal parameters which require definition at each diffusion node inlet. Four of these parameters need to be input while the remainder are computed within the program.

The parameters which must be input are:

1. Thermal capacitance, $MC_p$
2. Heat transfer coefficient, $UA$
3. Initial component temperature
4. Initial fluid temperature
The other two parameters are computed within the program and need not be assigned values on the node data card. These two parameters are,

1. Dynamic thermal capacitance (referred to as "\( \text{WC}_p \)" or "flowrate")
2. Heat load, \( Q \)

Passive thermal nodes need only a value for the thermal capacitance and component temperature. Boundary nodes need only component temperature, and no data is required for arithmetic nodes. There must be a node data card for each node in the model regardless of whether or not any thermal parameters need to be specified for that node. Values will default to zero where a value is not given.

4.1.2 Node Coupling Data

The node coupling cards contain the following data:

1. I, J - the coupled nodes
2. \( UA_{ij} \) - conduction/convection coupling heat transfer coefficient
3. \( \sigma \varepsilon AF_{ij} \) - radiation coupling heat transfer coefficient.

There is a section of the START routine which rearranges this data such that one card for each pair of nodes will handle the coupling from I to J and conversely. The order of the nodes on the card is insignificant. There are several boundary nodes in the model strictly for coupling components to the vehicle structure and ambient air, the coupling cards for these node pairs also contain a flag for including heat loss to the structure in the heat balance equations in the subroutine QBAL.
4.1.3 Loss Management Matrix

The loss management matrix (LMMTRX) is one in which each row represents an actuator, and the first three columns represent the actuator's primary, first standby, and second standby systems, respectively. The fourth column is filled with zeroes for ease of manipulating the data. Each card has the actuator node number on it where it won't be read by the computer for ease in inserting or removing cards as the list of actuators changes. The data in the matrix for the present list of actuators is on Figure 4-1.
Figure 4-1  Loss Management Matrix

<table>
<thead>
<tr>
<th>Primary</th>
<th>1st Standby</th>
<th>2nd Standby</th>
<th>Column of Zeroes</th>
<th>Actuator number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
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<td>5</td>
</tr>
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<td>0</td>
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<td>6</td>
</tr>
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<td>0</td>
<td>7</td>
</tr>
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<td>0</td>
<td>15</td>
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</tr>
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</tbody>
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## Loss Management Matrix (cont'd)

<table>
<thead>
<tr>
<th>Primary</th>
<th>1st Standby</th>
<th>2nd Standby</th>
<th>Column of Zeroes</th>
<th>Actuator number</th>
</tr>
</thead>
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<td>3</td>
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<td>43</td>
</tr>
</tbody>
</table>
4.1.4 System Configuration Matrix

The system configuration matrix, IPDO, is comprised of each possible combination of pressurized, depressurized and off systems. Each row is input on a separate card with the row number in a column not read by the computer. This row number is used as the system configuration flag. The three columns represent systems 1, 2, and 3, respectively. After the system configuration flag is read from the input tape, the matrix is checked for the configuration of each system and computes the applicable pump efficiency and total system thermal capacitance and builds the arrays of actuators going to each system. The system configuration matrix is shown in Figure 4-2.
<table>
<thead>
<tr>
<th>System 1</th>
<th>System 2</th>
<th>System 3</th>
<th>Configuration Flag</th>
</tr>
</thead>
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<td>11</td>
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</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>27</td>
</tr>
</tbody>
</table>
4.1.5 Line data (ALT model only)
The line data, which is read from a data tape contains the following information on each record.
1. the line number
2. a flag to distinguish between forward and reverse flow in system 1 landing gear circuit
3. coupling node number (structure node minus 250)
4. complete list of the actuators serviced by this line
5. the line number
6. line length
7. line diameter

4.1.6 Boundary conditions data (ALT model only)
The model is presently set up with an ambient air temperature vs altitude table hard coded into the subroutine BOUNDT. This table includes information for a typical cold day, hot day, and normal day profile. Another array of coefficients is hard coded in the routine which is used in the computation of secondary structure temperature and the vehicle compartment air temperature. The input required for this computation is a flag on the mission control card (described in Appendix A.1) which tells which type of ambient air profile is desired for the mission being analyzed. The computed structure temperature is stored in the component temperature locations for these same structure boundary nodes. Both values are used in determining the heat loss in the lines calculated in THERMP and THERMR. The structure temperatures are also used for the heat transfer solutions.
for coupling between components and boundary nodes.

If a mission analysis is desired which needs a profile not provided by the subroutine, BOUNDT, the program can be modified to accept a timeline namelist of boundary temperatures. Values for each timestep can be found by interpolating between the values in the namelist in the same manner as the program interpolates for each altitude value. The data required in each set of the namelist profile would include:

1. The time at which the temperature values in the namelist apply
2. The secondary structure temperature
3. The vehicle compartment air temperature
4. The ambient air temperature.

4.2 Mission Timeline Data

For any mission analyzed a mission timeline input tape is required. The following data is required on each record.

1. Time, UPTIME
2. Actuator flowrates, FL
3. Total system flowrates, TFL
4. Pump shaft horsepower, SKIP (not used by TAHAP-power-values used are internally generated)
5. System configuration code, IFLAG1
6. APU operating speed flag, ISPD1
7. Vehicle load, GRAV
8. Altitude, ALT2
Although the set of actuators for OV-101 does not include some of the actuators that will be on the OV-102 vehicle there will be words on each tape record for all of the actuators. Since the last six actuators in the OV-102 list are not applicable to OV-101 their flowrates will be read into a different array and be ignored. Zeros will be given for the flowrates of the actuators that are not applicable to the particular version being used. This procedure allows the input tape to be created in one standard format.

The specific format, data types, and units for the mission timeline tape are given in Appendix A.1.
5.0 OUTPUT DATA DESCRIPTION

The data generated by TAHAP is output in two forms; tabular data printout received every time the program is run and plots, from the CALCOMP plotter, which are only generated if desired. Although there is presently no capability in the program for graphic output via microfilm or microfiche, the tabular data printout may be output via microfilm or microfiche through the addition of a control card. The following sections describe the data generated by TAHAP, along with reference to the places in the program where the data is generated. Sample output is shown in Appendix E.

5.1 Tabular Data Printout

Each of the following sets of data, except the initial output is printed at the print frequency input on the run control card.

5.1.1 Input Data Printout

The first set of tabular data printout is generated by the START subroutine, and is a printout of the card input data. This set of printout consists of:

1. the node coupling data as it has been rearranged by START
2. the node thermal data initial values
3. the card images of the plot input data cards
4. the system configuration matrix
5. the loss management matrix

The next set of tabular data printout is generated by the LILOAD subroutine, and is a printout of the line data input. (ALT model only)
1. Each line number, its coupling node and the list of actuators serviced by that line
2. A list of each line number with its location in the array of line numbers

5.1.2 Namelist Data
The namelist, UPDATE, is printed to show which timeline values were used in calculating the data that follows it. Some of this data is read from the timeline input tape and the rest is calculated internally. The parameters output via namelist are:
1. UPTIME, time to update information
2. Total system flowrates resulting from averaging
3. Actuator flowrates resulting from averaging
4. POWER, computed from averaged flowrate
5. SKIP, power values on the timeline tape
6. ALT2, altitude value read from timeline tape
7. ALT, altitude resulting from interpolation
8. IFLAG, system configuration code
9. ISPD, system operating speed flag.

5.1.3 Line heat losses (ALT model only)
Following the namelist output is the line heat loss output from THERMP and THERMR for each system.
1. The actuator number and the lines attached to them
2. The coupling node number
3. Line length
4. Inlet, outlet, and boundary temp for each line
5. Heat loss rates (BTU/min) and flowrate (gpm) in each line

This data for each system is followed by the total heat loss values for the lines on that system.

5.1.4 Boiler Water Level (ALT model only)

The amount of water (lbm) in the boiler and the amount of water (lbm) transferred from the storage tank to the boiler is tracked and is printed out for each system. These numbers are generated in MAIN1.

5.1.5 Heat Balance - Error Values

For the purpose of error detection the total heat input to the APU/hydraulic system is compared with the sum of the heat stored and the heat leaving the system. The values, computed for the three systems combined, are summed in the subroutine QBAL.

The eight values output are:
1. BTU's in due to main pump shaft power
2. BTU's in due to turbine heat leak
3. Total heat in
4. BTU's out by water boiloff
5. BTU's stored in capacitance
6. BTU's out due to coupling to structure
7. Total heat out
8. Total heat in - Total heat out

The titles for these columns of output are read from input cards.

5.1.6 BOILP Output

To track the operation of the water boiler (OV-101) and the pool
mode for the spray boiler (OV-102) the following values calculated in the subroutine, BOILP, are printed.

1. Inside boiler pressure, psia
2. Ambient air pressure, psia
3. The pressure difference, psia
4. The saturation temperature, °R
5. The boiling rate ( BTU/min)
6. The flag to tell if the steam vent is choked (=2) or unchoked (=1)
7. The number of iterations required to find a pressure solution.

5.1.7 Actuator Node Number List

Due to the changes in system configuration throughout a mission, the list of actuators used by each system changes. A list of the actuators on each system is printed out each print interval. Due to the use of the loss management matrix without regard to isolation valves, an actuator will appear to be on its primary system even if it is isolated at the time or not applicable to a particular vehicle (i.e. engine and umbilical retract actuators listed on ALT missions.) The actuators have zero flowrates and have no effect on the system.

5.1.8 Node Thermal Data

The mission time and then the following data is printed out for each node in the INODES array which is defined in the main program.

1. Node number and name
2. Component temperature, °F
3. Inlet fluid temperature, °F

4. Thermal capacitance, C, BTU/°R

5. Heat transfer coefficient, UA, BTU/hr-°R

6. Dynamic thermal capacitance, \( \frac{wcp}{hr\ lb\ °R} \)

7. Heat load, Q, BTU/hr.

Some accumulated heat loss values are printed out in the "UA" column of the ALT version next to the structure nodes where there would ordinarily be zeroes. Following is a list of the structure node number and the value printed there.

250 - APU heat, system 1
251 - APU heat, system 2
252 - APU heat, system 3
253 - heat out by water, system 1
254 - heat out by water, system 2
255 - heat out by water, system 3
256 - line heat loss to air and structure, system 1
257 - line heat loss to air and structure, system 2
258 - line heat loss to air and structure, system 3
259 - component heat loss to air and structure, system 1
260 - component heat loss to air and structure, system 2
261 - component heat loss to air and structure, system 3

5.1.9 Accumulated Consumables

At the end of each set of node thermal data, the following consumables values are printed for each system.

1. accumulated water usage (lbm)
2. accumulated fuel usage (lbm)
3. accumulated energy usage (hp-hr)

5.1.10 Summary Table

At the end of the mission a consumables summary table which shows loaded and consumed values for fuel and water along with remaining margins is printed. The accumulated water values are tracked in BOILP and the accumulated fuel values are tracked in FUEL. The
Summary table values are collected and printed out in the subroutine PRTTAB. Several constants for the table are input from cards. The format and definition of these cards is in Appendix A.

5.2 Graphical Output

Several different parameters are available for plotting with no changes to the program. The parameters which will be stored on the CALCOMP tape on any given run will be determined by the input plot cards. The format of those cards is given in Appendix A. On these cards there is a space for the plot type number associated with the type of plot desired. The following is a list of the available plot types with the type number. (Note: all plots have ground elapsed time as the independent parameter). Plot types 6-16 were designed for ECLSS and will not be enumerated.

1. fluid temperature (°F)
2. component temperature (°F)
3. flowrate (gpm)
4. heat rate (BTU/hr)
5. water remaining (lbm)
17. fuel used (lbm)
18. energy used (hp-hr)
19. fuel remaining (lbm)
20. ambient pressure
21. boiler pressure
22. miscellaneous; G(X,3) (boiling rate), altitude
23. miscellaneous; G(X,7) (error heat load values, power)

Due to the method of storage allocation in TAHAP, a node number is required for each plot card. For some type of plots this isn't applicable (i.e. power, altitude, fuel, and pressure) so these variables have been assigned to portions of the G-array or C-array as listed in Table C-1 or assigned an arbitrary number (use 35 for altitude.) The node number and plot type are used in PLOOT.
along with the value of the plotting variable to put the necessary information onto high speed drum. Minor changes can be made within the PLOOT routine so that new parameters can be plotted as long as the variable needed is in COMMON.

The plot titles are processed in the subroutine DRAW and are based on the plot type number. The other support routines for DRAW are SCAL and ICNVRT.

If it is desired to change graphics routines, the PLOOT and DRAW routines can be deleted and replaced with a routine which generates a standard binary data tape with time as the first word on each record. With such a data tape several of the graphics packages available on EXEC 2 or EXEC 8 (e.g. STLPLT, TRWPLT) can easily be implemented.
6.0 SUBROUTINE REQUIREMENTS

This section consists of a detailed description of each subroutine called by either the ALT or OFT versions of TAHAP. The description includes each of the following items where applicable.

1. Identification
2. Purpose
3. Supporting Subroutines
4. Argument List Definitions
5. Common Block Reference
   A list of the common blocks used by that routine along with each variable input or output from the routine by that block
6. Local Variable Definitions
7. Functional Flowchart
8. Subroutine Listing (see Appendix D)
Subroutine BOILP

Identification

Name - BOILP
Author/Company - T. DeLuna/MDTSCO
Machine/Language - UNIVAC 1108, EXEC 2 System/FORTRAN V

Purpose

To determine sensible and evaporative heat sink performance of water boiler and to compute water usage.

Argument List Definition

M - Inlet node of lube oil heat exchanger
M11 - Outlet node of lube oil heat exchanger
M2 - Inlet node of hydraulic heat exchanger
M32 - Outlet node of hydraulic heat exchanger
P2 - Ambient air pressure
EA - Effective steam vent orifice area
STVC - Steam valve closed flag
STVO - Steam valve open flag

Common Block Reference/Input-Output Variables

<table>
<thead>
<tr>
<th>Block Name</th>
<th>Input</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARRAY</td>
<td>G(M1,1)</td>
<td>G(M1,I), I=1,6, G(M2,I), I=1,6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>G(M1,I), I=8,9, G(M2,I), I=8,9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FLAG, ITER</td>
</tr>
<tr>
<td>BLANK COMMON</td>
<td>P(M1,L), P(M2,L), F(M1,L)</td>
<td>P(M11,6), P(M22,L), F(M11,L)</td>
</tr>
<tr>
<td></td>
<td>F(M2,L), C(M1,3), C(M2,3)</td>
<td>F(M22,L), C(M11,3), C(M22,3)</td>
</tr>
<tr>
<td>COMEV P</td>
<td>IWAT</td>
<td>WAT, DN, WATLFT</td>
</tr>
<tr>
<td>TYME</td>
<td>TIMSUM</td>
<td>SUMMARY (I,J), I=15,17, J=1,3</td>
</tr>
</tbody>
</table>

60
## Local Variable Definitions

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Units</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>R</td>
<td></td>
<td>Constants derived for conversion from pressure to saturation temperature from subroutine DEWPT in FEAR</td>
</tr>
<tr>
<td>B</td>
<td>R</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>R</td>
<td></td>
<td></td>
</tr>
<tr>
<td>COEF</td>
<td>R</td>
<td></td>
<td>Constants for determining heat of vaporization from temperature</td>
</tr>
<tr>
<td>CRTPR</td>
<td>R</td>
<td></td>
<td>Critical Pressure ratio</td>
</tr>
<tr>
<td>DELW</td>
<td>R</td>
<td>lbm.</td>
<td>Water boiled this timestep</td>
</tr>
<tr>
<td>DELTAP</td>
<td>R</td>
<td>PSIA</td>
<td>Pressure difference (ambient-boiler)</td>
</tr>
<tr>
<td>FLAG</td>
<td>R</td>
<td></td>
<td>Flag for type of flow, 1=unchoked, 2=choked</td>
</tr>
<tr>
<td>GAMMA</td>
<td>R</td>
<td></td>
<td>Ratio of specific heats for steam</td>
</tr>
<tr>
<td>GRAV</td>
<td>R</td>
<td>ft-lbm/lbf-sec²</td>
<td>Conversion from lbf to lbm</td>
</tr>
<tr>
<td>H</td>
<td>R</td>
<td></td>
<td>Heat of vaporization</td>
</tr>
<tr>
<td>ITTER</td>
<td>R</td>
<td></td>
<td>Number of iterations to get a pressure solution</td>
</tr>
<tr>
<td>PI</td>
<td>R</td>
<td>PSIA</td>
<td>Boiler pressure</td>
</tr>
<tr>
<td>PIDOT</td>
<td>R</td>
<td></td>
<td>Time derivative of boiler pressure</td>
</tr>
<tr>
<td>PIOLD</td>
<td>R</td>
<td>PSIA</td>
<td>Pressure calculated last comp cycle</td>
</tr>
<tr>
<td>TEMPS</td>
<td>R</td>
<td>°R</td>
<td>Saturation temperature</td>
</tr>
<tr>
<td>WMDOT</td>
<td>R</td>
<td>lbm/hr</td>
<td>Boiling rate</td>
</tr>
<tr>
<td>WNDOT</td>
<td>R</td>
<td>lbm/min</td>
<td>Boiling rate</td>
</tr>
</tbody>
</table>
FIGURE 6-1 FUNCTIONAL FLOWCHART FOR BOILP

BOILP

DEFINE VARIABLES WHICH WILL NOT CHANGE DURING THE ITERATION LOOP

COMPUTE SATURATION TEMPERATURE FROM AMBIENT PRESSURE

DETERMINE HEAT OF VAPORIZATION OF BOILER

DEFINE CONSTANT TERMS OF DIFFERENTIAL EQUATION

COMPUTE CRITICAL PRESSURE RATIO

A

IS CURRENT PRESSURE RATIO LESS THAN CRITICAL PRESSURE RATIO?

YES

B

NO

IS WATER BOILING?

NO

YES

UNCHOKED STEAM VENT FLOW

C
USE ITERATIVE PROCESS TO SOLVE DIFFERENTIAL EQUATION FOR UNCHOKED STEAM VENT FLOW FOR A PRESSURE SOLUTION

A

USE PRESSURE SOLUTION TO COMPUTE SATURATION TEMPERATURE

B

IS WATER BOILING?

NO

YES

USE ITERATIVE PROCESS TO SOLVE DIFFERENTIAL EQUATION FOR CHOKED STEAM VENT FLOW FOR PRESSURE SOLUTION

D

COMPUTE WATER USED THIS TIMESTEP, LUBE OIL HEAT EXCHANGER OUTLET FLUID TEMP, AND THE HYDRAULIC HEAT EXCHANGER OUTLET FLUID TEMP

E

ACCUMULATE WATER CONSUMPTION VALUES FOR SUMMARY TABLE

CHOKED STEAM VENT FLOW
DEFINE LUBE OIL AND HYDRAULIC FLUID HEAT EXCHANGER OUTLET FLOWRATES

STORE VARIOUS PARAMETERS (E.G., BOILING RATE, AMBIENT AIR PRESSURE, BOILER PRESSURE) FOR PRINTING AND PLOTTING

RETURN

CALL PLATEC (LUBE OIL HEAT EXCHANGER)
DETERMINE SENSIBLE HEAT SINK PERFORMANCE OF HEAT EXCHANGER CONSIDERING COUPLING TO GEARBOX, AND TO BOUNDARY NODE

CALL PLATE (HYDRAULIC FLUID HEAT EXCHANGER)
DETERMINE SENSIBLE HEAT SINK PERFORMANCE OF HEAT EXCHANGER

COMPUTE BOILING RATE AND AMOUNT OF WATER BOILED THIS TIMESTEP

STORE VARIOUS PARAMETERS (E.G., SATURATION TEMP, HEAT OF VAPORIZATION, PRESSURES) FOR PRINTING AND PLOTTING

RETURN
Subroutine BOUNDT (101 only)

Identification

Name - BOUNDT
Author/Company - C. A. Zook/MDTSCO
Machine/Language - Univac 1108, EXEC 2 System/FORTRAN V

Purpose
To determine the ambient air temperature and calculate the structure temperature and the compartment air temperature at each of the boundary nodes.

Common Block Reference/Input-Output Variables

<table>
<thead>
<tr>
<th>Block Name</th>
<th>Input</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALTD</td>
<td>ALT</td>
<td></td>
</tr>
<tr>
<td>Blank Common</td>
<td>IDUM(19),</td>
<td>DUM(2),</td>
</tr>
<tr>
<td></td>
<td>P(M,K),M=250,261</td>
<td>P(M,L),M=250,261</td>
</tr>
<tr>
<td></td>
<td>F(M,K),M=250,261</td>
<td>F(M,L),M=250,261</td>
</tr>
</tbody>
</table>

Local Variable Definitions

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Units</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALTEMP(X,1)</td>
<td>R</td>
<td>ft</td>
<td>Altitude values for table look-up</td>
</tr>
<tr>
<td>ALTEMP(X,2)</td>
<td>R</td>
<td>°R</td>
<td>Cold Day ambient air temp for corresponding altitude</td>
</tr>
<tr>
<td>ALTEMP(X,3)</td>
<td>R</td>
<td>°R</td>
<td>Hot Day ambient air temp for corresponding altitude</td>
</tr>
<tr>
<td>ALTEMP(X,4)</td>
<td>R</td>
<td>°R</td>
<td>Normal Day ambient air temp for corresponding altitude</td>
</tr>
<tr>
<td>BTEMP</td>
<td>R</td>
<td>°R</td>
<td>Ambient air temp at current altitude for predetermined type of environmental condition</td>
</tr>
<tr>
<td>FACTK</td>
<td>R</td>
<td>1/sec</td>
<td>Coefficients used in determining boundary temps</td>
</tr>
</tbody>
</table>
Subroutine DRAW

Identification
Name - DRAW
Author/Company - FEAR/TRW with major modification by G. Steines/MDTSCO
Machine/Language - UNIVAC 1108, EXEC 2 system/FORTRAN V

Purpose
To retrieve the plot data from high speed drum, rearrange it, prepare scaling and call CALCOMP routines.

Supporting Subroutines
CCP - CALCOMP routines
CDATE - Checks date for plot title
ICNVRT - Converts numeric to hollerith for plot title
SCAL - Performs x and y-axis scaling

Common Block Reference/Input-Output Variables

Block Name   Input   Output
Blank Common DUM(25)
LUMP2        TITLE, BIG, WFE
PSST         NPLTS, I PLT, JPLT, TSTP, XAXIS, YAXIS, NOPLOT, NPLPTS, NTR, JWRADR, IRDADR

Local Variable Definitions

Name   Type Units Description
ALPHA  R   Array of data for 1st trace in group
BETA   R   Array of data for 2nd trace in group
BIG    R   Max value for y-axis (input)
DATUM  R   Array containing data for all the traces in the group
DPAR   R   Delta y value for y-axis
<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Units</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DTIME</td>
<td>R</td>
<td>hrs</td>
<td>Delta x value for x-axis</td>
</tr>
<tr>
<td>GAMMA</td>
<td>R</td>
<td></td>
<td>Array of data for 3rd trace in group</td>
</tr>
<tr>
<td>IDIV</td>
<td>I</td>
<td></td>
<td>Counter for frequency of points skipped</td>
</tr>
<tr>
<td>IPLT</td>
<td>I</td>
<td></td>
<td>Node number of parameter being plotted</td>
</tr>
<tr>
<td>IRDADR</td>
<td>I</td>
<td></td>
<td>Location on drum at which to start reading data</td>
</tr>
<tr>
<td>ISAVAD</td>
<td>I</td>
<td></td>
<td>Storage variable for starting location of data on drum</td>
</tr>
<tr>
<td>IWRADR</td>
<td>I</td>
<td></td>
<td>Location on drum at which</td>
</tr>
<tr>
<td>KTRL</td>
<td>I</td>
<td></td>
<td>Flag for direction of plot on paper roll</td>
</tr>
<tr>
<td>NIP</td>
<td>I</td>
<td></td>
<td>Counter used to determine whether</td>
</tr>
<tr>
<td>NNPLTS</td>
<td>I</td>
<td></td>
<td>Number of plots plus 1 (x)</td>
</tr>
<tr>
<td>NSET</td>
<td>I</td>
<td></td>
<td>Number of traces on plot</td>
</tr>
<tr>
<td>NSETSVD</td>
<td>I</td>
<td></td>
<td>Total number of traces in this group of 5 (max)</td>
</tr>
<tr>
<td>PARO</td>
<td>R</td>
<td></td>
<td>Starting value on y-axis</td>
</tr>
<tr>
<td>PHI</td>
<td>R</td>
<td></td>
<td>Array of data for 4th trace</td>
</tr>
<tr>
<td>REST</td>
<td>R</td>
<td></td>
<td>Array into which to put data from record of high speed drum just read</td>
</tr>
<tr>
<td>STIMS</td>
<td>R</td>
<td></td>
<td>Array containing X values</td>
</tr>
<tr>
<td>THETA</td>
<td>R</td>
<td></td>
<td>Array of data for 5th trace</td>
</tr>
<tr>
<td>TITEL</td>
<td>I</td>
<td></td>
<td>Array containing number of y-titles to use for current group</td>
</tr>
<tr>
<td>TO</td>
<td>R</td>
<td></td>
<td>First value on X-axis</td>
</tr>
<tr>
<td>YTILE</td>
<td>I</td>
<td></td>
<td>Hollerith array of y-axis titles</td>
</tr>
<tr>
<td>XMAX</td>
<td>R</td>
<td></td>
<td>Max value for y-axis (determined)</td>
</tr>
<tr>
<td>XMIN</td>
<td>R</td>
<td></td>
<td>Min value for y-axis (determined)</td>
</tr>
</tbody>
</table>
FIGURE 6-2 FUNCTIONAL FLOWCHART OF SUBROUTINE DRAW

DRAW

PRINT OUT ESTIMATED PLOTTING TIMES

CALL SCAL (TSTP, TSTRT, XAXIS, DTIME, TQ, ERR)
Determine X-Axis Scaling

Determine if any data points are to be skipped

F

Determine number of parameters (NTRC) to read (max 5)

CALL RREAD
Read NTRC parameters from high speed drum into datum

Prepare Y-scaling. Determine scaling if SCAL values were not input.

CALL SCAL (XMAX, XMIN, XAXIS, DPAR, PARO, ERR)
Determine necessary Y-axis scaling values

A
PREPARE Y-AXIS TITLE BY CONVERTING THE NODE NUMBER TO HOLLERITH AND INSERTING IT IN THE Y-TITLE ARRAY FOR THAT TYPE PLOT, YTILE (5, NUL)

DETERMINE NUMBER OF TRACES ON THIS PLOT GO TO THE CALL TO CCP(1) WHICH CORRESPONDS TO THAT NUMBER OF TRACES (NSET)

CALL CCP (1, ETC)
DRAW THE SET OF DEPENDENT VARIABLE AXES, SCALES, AND TITLES DEFINES LEFT BOUNDARY OF PLOTTING AREA

CALL CCP (2, J, 1)
PLOTS FUNCTIONS FROM CCP (1)
J = NUMBER OF POINTS ON PLOT

CALL CCP (5, 32767, PLOTIM)
PLOTS INDEPENDENT AXIS, SCALES, AND TITLE AND POSITIONS PEN FOR NEXT PLOT

ARE THERE ANY MORE PLOTS? (X-1+NSETSV > NPLTS)?

YES
FINISHED WITH NUMBER OF TRACES IN THIS PLOT GROUP?

YES

NO

B

C

D

E
C

MOVE DATA, SCALING, AND TITLE OF NEXT TRACE IN THIS PLOT GROUP INTO POSITION FOR PLOTTING
* REDEFINE PAR0, DPAR, NSET

D

INCREMENT COUNTER FOR NUMBER OF TRACES
X = X + NTRC

E

CALL CCP(6)
MARK END OF PLOT TAPE TO SIGNAL OPERATOR THAT PLOTTING IS FINISHED

F

CALL EXIT
Subroutine FLIP

Identification
Name - FLIP
Author/Company - FEAR/TRW - this routine formerly part of PRINT routine
Machine/Language - UNIVAC 1108, EXEC 2 system/FORTRAN V

Purpose
To reverse values of timing indices K and L, to update values for cycling fluid and component temperatures.

Common Block Reference/Input-Output Variable

<table>
<thead>
<tr>
<th>Block Name</th>
<th>Input</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Block Common</td>
<td>K,L</td>
<td>K,L</td>
</tr>
</tbody>
</table>

No functional flowchart necessary.
Subroutine FLOPWR

Identification

Name - FLOPWR
Author/Company - T. DeLuna/MDTSCO
Machine/Language - UNIVAC 1108, EXEC 2 system/FORTRAN V

Purpose

To compute pump efficiency shaft horsepower and case drain flowrate.
Also converts units on flowrate from gal/min to lbm-BTU/hr-lbm-°R considering a constant specific heat and density.

Support routine

FUNC - Function subprogram which outputs value of polynominal curve fit evaluated at a given X.

Argument List Definition

I - System no.
N - Node number counter - used to differentiate between identical nodes on each system.

Common Block Reference/Input-Output Variables

<table>
<thead>
<tr>
<th>Block Name</th>
<th>Input</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blank Common</td>
<td>F(N+4,K)</td>
<td>C(N+1,3), I=4,6</td>
</tr>
<tr>
<td>HYD</td>
<td>IPDO, ISPD, IFLAG, TFLW</td>
<td>POWER</td>
</tr>
<tr>
<td>PRESR</td>
<td></td>
<td>PDRP</td>
</tr>
</tbody>
</table>

Local Variable Definition

- COEF1 thru COEF5 are used to calculate pump efficiency from total system flowrate
<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Units</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CDFLW</td>
<td>R</td>
<td>gal/min</td>
<td>Case drain flowrate at current temperature</td>
</tr>
<tr>
<td>CDH</td>
<td>R</td>
<td>gal/min</td>
<td>Case drain flowrate at 240°F pressurized</td>
</tr>
<tr>
<td>CDL</td>
<td>R</td>
<td>gal/min</td>
<td>Case drain flowrate at 105°F pressurized</td>
</tr>
<tr>
<td>COEF1</td>
<td>R</td>
<td></td>
<td>Coeff. for pressurized mode, 100% speed TFLW &lt; 10 gpm</td>
</tr>
<tr>
<td>COEF2</td>
<td>R</td>
<td></td>
<td>Coeff. for pressurized mode, 110% speed TFLW &lt; 10 gpm</td>
</tr>
<tr>
<td>COEF3</td>
<td>R</td>
<td></td>
<td>Coeff. for pressurized mode, 110% speed TFLW ≥ 10 gpm</td>
</tr>
<tr>
<td>COEF4</td>
<td>R</td>
<td></td>
<td>Coeff. for pressurized mode, 110% speed TFLW ≥ 70 gpm</td>
</tr>
<tr>
<td>COEF5</td>
<td>R</td>
<td></td>
<td>Coeff. for depressurized mode</td>
</tr>
<tr>
<td>COEF6</td>
<td>R</td>
<td></td>
<td>Coeff for depressurized mode</td>
</tr>
<tr>
<td>COEF7</td>
<td>R</td>
<td></td>
<td>Coeff. for pressurized mode, 105°F fluid</td>
</tr>
<tr>
<td>ICNFIG</td>
<td>I</td>
<td></td>
<td>Operating configuration: 3=Pres, 2=Depress, 1=off</td>
</tr>
<tr>
<td>M</td>
<td>I</td>
<td></td>
<td>Operating speed flag: 1=100%, 2=110%</td>
</tr>
<tr>
<td>PEFF</td>
<td>R</td>
<td></td>
<td>Pump Efficiency</td>
</tr>
<tr>
<td>Q</td>
<td>R</td>
<td>gal/min</td>
<td>Total system flowrate</td>
</tr>
</tbody>
</table>

COEF8 thru COEF8 are used to calculate case drain flowrate from total system flowrate.
PART A
COMPUTE PUMP EFFICIENCY AS FUNCTION OF TOTAL SYSTEM DISCHARGE FLOWRATE
PEFF = f(TFLW)

PART B
COMPUTE POWER AS FUNCTION OF TOTAL SYSTEM DISCHARGE FLOW, SYSTEM PRESSURE AND PUMP EFFICIENCY
POWER = f(TFLW, PDRP, PEPP)

PART C
COMPUTE CASE DRAIN FLOWRATE AS A FUNCTION OF TOTAL SYSTEM FLOWRATE
COFLW = f(TFLW)

PART D
CONVERT TOTAL SYSTEM DISCHARGE FLOW AND CASE DRAIN FLOWRATE FROM GPM TO WCp.
COMPUTE FLOWRATE INTO PUMP AS COMBINATION OF DISCHARGE FLOWRATE AND CASE DRAIN FLOW.
C(N+4, 3) = C(N+5, 3) + C(N+6, 3)

RETURN
Subroutine FUEL

Identification

Name - FUEL
Author/Company - T. DeLuna/MDTSCO
Machine/Language - UNIVAC 1108, EXEC 2 system/FORTRAN V

Purpose

To determine accumulated fuel and energy consumed, fuel remaining and prepare accumulated fuel usage values for summary table.

Argument List Definition

TOTFUL - total fuel loaded or total usable fuel depending on form of fuel plot required (defined in MAIN)
P2 - ambient air pressure

Common Block Reference/Input-Output Variables

<table>
<thead>
<tr>
<th>Block Name</th>
<th>Input</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blank Common</td>
<td>TIME, DELT</td>
<td>C(I,J), I=275,277, J=17,19</td>
</tr>
<tr>
<td>TYME</td>
<td>TIMSUM</td>
<td>SUMARY(I,J), I=5,7, J=1,3</td>
</tr>
<tr>
<td>HYD</td>
<td>POWER, ISPD</td>
<td></td>
</tr>
</tbody>
</table>

Local Variable Definitions

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Units</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>BAND</td>
<td>R</td>
<td></td>
<td>Value for creating band around time value so that summary table values will only be computed once.</td>
</tr>
<tr>
<td>ENERGY</td>
<td>R</td>
<td>hp-hrs</td>
<td>Energy consumed on current comp cycle</td>
</tr>
<tr>
<td>FRATE1</td>
<td>R</td>
<td>1bm/hr</td>
<td>Fuel usage rate at sea level</td>
</tr>
<tr>
<td>FRATE2</td>
<td>R</td>
<td>1bm/hr</td>
<td>Fuel usage rate in space</td>
</tr>
<tr>
<td>FURATE</td>
<td>R</td>
<td>1bm/hr</td>
<td>Fuel usage rate at current altitude</td>
</tr>
<tr>
<td>M</td>
<td>I</td>
<td></td>
<td>Operating speed flag, 1=100%, 2=110%</td>
</tr>
<tr>
<td>PU</td>
<td>R</td>
<td>1bm</td>
<td>Fuel consumed on current comp cycle</td>
</tr>
<tr>
<td>PWR</td>
<td>R</td>
<td>hp</td>
<td>Shaft horsepower for current system</td>
</tr>
</tbody>
</table>
FIGURE 6-4 FUNCTIONAL FLOWCHART OF FUEL

FUEL

DO I = 1, NTURBN

DETERMINE HORSEPOWER, PWR, AND OPERATING SPEED, M, FOR SYSTEM I

M = 1

GO TO M

M = 2

CALCULATE FUEL USAGE RATES AT SEA LEVEL AND SPACE AT 100% SPEED. FRATE1, FRATE2

INTERPOLATE TO FIND FUEL USAGE VALUE FOR CURRENT ALTITUDE, FURATE

CALCULATE FUEL USAGE RATES AT SEA LEVEL AND SPACE AT 110% SPEED FRATE1, FRATE2

COMPUTE FUEL, PU, AND ENERGY, ENERGY, USED THIS COMPUTATION CYCLE BY SYSTEM I

ACCUMULATE FUEL AND ENERGY CONSUMED AND COMPUTE FUEL REMAINING. PREPARE ACCUMULATED VALUES FOR SUMMARY TABLE.
Function Subprogram FUNC

Identification

Name - FUNC
Author/Company - C. Avis/LEC
Machine/Language - UNIVAC 1108, EXEC 2 system/FORTRAN V

Purpose

To output value of a polynomial current fit at a given X.

Argument List Definition

E - array name for coefficients being used
X - variable at which to evaluate the polynomial
FUNC - the value of the polynomial at X.

No functional flowchart necessary
Subroutine HYDACT

Identification

Name - HYDACT
Author/Company - T. DeLuna/MDTSCO
Machine/Language - UNIVAC 1108, EXEC 2 system/FORTRAN V

Purpose

To build the arrays of actuators assigned to each system for specified system configuration and to compute the resultant total thermal capacitance and heat load on each system.

COMMON Block Reference/Input-Output Variables

<table>
<thead>
<tr>
<th>Block Name</th>
<th>Input</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blank Common</td>
<td>C(X,1), X=1,43,</td>
<td>IDUM(I) I=1],13</td>
</tr>
<tr>
<td></td>
<td>C(X,4), X=1,43</td>
<td></td>
</tr>
<tr>
<td>ACT</td>
<td>NACT, FLW</td>
<td>NHYD, NYOUT,</td>
</tr>
<tr>
<td>HYD</td>
<td>IPDO, LMNTRY, IFLAG</td>
<td></td>
</tr>
<tr>
<td>PRESR</td>
<td>PDRP</td>
<td></td>
</tr>
</tbody>
</table>

Local Variable Definitions

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Units</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICNFIG</td>
<td>I</td>
<td></td>
<td>Operating, configuration, 3-pressurized 2=depressurized, 1-off</td>
</tr>
<tr>
<td>ISYS</td>
<td>I</td>
<td></td>
<td>System number found in loss management matrix. Final value is system that a particular actuator is on for current comp cycle.</td>
</tr>
<tr>
<td>J</td>
<td>I</td>
<td></td>
<td>Index used for each actuator.</td>
</tr>
<tr>
<td>JK</td>
<td>I</td>
<td></td>
<td>Position of actuator in actuator array for system just assigned to</td>
</tr>
<tr>
<td>JL</td>
<td>I</td>
<td></td>
<td>Total number of actuators on each system</td>
</tr>
<tr>
<td>LM</td>
<td>I</td>
<td></td>
<td>Column of loss management matrix being checked</td>
</tr>
<tr>
<td>Name</td>
<td>Type</td>
<td>Units</td>
<td>Description</td>
</tr>
<tr>
<td>------</td>
<td>------</td>
<td>-------</td>
<td>--------------------------------------------------</td>
</tr>
<tr>
<td>LMC</td>
<td>I</td>
<td></td>
<td>Operating mode of column of matrix being directed</td>
</tr>
<tr>
<td>NOD</td>
<td>I</td>
<td></td>
<td>Actuator number on sys I</td>
</tr>
</tbody>
</table>
FIGURE 6-5 FUNCTIONAL FLOWCHART OF HYDACT

HYDACT

INITIALIZE COUNTER, JK, OF ACTUATORS AT ZERO

DO I = 1, NTURBN

INITIALIZE COUNTER OF ACTUATORS FOR SYSTEM I AND ZERO ARRAY OF ACTUATOR INLET AND OUTLET NODES ON SYSTEM I

DO J = 1, NACT

IS ANY SYSTEM PRESSURIZED?
(CHECK PRIMARY, 1ST AND 2ND STANDBYS RESPECTIVELY)
LMC ≥ 3

YES

ASSIGN ACTUATOR TO FIRST PRESSURIZED SYSTEM ENCOUNTERED AND ADD 1 TO NUMBER OF ACTUATORS ON THAT SYSTEM

NO

IS ANY SYSTEM DEPRESSURIZED?
(CHECK PRIMARY, 1ST AND 2ND STANDBYS RESPECTIVELY)
2 ≤ LMC < 3

YES

ASSIGN ACTUATOR TO FIRST DEPRESSURIZED SYSTEM ENCOUNTERED ADD 1 TO NUMBER OF ACTUATORS ON THAT SYSTEM

NO

ASSIGN ACTUATOR TO ITS PRIMARY SYSTEM. ISYS = LMMTRX (J, 1)

ASSIGN ACTUATOR NODE A POSITION (JK) IN THE ACTUATOR ARRAY FOR THE SYSTEM TO WHICH ACTUATOR WAS ASSIGNED

ASSIGN INLET NODE OF ACTUATOR J TO JKTH POSITION OF INLET NODE ARRAY AND OUTLET NODE TO JKTH POSITION OF OUTLET NODE ARRAY
DO I = 1, NTURBN

RECALL TOTAL NUMBER OF ACTUATORS, JL, ON SYSTEM I.

ZERO VALUES FOR THERMAL CAPACITANCE AND HEAT LOAD OF THE HYDRAULIC SYSTEM I COMPUTED LAST CYCLE.

DO ND = 1, JL

DETERMINE ACTUATOR INLET NODE, NOD, CORRESPONDING TO NDTH POSITION IN ACTUATOR ARRAY. SUM THERMAL CAPACITANCE OF HYDRAULIC SYSTEM I.

\[
C(x, 1) = C(x, 1) + C(NOD, 1)
\]

DETERMINE PRESSURE DROP, PDRP, FOR SYSTEM I IN ITS PRESENT CONFIGURATION, ICNFIG.

CALCULATE HEAT LOAD OF ACTUATOR, NOD.

\[
C(NOD, 4) = FLW(NOD) \times PRDP(ICNFIG) \times CONVERSION FACTOR
\]

SUM HEAT LOAD ON HYDRAULIC SYSTEM I

\[
C(x, 4) = C(x, 4) + C(NOD, 4)
\]

CONVERT ACTUATOR FLOWRATE (GPM) TO \( WCP \) (LBM-BTU/HR-LBM°R) ASSUMING CONSTANT DENSITY AND SPECIFIC HEAT

RETURN
Subroutine HYDFLD

Identification

Name	 - HYDFLD
Author/Company	 - T. DeLuna/MDTSCQ
Machine/Language	 - UNIVAC 1108, EXEC 2 system/FORTRAN V

Purpose

To compute specific heat and density of the hydraulic fluid and the heat transfer coefficient for the hydraulic heat exchanger.

Support Routine

FUNC - outputs value of a polynomial curve fit at a given X.

Argument List Definition

I - System number
N - Node number counter - used to differentiate between identical nodes on each system

Common Block Reference/Input-Output Variables

Block Name	 Input	 Output
Blank Common	 F(X,K),K,C(X,3) 	 C(X,2)
PRESR	 SPH, DENS

Local Variable Definitions

Name	 Type	 Units	 Description
CPCOEF	 R	 Coeff. for calculating specific heat of hydraulic fluid
RHOCOF	 R	 Coeff for calculating density of hydraulic fluid
TEMP	 R	 °R	 Fluid temperature

No functional flowchart necessary.
Function Subprogram ICNVRT

Identification

Name - ICNVRT
Author/Company - FEAR/TRW
Machine/Language - UNIVAL 1108, EXEC 2 system/FORTRAN V

Purpose
To convert an integer number to hollerith characters so that they can be
included in the plot title.

Argument List Definition
II - Node number of node being plotted.

Local Variable Definition

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Units</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>IIA</td>
<td>I</td>
<td></td>
<td>Digit holding hundredths place of node no.</td>
</tr>
<tr>
<td>II10</td>
<td>I</td>
<td></td>
<td>Digit holding times place of node no.</td>
</tr>
<tr>
<td>II1</td>
<td>I</td>
<td></td>
<td>Digit holding units place of node no.</td>
</tr>
</tbody>
</table>

No Functional Flowchart Necessary
Subroutine LILOAD (ALT model only)

Identification
Name - LILOAD
Author/Company - J. L. Walker/MDTSCO
Machine/Language - UNIVAC 1108, EXEC 2 system/FORTRAN V
Purpose
To read in line data and construct actuator-time matrix.

Common Block Reference/Input-Output Variables

Block Name       Input                  Output
LINES            LINUM, LDGF, KNODE, LTH,
                 IBIG, SPACE, NODLIN, NLCNT
                 SHAPE, EMISS

Local Variable Definition

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Units</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>LINODE</td>
<td>I</td>
<td></td>
<td>Array of actuator nodes serviced by line, LLNUM</td>
</tr>
<tr>
<td>LLNUM</td>
<td>I</td>
<td></td>
<td>Line number</td>
</tr>
<tr>
<td>LNCNT</td>
<td>I</td>
<td></td>
<td>Index for LINODE array</td>
</tr>
<tr>
<td>LN</td>
<td>I</td>
<td></td>
<td>Actuator node in LNCNT of LINODE array</td>
</tr>
<tr>
<td>NLCNT</td>
<td>I</td>
<td></td>
<td>Counter for number of lines servicing a particular actuator</td>
</tr>
<tr>
<td>NL</td>
<td>I</td>
<td></td>
<td>Column number in actuator-line matrix of the line index number</td>
</tr>
</tbody>
</table>
FIGURE 6-6 FUNCTIONAL FLOWCHART FOR LLOAD

1. INITIALIZE DATA FOR SHAPE, EMISS, SPACE
2. ZERO LINE COUNTER LINEX

B

3. ZERO COUNTER FOR NUMBER OF ACTUATORS IN LINODE ARRAY FOR A GIVEN LINE
4. ZERO LINODE ARRAY
5. INCREMENT LINE COUNTER, LINDEX

READ IN LINE DATA FROM TAPE, LINUM LDGF, KNODE, LINODE, LLNUM, LTH, IBIG, FOR ONE LINE

ADD 250 TO KNODE TO AGREE WITH BOUNDARY NODE SCHEME IN MAIN PROGRAM

DETERMINE WHICH ACTUATORS THIS LINE SERVICES FROM LINODE ARRAY. INCREMENT EACH CORRESPONDING ACTUATOR ROW OF NLCNT FOR EACH ACTUATOR ENCOUNTERED

FILL THE CORRESPONDING POSITIONS OF THE ACTUATOR-LINE MATRIX, NODLIN, WITH THE LINE INDEX, LINDEX, FOR EACH ACTUATOR ENCOUNTERED

PRINTOUT LINE DATA FOR THIS LINE, LINUM, KNODE, LINODE

A
IS THERE ANY MORE LINE DATA TO READ FROM THE TAPE?

PRINTOUT THE TOTAL NUMBER OF LINES, THE LINE NUMBERS AND THEIR INDEXES

RETURN
Subroutine LINFL0 (ALT model only)

Identification
Name	- LINFL0
Author/Company	- J. L. Walker/MDTSC0
Machine/Language - UNIVAC 1108, EXEC 2 system/FORTRAN V

Purpose
To compute the flowrate in each of the hydraulic lines.

Argument List Definition
IS - System number

Common Block Reference/Input-Output Variables

<table>
<thead>
<tr>
<th>Block Name</th>
<th>Input</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blank Common</td>
<td>IDUM</td>
<td></td>
</tr>
<tr>
<td>.ACT</td>
<td>NHYD, FLW</td>
<td></td>
</tr>
<tr>
<td>LINES</td>
<td>LDGF, LINUM, NLCNT NODLIN</td>
<td>FLOWL</td>
</tr>
</tbody>
</table>

Local Variable Definition

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Units</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>INTG1</td>
<td>I</td>
<td></td>
<td>First two digits of line number</td>
</tr>
<tr>
<td>INTG2</td>
<td>I</td>
<td></td>
<td>First digit times 10</td>
</tr>
<tr>
<td>INTG3</td>
<td>I</td>
<td></td>
<td>2nd digit of line number. Line is pressure line if off, return if even.</td>
</tr>
<tr>
<td>KEY1</td>
<td>I</td>
<td></td>
<td>System flag for pressure lines</td>
</tr>
<tr>
<td>KEY2</td>
<td>I</td>
<td></td>
<td>System flag for return lines</td>
</tr>
<tr>
<td>JK</td>
<td>I</td>
<td></td>
<td>Number of actuators on system IS</td>
</tr>
<tr>
<td>LLL</td>
<td>I</td>
<td></td>
<td>Number of lines servicing actuator NN</td>
</tr>
<tr>
<td>NN</td>
<td>I</td>
<td></td>
<td>Actuator node on system IS</td>
</tr>
</tbody>
</table>
DEFINE SYSTEM FLAGS, KEY1 AND KEY2

DETERMINE NUMBER, JK OF ACTUATORS ON SYSTEM IS

DO ND = 1, JK

RETRIEVE NODE NUMBER, NN, OF ACTUATOR IN ACTUATOR ARRAY NHYD

DETERMINE TOTAL NUMBER OF LINES, LLL, ON ACTUATOR NN

DO LL = 1, LLL

RETRIEVE LINE NUMBER OF LINE CONNECTED TO ACTUATOR, NN, COMPUTE FLAGS WHICH TELL SYSTEM NUMBER AND WHETHER IT IS A PRESSURE OR RETURN LINE FROM THE LINE NUMBER.

ADD ACTUATOR FLOWRATE TO THE FLOWRATE FOR ALL LINES SERVICING THAT ACTUATOR

RETURN
Subroutine LOOP

Identification
Name - LOOP
Author/Company - FEAR/TRW
Machine/Language - UNIVAC 1108, EXEC 2 system/FORTRAN V

Purpose
To define starting node of thermal loop with most recent fluid temperature.

Argument List Definition
N - node to be updated

Common Block Reference/Input-Output Variables

<table>
<thead>
<tr>
<th>Block Name</th>
<th>Input</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blank Common</td>
<td>F(N,K)</td>
<td>F(N,L)</td>
</tr>
</tbody>
</table>

No Functional Flowchart Necessary
Subroutine LUBOIL

Identification

Name - LUBOIL
Author/Company - T. DeLuna/MDTSCO
Machine/Language - UNIVAC 1108, EXEC 2 system/FORTRAN V

Purpose

To compute specific heat and density of the lubrication oil, the flowrate, \( WC_p \), through the gearbox assuming constant flowrate in gal/min and the heat transfer coefficient of the lube oil heat exchanger.

Argument List Definition

I - System number
N - Node number counter - used to differentiate between identical nodes for each system.

Common Block Reference/Input-Output Variables

<table>
<thead>
<tr>
<th>Block Name</th>
<th>Input</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blank Common</td>
<td>( K, F(N+1,K) )</td>
<td>( C(N+2,2), C(N+1,3), C(N+1,4) )</td>
</tr>
<tr>
<td>HYD</td>
<td>ISPD, POWER</td>
<td></td>
</tr>
</tbody>
</table>

Local Variable Definitions

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Units</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DENS</td>
<td>R</td>
<td>lb/ft(^3)</td>
<td>Density of lube oil</td>
</tr>
<tr>
<td>SPH</td>
<td>R</td>
<td>BTU/lb °R</td>
<td>Specific heat of lube oil</td>
</tr>
<tr>
<td>TBAR</td>
<td>R</td>
<td>°R</td>
<td>Average of temperature across gearbox</td>
</tr>
</tbody>
</table>
FIGURE 6-8. FUNCTIONAL FLOWCHART OF LUBOIL

LUBOIL

COMPUTE THE TEMPERATURE AVERAGE ACROSS GEARBOX, SPECIFIC HEAT AND DENSITY OF LUBE OIL TBAR, SPHL, DENS

YES

IS APU AT 110% SPEED, ISPD = 2?

NO

CALCULATE HEAT REJECTION RATE AND LUBE OIL FLOWRATE FOR 100% SPEED

CALCULATE HEAT REJECTION RATE AND LUBE OIL FLOWRATE FOR 110% SPEED

CONVERT TBAR TO °F

COMPUTE HEAT TRANSFER COEFFICIENT, C(X, 2), FOR LUBE OIL HEAT EXCHANGER

RETURN
Subroutine MIX

Identification

Name - MIX
Author/Company - FEAR/TRW
Machine/Language - UNIVAC 1108/EXEC 2 system/FORTRAN V

Purposes

To determine resultant fluid flowrate, WCP, and temperature when mixing fluid flow from two or more branches.

Argument List Definition

N - Node resulting from mix
NODES - Number of nodes to mix into N
INDEX - Array of nodes to be mixed

Common Block Reference/Input-Output Variables

Block Name Input Output
Blank Common F(INDEX(I),6) F(N,L), C(N,3)

Local Variable Definitions

Name Type Units Description
SUM1 R BTU/hr Sum of the flowrate in each branch times its fluid temperature
ZUM R lbm-BTU/hr-lbm-°R Sum of the flowrate in each branch

No Functional Flowchart Necessary

Note: The DIMENSION of INDEX must be defined in MAIN. The values for INDEX and the flowrate at each node in INDEX must also be supplied.
Subroutine MOD

Identification

Name - MOD
Author/Company - FEAR/TRW, modified by J. L. Walker and T. DeLuna/MDTSCO
Machine/Language - UNIVAC 1108, EXEC 2 system, FORTRAN V

Purpose

To solve equations for proportioning flow split between two branches in response to prescribed temperature, location and proportional gains.

Argument List Definition

N - Node to split
I - Split N into I, Flow XM
J - Split N into J, Flow 1-XM
M - Control node
TC - Control temperature
R - Desired gain, XM change per degree
MAX - Max value of XM
MIN - Min value of XM

Common Block Reference/Input-Output Variables

<table>
<thead>
<tr>
<th>Block Name</th>
<th>Input</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blank Common</td>
<td>F(N,L), F(I+1,L), F(M,L)</td>
<td>C(I,3), C(J,3)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C(N,3)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>F(I,L), F(J,L)</td>
</tr>
</tbody>
</table>

Local Variable Definition

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Units</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>XM</td>
<td>R</td>
<td></td>
<td>Fraction of flowrate at N to assign to I</td>
</tr>
<tr>
<td>GG</td>
<td>R</td>
<td></td>
<td>Max value of XM minus a bias</td>
</tr>
<tr>
<td>HH</td>
<td>R</td>
<td></td>
<td>Min value of XM plus a bias</td>
</tr>
<tr>
<td>FOD</td>
<td>R</td>
<td>93</td>
<td>Adjustment to XM for desired gain</td>
</tr>
</tbody>
</table>
FIGURE 6-9 FUNCTIONAL FLOWCHART FOR MOD.

MOD

COMPUTE RATIO OF TEMPERATURES AND ADJUST RATIO FOR DESIRED GAIN RESULTING IN XM, FRACTION OF SPLIT NODE FLOWRATE TO USE FOR COMPUTING FLOWRATE AT I.

CALCULATE MAXIMUM AND MINIMUM VALUES FOR FLOWRATE CONSIDERING A BIAS OF .005 LB/HR.

IS XM > MIN?

NO

XM EQUALS MINIMUM

IS XM < MAX?

YES

XM EQUALS MAXIMUM

A
FLOWRATE AT I EQUALS XM TIMES
FLOWRATE AT N
\[ C(I, 3) = XM \times C(N, 3) \]

FLOWRATE AT J EQUALS REMAINDER OF
FLOWRATE AT N
\[ C(J, 3) = C(N, 3) - 3(I, 3) \]

ASSIGN FLUID TEMPERATURES
AT I AND J EQUAL TO FLUID
TEMPERATURE AT N

RETURN
Subroutine Pass

Identification

Name - Pass
Author/Company - FEAR/TRW.
Machine/Language - UNIVAC 1108, EXEC 2 system/FORTRAN V

Purpose

To solve equations for heat transfer from a passive component.

Argument List Definition

II - Node number of passive component.

See FEAR USER's GUIDE for further documentation

No Functional Flowchart
Subroutine PLATE

Identification

Name - PLATE (PLATO, GPLT(ECLSS only)) modifications for PLATO by T. DeLuna/MDTSCO
Author/Company - FEAR/TRW
Machine/Language - UNIVAC 1108, EXEC 2 system/FORTRAN V

Purpose

To determine diffusion node heating (PLATE) or to determine hydraulic and diffusion node heating (PLATO)

Argument List Definition

M - Inlet node of component
N - Outlet node of component

Common Block Reference/Input-Output Variables

Block Name Reference/Input-Output Variables

Blank Common

C(M,3), C(N,4), F(M,L) Input

F(N,L), C(N,3) Output

C(M,2), P(M,K), C(M,1) Input

P(M,L) Output

DELT

Local Variable Definitions

Name | Type | Units | Description
--- | --- | --- | ---
CMTRM3 | R | BTU/hr-°R | Thermal capacitance
PMLMK | R | °R | Sum of the present and past values of component temperature
ICUP | I | | Flag to signal that PLATO has been called.
SAVEQ | R | BTU/hr | Heat load of inlet-saved to be retrieved later
SAVET | R | °R | Fluid temp of inlet-saved to be retrieved later
TOFML | R | °R | Twice the fluid temperature of the inlet
UAWCP | R | | Ratio of the heat transfer coefficient of the inlet to the mass flowrate of the inlet.
FIGURE 6-10 FUNCTIONAL FLOWCHART OF PLATE

PLATE

DEFINE OUTLET FLOWRATE EQUAL TO INLET FLOWRATE

PLATO

DEFINE OUTLET FLOWRATE EQUAL TO INLET FLOWRATE.
SAVE INLET FLUID TEMPERATURE AND HEAT LOAD. SET ICUP = 1

REDEFINE INLET FLUID TEMPERATURE AND HEAT LOAD TO PUT HALF OF THE WORK HEAT INTO THE FLUID.

COMPUTE COMPONENT TEMPERATURE AND OUTLET FLUID TEMPERATURE

ICUP = 0?

YES

RETURN

NO

RESET INLET FLUID TEMPERATURE AND HEAT LOAD TO ORIGINAL VALUES. UPDATE OUTLET FLUID TEMPERATURE TO INCLUDE HALF OF THE WORK HEAT

RETURN
Subroutine PLATEC

Identification

Name - PLATEC (entry PLATOC, GPLTC(ECLSS only))

Author/Company - FEAR/TRW

Machine/Language - Univac 1108, EXEC 2 system/FORTRAN V

Purpose

To determine diffusion node heating for components thermally coupled to other components or boundary nodes (PLATEC), or to determine hydraulic and diffusion node heating for components thermally coupled to other components or boundary nodes. (PLATOC)

Supporting Subroutine

PLATE (PLATO) - Computes the heating after PLATEC (PLATOC) has factored the thermal coupling into the heat load.

Argument List Definition

II - Inlet node of component

JJ - Outlet node of component.

Common Block Reference/Input-Output Variables

<table>
<thead>
<tr>
<th>Block Name</th>
<th>Input</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blank Common</td>
<td>C(II,4), P(II,K), P(NOW,K)</td>
<td>C(II,4)</td>
</tr>
<tr>
<td>GLOB</td>
<td>KEEP, IBIG, VAL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>LEEP, JBIG, RVAL</td>
<td></td>
</tr>
</tbody>
</table>

Local Variable Definitions

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Units</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AA</td>
<td>R</td>
<td>BTU/hr</td>
<td>Variable for saving heat load on component</td>
</tr>
<tr>
<td>Name</td>
<td>Type</td>
<td>Units</td>
<td>Description</td>
</tr>
<tr>
<td>------</td>
<td>------</td>
<td>-------</td>
<td>-------------</td>
</tr>
<tr>
<td>ICUP</td>
<td>I</td>
<td></td>
<td>Flag to signal that PLATOC has been called</td>
</tr>
<tr>
<td>NSTRT</td>
<td>I</td>
<td></td>
<td>First position in IBIG array that contains node that node II is coupled to</td>
</tr>
<tr>
<td>NTRY</td>
<td>I</td>
<td></td>
<td>Last position in IBIG array that contains node that node II is coupled to</td>
</tr>
<tr>
<td>SUM</td>
<td>R</td>
<td></td>
<td>Sum of the products of coupling value and temperature difference for each node that II is coupled to</td>
</tr>
<tr>
<td>TEMP</td>
<td>R</td>
<td>°R</td>
<td>Temperature difference between node II and node which II is coupled to for conduction/convection coupling. Difference of temperature values to the 4th power for node II and each of the nodes which II is coupled to for radiation coupling</td>
</tr>
</tbody>
</table>

Note: Coupling values for node II to structure nodes or other components should be input through subroutine START. See Sec. 4.1.2 Node Coupling Data and Appendix A.I.
FIGURE 6-11 FUNCTIONAL FLOWCHART FOR PLATEC

1. SAVE INLET HEAT LOAD

2. SET ICUP = 1

3. DETERMINE POSITIONS IN ARRAY OF COUPLING NODES (IBIG), IN WHICH NODE NUMBERS FOR NODES COUPLED TO NODE II FOR CONDUCTION/CONVECTION COUPLING ARE STORED

DO I = NSTRT, NTRY

4. COMPUTE TEMPERATURE DIFFERENCE BETWEEN COMPONENT TEMPERATURE OF NODE II AND COMPONENT TEMP OF NODE COUPLED TO IBIG(I) FOR CONDUCTION/CONVECTION COUPLING

5. SUM THE PRODUCTS OF THE COUPLING VALUES AND THE TEMPERATURE DIFFERENCE.

6. SUBTRACT HEAT LOSS TO COUPLED NODES FROM INLET HEAD LOAD
DETERMINE POSITIONS IN ARRAY OF COUPLING NODES (JBIG) IN WHICH NODE NUMBERS FOR NODES COUPLED TO NODE II FOR RADIATION COUPLING ARE STORED, IF ANY.

DO I = NSTRT, NTRY

COMPUTE DIFFERENCE OF COMPONENT TEMP OF NODE II TO THE 4TH POWER AND THE COMPONENT TEMP OF THE NODE COUPLED TO NODE II TO THE 4TH POWER

SUM THE PRODUCTS OF THE COUPLING VALUES AND THE TEMPERATURE DIFFERENCE.

SUBTRACT HEAT LOSS TO COUPLED NODES FROM INLET HEAT LOAD

ICUP = 1?

YES
CALL PLATO(II, JJ)

NO
CALL PLATE(II, JJ)

RESET ICUP = 0.
RESET INLET HEAT LOAD TO ORIGINAL VALUE.

RETURN
Subroutine PLOOT

Identification
Name - PLOOT
Author/Company - FEAR/TRW, modified by T. DeLuna/MDTSCO
Machine/Language - Univac 1108, EXEC 2 system/FORTRAN V

Purpose
To put data for plotting on high speed drum for each plot defined by the
plot input cards. (See Sec. 5.2 and Appendix A.1)

Supporting Routine
RWRITE - Subroutine in RANDIO utility routines for accessing high speed drum.
Arguments defined in local variable definitions

Common Block Reference/Input-Output Variables

<table>
<thead>
<tr>
<th>Block Name</th>
<th>Input</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALTD</td>
<td>ALT</td>
<td></td>
</tr>
<tr>
<td>ARRAY</td>
<td>G(MUG,I), I=1,2,3,7</td>
<td></td>
</tr>
<tr>
<td>BLANK COMMON</td>
<td>TIME, F(MUG,L), P(MUG,L), C(MUG,I) I=1,19</td>
<td></td>
</tr>
<tr>
<td>COMEVP</td>
<td>WATLFT</td>
<td></td>
</tr>
<tr>
<td>PSST</td>
<td>IPLT, JPLT, NPLTS</td>
<td>NPLPTS,IWRADR</td>
</tr>
</tbody>
</table>

Local Variable Definitions

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Units</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISTAT</td>
<td>I</td>
<td></td>
<td>Status word for utility package</td>
</tr>
<tr>
<td>IWRADR</td>
<td>I</td>
<td></td>
<td>Address on drum at which to write data</td>
</tr>
<tr>
<td>NIX</td>
<td>I</td>
<td></td>
<td>Counter for number of plots</td>
</tr>
<tr>
<td>NNPLTS</td>
<td>I</td>
<td></td>
<td>Number of plots plus X-parameter</td>
</tr>
<tr>
<td>MUG</td>
<td>I</td>
<td>103</td>
<td>Plot type</td>
</tr>
<tr>
<td>MUG</td>
<td>I</td>
<td></td>
<td>Node number being plotted</td>
</tr>
<tr>
<td>Name</td>
<td>Type</td>
<td>Units</td>
<td>Description</td>
</tr>
<tr>
<td>-------</td>
<td>------</td>
<td>-------</td>
<td>--------------------------------------------------------------</td>
</tr>
<tr>
<td>PLANET</td>
<td>R</td>
<td></td>
<td>Array containing value of each plot parameter at this time point</td>
</tr>
<tr>
<td>XX</td>
<td>R</td>
<td></td>
<td>Value to be placed in PLANET array</td>
</tr>
</tbody>
</table>

Note: The PLOOT routine must be called prior to the call to PRINT or SELECT so that the value of TIME will agree with the data being plotted.
FIGURE 6-1?
FUNCTIONAL FLOWCHART FOR PLOOT

- INITIALIZE COUNTER FOR NUMBER OF PLOTS (NIX)
  - ASSIGN VALUE FOR TIME AS FIRST WORD
    OF RECORD ON DRUM

- INCREMENT COUNTER FOR NUMBER OF PLOTS
  (NIX)
- DETERMINE NODE NUMBER BEING PLOTTED,
  MUG, AND PLOT TYPE (NUG)

GO TO NUG
(COMPUTED GO TO)

- NUG = 1
  - XX = FLUID TEMP. (F(MUG, L))

- NUG = 2
  - XX = COMPONENT TEMP (P(MUG, L))

- NUG = 3
  - XX = FLOWRATE (C(MUG, 3))

- NUG = 4
  - XX = HEAT RATE (C(MUG, 4))

- NUG = 5
  - XX = WATER REMAINING (NATLFT)

- NUG = 6 THRU 16
  - XX = ECLSS PARAMETERS
    (NOT APPLICABLE TO APU/HYDRAULICS)
ASSIGN XX TO \((NIX+1)\)TH POSITION OF PLOTTING DATA ARRAY (PLANET)

IS THERE MORE PLOT DATA TO PUT ON DRUM FOR THIS TIME STEP?

CALL RWRITE
WRITE DATA IN PLANET ARRAY ON HIGH SPEED DRUM
INCRMENT WRITING ADDRESS ON DRUM

RETURN
Subroutine PRINT

Identification

Name - PRINT (SELECT)

Author/Company - FEAR/TRW, modified by T. DeLuna/MDTSCO

Machine/Language - Univac 1108, EXEC 2 system/FORTRAN V

Purpose

To printout node data of interest at specific time intervals.

Argument List Definition

Note: There are no arguments in the call to PRINT. The following arguments are in the call to the entry point (SELECT)

NP - Total number of nodes to print out

NMP - Number of nodes to list as component nodes (less than NP)

IPARI - Array of node numbers to be printed

IO - Flag to signal that SELECT has been called. Must not equal any node number in INODES array.

Common Block Reference/Input-Output Variables

<table>
<thead>
<tr>
<th>Block Name</th>
<th>Input</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACT</td>
<td>NHYD, NHYOUT</td>
<td></td>
</tr>
<tr>
<td>ALT</td>
<td>BH2O, BH2OF, IALT</td>
<td></td>
</tr>
<tr>
<td>ARRAY</td>
<td>FLAG, G(I,7)I=1,8</td>
<td></td>
</tr>
<tr>
<td></td>
<td>G(I,J)J=1,2,3,8,9</td>
<td>I=102,152,202</td>
</tr>
<tr>
<td></td>
<td>ITER</td>
<td></td>
</tr>
<tr>
<td>BLANK COMMON</td>
<td>L,DELT,TIME,TSSTOP,NNODES</td>
<td>TIME</td>
</tr>
<tr>
<td></td>
<td>P(300,L), F(300,L), IDUM</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C(300,J), J=1,2,3,4,17,18,20</td>
<td></td>
</tr>
<tr>
<td>COMEPV</td>
<td>IWAT, NWAT, WAT</td>
<td></td>
</tr>
<tr>
<td>PRT</td>
<td>AERROR, ANAME, ICNT, IPRNT</td>
<td>ICNT</td>
</tr>
</tbody>
</table>
### Local Variable Description

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Units</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>IHR</td>
<td>I</td>
<td>hrs</td>
<td>Current mission time</td>
</tr>
<tr>
<td>IMIN</td>
<td>I</td>
<td>min.</td>
<td>Current mission time</td>
</tr>
<tr>
<td>SEC</td>
<td>R</td>
<td>sec.</td>
<td>Current mission time</td>
</tr>
<tr>
<td>IP</td>
<td>I</td>
<td></td>
<td>Flag =1 if PRINT called =2 if SELECT called</td>
</tr>
<tr>
<td>ISKP</td>
<td>I</td>
<td></td>
<td>Flag to restrict print of certain data on first call to the subroutine</td>
</tr>
<tr>
<td>IEND</td>
<td>I</td>
<td></td>
<td>Flag to designate amount of C array to print out. =4 for APU/Hydraulics</td>
</tr>
<tr>
<td>JM</td>
<td>I</td>
<td></td>
<td>Total number of actuators on a system</td>
</tr>
<tr>
<td>NAD</td>
<td>I</td>
<td></td>
<td>Array of inlet nodes on a system</td>
</tr>
<tr>
<td>NADE</td>
<td>I</td>
<td></td>
<td>Array of outlet nodes on a system</td>
</tr>
<tr>
<td>NMP1</td>
<td>I</td>
<td></td>
<td>Start of loop for printing node number connected with fuel used.</td>
</tr>
<tr>
<td>NMP3</td>
<td>I</td>
<td></td>
<td>End of loop for printing node numbers connected with fuel used.</td>
</tr>
<tr>
<td>VMP4</td>
<td>I</td>
<td></td>
<td>Start of loop for printing node numbers connected with energy used</td>
</tr>
<tr>
<td>NMP6</td>
<td>I</td>
<td></td>
<td>End of loop for printing node numbers connected with energy used.</td>
</tr>
<tr>
<td>NUP</td>
<td>I</td>
<td></td>
<td>Counter used for incrementing TIME</td>
</tr>
</tbody>
</table>
FIGURE 6-13 FUNCTIONAL FLOWCHART FOR PRINT

PRINT

ACCUMULATE ECLSS CONSUMABLES

INCREMENT PRINT FREQUENCY COUNTER
ICNT = ICNT + 1

IS TIME WITHIN COMP CYCLE OF STOP TIME?
ABS (TIME-TSTOP) ≤ DELT

NO

IS IT TIME TO PRINTOUT DATA?
ICNT/IPRINT > 1

YES

NO

IS THIS AN ALT MISSION?
IALT = 1

YES

PRINTOUT WATER BOILER LEVEL AND AMOUNT TRANSFERRED
BH20, BH20F

NO

B
PRINT OUT HEAT BALANCE VALUES (OUTPUT FROM QBAL)
AERROR, G(I, 7), I = 1, 8

PRINT OUT OUTPUT FROM BOILP, P1, P2, TEMPR,
WNDOT, FLAG, ITTER

PRINT OUT LIST OF INLET AND OUTLET NODES FOR EACH HYDRAULIC SYSTEM, NAD, NADE

PRINT OUT CURRENT TIME IN DECIMAL HRS AND HRS:MIN:SEC TIME, IHR, IMIN, ISEC

CHECK PRINT/SELECT-flag. SHOULD EVERY NODE BE PRINTED? IP = 2

PRINT THERMAL DATA FOR SELECTED NODES, INODES P, F, C(X, I) I = 1, 4

PRINT THERMAL DATA FOR ALL NODES P, F, C(X, I) I = 1, 4
PRINTOUT WATER (WAT),
FUEL (C(X, 17)),
AND ENERGY (C(X, 18)) CONSUMED

SKIP OVER PRINTING OF
ECLSS CONSUMABLES

INCREMENT COMPUTATION
CYCLE COUNTER, NUP,
AND UPDATE TIME

RETURN
Subroutine QBAL

Identification

Name	 - QBAL
Author/Company	 - T. DeLuna/MDTSCO
Machine/Language	 - UNIVAC 1108/EXEC 2 system/FORTRAN V

Purpose

To perform a heat balance for accuracy assessment and error detection by comparing total system heat input to total heat dissipation.

Common Block Reference/Input-Output Variables

<table>
<thead>
<tr>
<th>Block Name</th>
<th>Input</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACT</td>
<td>NACT</td>
<td></td>
</tr>
<tr>
<td>ARRAY</td>
<td>TINIT, G(X,4), G(X,5)</td>
<td>G(I,7), I=1, 8</td>
</tr>
<tr>
<td>BLANK COMMON</td>
<td>C(X,1), C(X,4), P(X,6)</td>
<td>C(I,2), I=250,262</td>
</tr>
<tr>
<td>EXTRA</td>
<td>ICOUP</td>
<td></td>
</tr>
<tr>
<td>GLOB</td>
<td>KEEP, IBIG, VAL</td>
<td>LEEP, JBIG, RVAL</td>
</tr>
</tbody>
</table>

Local Variable Definitions

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Units</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DUMM1</td>
<td>R</td>
<td>BTU</td>
<td>Total heat stored in component capacitance by one system counting boiler capacitance twice</td>
</tr>
<tr>
<td>DUMM2</td>
<td>R</td>
<td>BTU</td>
<td>Heat stored in capacitance of boiler</td>
</tr>
<tr>
<td>NSTRT</td>
<td>I</td>
<td></td>
<td>First structure node that node (N+N1) is coupled to</td>
</tr>
<tr>
<td>NTRY</td>
<td>I</td>
<td></td>
<td>Last structure node that node (N+N1) is coupled to</td>
</tr>
<tr>
<td>SUM</td>
<td>R</td>
<td>BTU/hr</td>
<td>Total BTU/hr out via conduction/convection for node (N+N1) for one comp cycle</td>
</tr>
<tr>
<td>Name</td>
<td>Type</td>
<td>Units</td>
<td>Description</td>
</tr>
<tr>
<td>--------</td>
<td>------</td>
<td>---------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>SUM</td>
<td>R</td>
<td>BTU/hr</td>
<td>Total BTU/hr out via conduction/convection for node (N+N1) for one comp cycle</td>
</tr>
<tr>
<td>SUMR</td>
<td>R</td>
<td>BTU/hr</td>
<td>Total BTU/hr out via radiation for node (N+N1)</td>
</tr>
<tr>
<td>TCCUP</td>
<td>R</td>
<td>BTU/hr</td>
<td>Total BTU/hr out via coupling to structure for one system for one comp cycle</td>
</tr>
<tr>
<td>TOTCUP</td>
<td>R</td>
<td>BTU/hr</td>
<td>Total BTU/hr out via coupling to structure for all three systems for one comp cycle</td>
</tr>
<tr>
<td>Ni</td>
<td>I</td>
<td></td>
<td>Index for looping through major components on each system.</td>
</tr>
</tbody>
</table>
FIGURE 6-14 FUNCTIONAL FLOWCHART FOR QBAL

 freelancer

 ZERO STORAGE LOCATION FOR HEAT STORED IN CAPACITANCE
 G(5, 7) = 0.

 DO M = 1, NACT

 SUM HEAT STORED IN CAPACITANCE OF ACTUATORS

 DO I = 1, NTURBN

 SUM APU HEAT FOR SYSTEM I AND FOR TOTAL OF ALL THREE SYSTEMS G(1, 7)

 SUM TURBINE HEAT IN FROM COUPLING ONLY G(2, 7)

 ADD APU HEAT AND TURBINE HEAT FOR TOTAL HEAT INTO SYSTEM:
 G(3, 7) = G(1, 7) + G(2, 7)

 SUM HEAT OUT VIA WATER BOILOFF FOR SYSTEM I AND FOR TOTAL OF ALL THREE SYSTEMS. G(4, 7)
ZERO TEMPORARY STORAGE LOCATION FOR
HEAT STORED IN CAPACITANCE OF MAJOR
COMPONENTS. DUMM1 = 0.

DO N1 = 1, 14

SUM HEAT STORED IN CAPACITANCE OF
MAJOR COMPONENTS AROUND LOOP OF
SYSTEM I, DUMM1

COMPUTE HEAT STORED IN CAPACITANCE OF
WATER BOILER, DUMM2, AND SUBTRACT IT FROM
DUMM1 SINCE DUMM1 ADDS THE WATER BOILER
HEAT TWICE.
ADD THIS TO HEAT STORED IN CAPACITANCE
OF ACTUATORS
G(5, 7) = G(5, 7) + DUMM1 - DUMM2

DO N1 = 1, 12

DETERMINE POSITIONS IN COUPLING ARRAY WHICH CONTAIN NODE NUMBERS AND COUPLING VALUES FOR NODE (N + N1)

DO J = NSTR, NTRY

SUM HEAT LOST TO STRUCTURE DUE TO
CONDUCTION/CONVECTION COUPLING BETWEEN
NODE (N + N1) AND NODE IN POSITION J

...
DO M = NSTRT, NTRY

SUM HEAT LOST TO STRUCTURE DUE TO
RADIATION COUPLING BETWEEN NODE (N + N1)
AND NODE IN POSITION M

- SUM TOTAL HEAT LOST TO STRUCTURE VIA
CONDUCTANCE FOR SYSTEM I
- SUM LINE LOSS AND COMPONENT LOSS FOR
  SYSTEM I
- SUM TOTAL HEAT LOST TO STRUCTURE
  FOR ALL THREE SYSTEMS G(6, 7)

SUM TOTAL HEAT OUT THROUGH WATER
CAPACITANCE AND CONDUCTANCE
G(7, 7) = G(4, 7) + G(5, 7) + G(6, 7)

SUM TOTAL BTU'S ERROR
TOTAL HEAT IN - TOTAL HEAT OUT
G(8, 7) = G(7, 7) - G(3, 7)

RETURN
Subroutine RSTART (OFT model only)

Identification
Name - RSTART
Author/Company - T. DeLuna/MDTSCO
Machine/Language - UNIVAC 1108, EXEC 2 system/FORTRAN V

Purpose
To provide the capability for reinitializing the component and fluid temperature after a particular mission analysis has been started. A flag in the main program determines whether a new set of node data cards is to be read in or the temperatures are to be set to a constant temperature.

Argument List Definition
ICHECK - Flag set so that routine will only be called once

Common Block Reference/Input - Output Variables

<table>
<thead>
<tr>
<th>Black Name</th>
<th>Input</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARRAY</td>
<td></td>
<td>TINIT</td>
</tr>
<tr>
<td>BLANK COMMON</td>
<td>IDUM, NNODES</td>
<td>P(X,1), P(X,2)</td>
</tr>
<tr>
<td>TYME</td>
<td></td>
<td>AMSNTM</td>
</tr>
</tbody>
</table>

Local Variable Definition

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Units</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>IRLST</td>
<td>I</td>
<td></td>
<td>Flag for type of temperature reinitialization</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1 = define as constant</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2 = read in new values</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Equivalenced to IDUM(14). Defined in MAIN2</td>
</tr>
</tbody>
</table>
FIGURE 6-15 FUNCTIONAL FLOWCHART FOR RSTART

RSTART

A

NO

IRST = 1?

YES

DO M = 1, 50

SET "CURRENT" AND "PREVIOUS" TEMPERATURE VALUE OF NODE M EQUAL TO CONSTANT. SAVE THIS INITIAL VALUE

DEFINE ACTUATOR TEMPERATURES

DEFINE MAJOR COMPONENT TEMPERATURES

DEFINE NODE NUMBER STARTING AND STOPPING PLACES FOR DO-LOOP INDEXING, I AND III

DO N = 1, NTURBN

DO M = I, III

SET "CURRENT" AND "PREVIOUS" TEMPERATURE VALUES OF NODE M EQUAL TO CONSTANT. SAVE THIS INITIAL VALUE.

REDEFINE I AND III FOR NEXT SYSTEM NODE NUMBERING

B
SET ICHECK EQUAL TO 1 TO PREVENT ROUTINE FROM BEING CALLED AGAIN

RETURN

READ REINITIALIZATION CARDS

DO I = 1, NNODES

READ IN "CURRENT" VALUE FOR FLUID AND COMPONENT TEMPERATURES IN DEGREES FAHRENHEIT

CONVERT "CURRENT" VALUE FROM °F TO °R

DEFINE "PREVIOUS" VALUE FOR FLUID AND COMPONENT TEMPERATURES EQUAL TO "CURRENT" VALUE

SET ICHECK EQUAL TO 1 TO PREVENT ROUTINE FROM BEING CALLED AGAIN

RETURN
Subroutine SCAL

Identification

Name - SCAL
Author/Company - FEAR/TRW
Machine/Language - UNIVAC 1108, EXEC 2 system/FORTRAN V

Purpose
To provide scaling for the x or y-axes. Support routine for DRAW.

Argument List Definition

XMAX - Maximum value of parameter being scaled (input)
XMIN - Minimum value of parameter being scaled (input)
XI - Axis length desired (input)
DX - Change in parameter per inch (output)
XO - Starting value of parameter (output)
XE - Error value used in iterating for best scaling.

Local Variable Definitions
This routine consists of a mathematical process which uses the maximum and minimum values along with a desired length and iterates for a solution for the change of the parameter per inch which will be some power of 10 times 1, 2 or 5 and result in the closest possible to the desired length. The local variables, A, B, C, D, E, and W are merely terms in the equations used in this process.

No Functional Flowchart Necessary.
Subroutine SPRAY (OFT model only)

Identification
Name - SPRAY
Author/Company - T. DeLuna/MDTSCO
Machine/Language - UNIVAC 1108/EXEC 2 system/FORTRAN V

Purpose
To determine the amount of water used to keep the hydraulic fluid and lubrication oil at or under their control temperatures. This subroutine was written from preliminary information and should be rewritten as soon as spray boiler design data becomes available.

Argument List Definitions
M1 - Inlet node of lube oil heat exchanger
M2 - Inlet node of hydraulic fluid heat exchanger
M11 - Outlet node of lube oil heat exchanger
M22 - Outlet node of hydraulic fluid heat exchanger
ISPRAY - Flag set to show the SPRAY routine has been called

Common Block Reference/Input-Output Variables

<table>
<thead>
<tr>
<th>Block Name</th>
<th>Input</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blank Common</td>
<td>P(M1,K), DELT, F(I,K), I=M11,M22</td>
<td></td>
</tr>
<tr>
<td></td>
<td>F(I,K), I=M1,M2</td>
<td>C(I,3), I=M11, M22</td>
</tr>
<tr>
<td></td>
<td>C(I,3), I=M1,M2</td>
<td></td>
</tr>
<tr>
<td>COMEVP</td>
<td>IWAT, WAT</td>
<td>WAT</td>
</tr>
<tr>
<td>Name</td>
<td>Type</td>
<td>Units</td>
</tr>
<tr>
<td>-------</td>
<td>------</td>
<td>-------</td>
</tr>
<tr>
<td>BTUH</td>
<td>R</td>
<td>BTU/hr</td>
</tr>
<tr>
<td>BTUL</td>
<td>R</td>
<td>BTU/hr</td>
</tr>
<tr>
<td>COEF</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>DELW</td>
<td>R</td>
<td>lbm</td>
</tr>
<tr>
<td>DIFFH</td>
<td>R</td>
<td>°R</td>
</tr>
<tr>
<td>DIFFL</td>
<td>R</td>
<td>°R</td>
</tr>
<tr>
<td>H</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>TCH</td>
<td>R</td>
<td>°R</td>
</tr>
<tr>
<td>TCL</td>
<td>R</td>
<td>°R</td>
</tr>
</tbody>
</table>
FIGURE 6-16 FUNCTIONAL FLOWCHART FOR SPRAY

SPRAY

SET ISPRAY EQUAL TO 1

COMPUTE HEAT OF VAPORIZATION FOR STEAM
AT PRESENT TEMPERATURE

COMPUTE DIFFERENCE BETWEEN LUBE OIL
TEMPERATURE AND CONTROL TEMP
F(M1, K) - TCL = DIFFL

IS LUBE OIL HOTTER THAN
CONTROL TEMP?

NO

YES

DETERMINE AMOUNT OF WATER NEEDED TO
BRING LUBE OIL TEMP DOWN TO CONTROL TEMP

COMPUTE DIFFERENCE BETWEEN HYDRAULIC
FLUID TEMP AND CONTROL TEMP
F(M2, K) - TCH = DIFFH

IS HYDRAULIC FLUID
TEMP HIGHER THAN
CONTROL TEMP?

NO

A

YES

B

123
DETERMINE AMOUNT OF WATER NEEDED TO BRING HYDRAULIC FLUID TEMP DOWN TO CONTROL TEMP

ADD TOTAL AMOUNT OF WATER USED TO AMOUNT USED SO FAR IN MISSION

DEFINE OUTLET FLOWRATES EQUAL TO INLET FLOWRATES

DEFINE OUTLET FLUID TEMPERATURES FOR LUBE OIL AND HYDRAULIC FLUID

RETURN
Subroutine START

Identification

Name - START

Author/Company - FEAR/TRW with major modifications by T. DeLuna/MDTSCO,

Machine/Language - UNIVAC 1108, EXEC 2 system/FORTRAN V

Purpose

To initialize data, read in block of input cards, consolidate array of thermal coupling values, and define print frequency

Supporting Subroutines

CLOCK - Utility routine which outputs time of day

PRINT - Increment print frequency counter, Initialize TIME incrementing
counter.

RINIT - RANDIO utility routine for acquiring starting address on high speed drum

Common Block Reference/Input-Output Variables

<table>
<thead>
<tr>
<th>Block Name</th>
<th>Input</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACT</td>
<td>NACT</td>
<td></td>
</tr>
<tr>
<td>Blank Common</td>
<td></td>
<td>A11</td>
</tr>
<tr>
<td>Extra</td>
<td></td>
<td>ICOUP</td>
</tr>
<tr>
<td>Glob</td>
<td></td>
<td>A11</td>
</tr>
<tr>
<td>HYD</td>
<td></td>
<td>IPDO, LMMTRX</td>
</tr>
<tr>
<td>LUMP2</td>
<td></td>
<td>A11</td>
</tr>
<tr>
<td>PRT</td>
<td></td>
<td>A11</td>
</tr>
<tr>
<td>PSST</td>
<td></td>
<td>A11</td>
</tr>
<tr>
<td>TYME</td>
<td></td>
<td>TIMSUM, AMSNTM, FUDGE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SUMARY(I,J) I=1,4, J=1,3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SUMARY(I,J) I=11,13,14, J-1,3</td>
</tr>
<tr>
<td>Name</td>
<td>Type</td>
<td>Units</td>
</tr>
<tr>
<td>--------</td>
<td>---------</td>
<td>-------</td>
</tr>
<tr>
<td>CLICK</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>ICOUPL</td>
<td>I</td>
<td></td>
</tr>
<tr>
<td>IERROR</td>
<td>I</td>
<td></td>
</tr>
<tr>
<td>IWORK</td>
<td>I</td>
<td></td>
</tr>
<tr>
<td>IZERO</td>
<td>I</td>
<td></td>
</tr>
<tr>
<td>JJ</td>
<td>I</td>
<td></td>
</tr>
<tr>
<td>LL</td>
<td>I</td>
<td></td>
</tr>
<tr>
<td>LOCK</td>
<td>I</td>
<td></td>
</tr>
<tr>
<td>MOREV</td>
<td>I</td>
<td></td>
</tr>
<tr>
<td>NCON</td>
<td>I</td>
<td></td>
</tr>
<tr>
<td>NJ</td>
<td>I</td>
<td></td>
</tr>
<tr>
<td>NK</td>
<td>I</td>
<td></td>
</tr>
<tr>
<td>NODE</td>
<td>I</td>
<td></td>
</tr>
<tr>
<td>NRAD</td>
<td>I</td>
<td></td>
</tr>
<tr>
<td>NSC</td>
<td>I</td>
<td></td>
</tr>
<tr>
<td>NSYSUP</td>
<td>I</td>
<td></td>
</tr>
<tr>
<td>WORDS</td>
<td>R (hollerith words)</td>
<td></td>
</tr>
<tr>
<td>WORK</td>
<td>R</td>
<td>126</td>
</tr>
</tbody>
</table>

(1) - conduction/convection
(2) - radiation
FIGURE 6-17 FUNCTIONAL FLOWCHART FOR START

START

ZERO ALL OF BLANK COMMON

READ IN TITLE FROM FIRST DATA CARD
PRINTOUT GREETING AND TITLE

READ IN DATA FROM NEXT THREE DATA CARDS: RUN CONTROL, PLOT CONTROL AND SUMMARY TABLE CONTROL CARD

READ IN NODE COUPLING CARDS

IS THERE ANY CONDUCTION COUPLING?

YES

REARRANGE CONDUCTION/CONVECTION COUPLING NODES FOR EASE IN RETRIEVING COUPLING INFORMATION LATER. CONSTRUCT IBIG AND VAL COUPLING ARRAYS.

NO

IS THERE ANY RADIATION COUPLING?

YES

NO

A

B 127
REARRANGE RADIATION COUPLING NODES FOR EASE IN RETRIEVING COUPLING INFORMATION LATER. CONSTRUCT JBIG AND RVAL COUPLING ARRAYS

PRINTOUT NUMBER OF NODES, DELTA TIME, START TIME, STOP TIME, PRINT INTERVAL NNODES, DELT, TIME, TSTOP, PRNT

PRINTOUT TITLES FOR NODE DATA

DO I = 1, NNODES

READ IN NODE NUMBER, APPLICABLE PARTS OF C-ARRAY, INITIAL COMPONENT AND FLUID TEMPS AND NODE NAME AND PRINTOUT SAME DATA

CONVERT TEMPERATURE VALUES FROM FAHRENHEIT TO RANKINE

READ IN PLOT INPUT CARDS CONTAINING: IPLT, JPLT, BIG, WEE, NTR, AND PRINTOUT THE SAME TIME

CALL RINIT
ACQUIRE HIGH SPEED DRUM ADDRESSES FOR SAVING PLOT DATA
C

READ IN HEAT BALANCE VALUE TITLES AERROR

READ IN AND PRINTOUT SYSTEM CONFIGURATION MATRIX, IPDO

READ IN AND PRINTOUT LOSS MANAGEMENT MATRIX, LMMTRX

READ IN CONSTANT LOADING AND RESERVES VALUES FOR FUEL AND WATER FOR SUMMARY TABLE, SUMARY

INITIALIZE K AND L, COMPUTE NUMBER OF COMP CYCLES BETWEEN PRINT INTERVALS FOR PRINT FREQUENCY COUNTER.
SET IDUM(8) = 1

CALL PRINT
INITIALIZE TIME INCREMENTING COUNTER, INCREMENT PRINT COUNTER

SET IDUM(8) = 2

RETURN
Subroutine THERMP (ALT model only)

Identification

Name	 - THERMP
Author/Company - J. L. Walker/MDTSCO
Machine/Language - UNIVAC 1108/EXEC 2 system/FORTRAN V

Purpose

To determine the heat loss and resultant fluid temperature in the hydraulic pressure lines from the pump to the actuators due to conduction convection and radiation coupling to vehicle structure and compartment air.

Argument List Definition

IS - System number
N1 - Node number counter - used to differentiate between identical nodes on each system
PAMB - Ambient air pressure

Common Block Reference/Input-Output Variable

<table>
<thead>
<tr>
<th>Block Name</th>
<th>Input</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACT</td>
<td>NHYD, FLW</td>
<td></td>
</tr>
<tr>
<td>Blank Common</td>
<td>IDUM, F(X,L), P(X,L)</td>
<td>C(I,A), I-251, 263 F(X,L)</td>
</tr>
<tr>
<td>LINES</td>
<td>FLOWL, IBIG, KNODE, LDGF, LINUM, LTH, NLCNT, NODLIN, SPACE, TEMPOT</td>
<td>TEMPIN, TEMPOT, QDOTL</td>
</tr>
<tr>
<td>PRT</td>
<td>ICNT, IPRNT</td>
<td></td>
</tr>
</tbody>
</table>
Local Variable Definitions

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Units</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AREA</td>
<td>R</td>
<td>in²</td>
<td>Area of the line segment being solved</td>
</tr>
<tr>
<td>BASE</td>
<td>R</td>
<td>BTU/hr-ft²·°F</td>
<td>Convection coefficient base factor for current temp</td>
</tr>
<tr>
<td>ILTH</td>
<td>I</td>
<td>in</td>
<td>Length of line segment to use in line solutions</td>
</tr>
<tr>
<td>ID</td>
<td>I</td>
<td></td>
<td>Line index of line being solved</td>
</tr>
<tr>
<td>INN</td>
<td>I</td>
<td></td>
<td>Number of line segments in line ID</td>
</tr>
<tr>
<td>INTG3</td>
<td>I</td>
<td></td>
<td>Second digit in line number</td>
</tr>
<tr>
<td>JK</td>
<td>I</td>
<td></td>
<td>Number of actuators on system IS</td>
</tr>
<tr>
<td>KEY1</td>
<td>I</td>
<td></td>
<td>Flag to determine if line ID is a pressure line for system IS</td>
</tr>
<tr>
<td>KEY2</td>
<td>I</td>
<td></td>
<td>Flag to determine if present line being solved is first line downstream of pump.</td>
</tr>
<tr>
<td>K1</td>
<td>I</td>
<td></td>
<td>Number of 16ths of an inch in diameter of line</td>
</tr>
<tr>
<td>K2</td>
<td>I</td>
<td></td>
<td>Structure node coupled to line ID</td>
</tr>
<tr>
<td>LASTID</td>
<td>I</td>
<td></td>
<td>Line index for the previous line solved</td>
</tr>
<tr>
<td>LTHEND</td>
<td>I</td>
<td>in</td>
<td>Line segment shorter than ILTH remaining at end of line or length of line shorter than ILTH</td>
</tr>
<tr>
<td>NAL</td>
<td>I</td>
<td></td>
<td>Number of lines to be solved for actuator NN</td>
</tr>
<tr>
<td>NN</td>
<td>I</td>
<td></td>
<td>Actuator inlet node number</td>
</tr>
<tr>
<td>T2</td>
<td>R</td>
<td>°R</td>
<td>Temperature of structure node that line ID is coupled to</td>
</tr>
<tr>
<td>TI</td>
<td>R</td>
<td>°R</td>
<td>Inlet fluid temperature of line segment</td>
</tr>
<tr>
<td>TC</td>
<td>R</td>
<td>°R</td>
<td>Predicted center temperature of line segment</td>
</tr>
<tr>
<td>TO</td>
<td>R</td>
<td>°R</td>
<td>Outlet fluid temperature of line segment</td>
</tr>
<tr>
<td>TEMPZ</td>
<td>R</td>
<td>°R³</td>
<td>Coefficient computed using boundary temperature and temperature at center point of line segment to linearize radiation coupling</td>
</tr>
<tr>
<td>TFILM</td>
<td>R</td>
<td>°R</td>
<td>Convection film temperature</td>
</tr>
<tr>
<td>TBEFF</td>
<td>R</td>
<td>°R</td>
<td>Effective boundary temperature</td>
</tr>
<tr>
<td>UACOND</td>
<td>R</td>
<td>BTU/hr-°R</td>
<td>Conduction coupling coefficient</td>
</tr>
<tr>
<td>UACONV</td>
<td>R</td>
<td>BTU/hr-°R</td>
<td>Linearized convection coupling coefficient</td>
</tr>
<tr>
<td>UARAD</td>
<td>R</td>
<td>BTU/hr-°R</td>
<td>Linearized radiation coupling coefficient</td>
</tr>
<tr>
<td>UA</td>
<td>R</td>
<td>BTU/hr-°R</td>
<td>Combined coupling coefficient</td>
</tr>
</tbody>
</table>
DETERMINE ACTUATOR NODE NUMBER, NN, OF NDTH ACTUATOR ON SYSTEM IS

DO LL = 1, NAL

DETERMINE LINE INDEX AND WHETHER LINE IS A PRESSURE OR RETURN FOR SYSTEM IS

DEFINE INLET FLUID TEMPERATURE EQUAL TO PUMP OUTLET TEMP IF FIRST LINE TO ACTUATOR, OR TO OUTLET TEMP OF LAST LINE SOLVED OTHERWISE...

DETERMINE AREA AND CONDUCTION COEFFICIENT OF ILTH INCH LINE SEGMENT, CONVERT FLOWRATE OF LINE ID, AND DETERMINE NUMBER OF LINE SEGMENTS, INN, IN LINE ID.
DO IN = 1, INN

IS LINE SEGMENT IITH INCHES LONG?

YES

DETERMINE AREA AND CONDUCTION COEFFICIENT OF SMALLER LINE SEGMENT

NO

COMPUTE INLET AND PREDICTED CENTER TEMPERATURE OF LINE SEGMENT, IN.

CALCULATE LINEARIZED RADIATION COUPLING COEFFICIENT FOR LINE SEGMENT, IN, USING TEMPERATURE AT CENTER OF LINE SEGMENT

CALCULATE LINEARIZED CONVECTION COUPLING COEFFICIENT FOR LINE SEGMENT, IN

ADD UP TOTAL COUPLING FOR LINE SEGMENT, IN.

COMPUTE EFFECTIVE BOUNDARY TEMPERATURE & OUTLET TEMPERATURE OF LINE SEGMENT, IN

SUM HEAT LOSS RATE IN LINE
D

ACCUMULATE HEAT LOSS RATE IN LINES

PRINT OUT LINE DATA FOR LINE ID PRINTING TEMPERATURES IN FAHRENHEIT

SET FLAGS TO SIGNAL THAT LINE CALCULATIONS WERE NOT FOR FIRST LINE IN PATH FROM PUMP TO ACTUATOR

SET ACTUATOR INLET TEMPERATURE EQUAL TO OUTLET TEMPERATURE OF LAST LINE IN LINE PATH

RETURN

A

B
Subroutine THERMR (ALT model only)

Identification

Name - THERMR

Author/Company - J. L. Walker/MDTSCO

Machine/Language - UNIVAC 1108, EXEC 2 system/FORTRAN V

Purpose

To determine heat loss and resultant fluid temperature in hydraulic return lines from the actuators to case drain mix node due to conduction, convection and radiation coupling to vehicle structure and compartment air.

Argument List Definition

IS - System number

N1 - Node number counter - used to differentiate between identical nodes on each system

PAMB - Ambient air pressure

Common Block Reference/Input-Output Variables

<table>
<thead>
<tr>
<th>Block Name</th>
<th>Input</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACT</td>
<td>NHYD, FLW</td>
<td></td>
</tr>
<tr>
<td>Blank Common</td>
<td>IDUM, F, P, DELT, C(I,4), I=251,263</td>
<td>C(X,3)</td>
</tr>
<tr>
<td>LINES</td>
<td>NODLIN, NLCNT, LINUM QDOTL</td>
<td>FLOWL, SPACE, LTH, LDGF</td>
</tr>
<tr>
<td>HYD</td>
<td>IPDO, IFLAG</td>
<td></td>
</tr>
<tr>
<td>PRESR</td>
<td>PDRP</td>
<td></td>
</tr>
<tr>
<td>PRT</td>
<td>ICHT, IPRNT</td>
<td></td>
</tr>
</tbody>
</table>
## Local Variable Definitions

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Units</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AREA</td>
<td>R</td>
<td>in²</td>
<td>Area of line segment being solved</td>
</tr>
<tr>
<td>BASE</td>
<td>R</td>
<td>BTU/hr-ft²-°R</td>
<td>Convection coefficient base factor for current kmp</td>
</tr>
<tr>
<td>CAPHR</td>
<td>R</td>
<td>BTU/min</td>
<td>System capacitance heat soak rate</td>
</tr>
<tr>
<td>ICNFIG</td>
<td>I</td>
<td></td>
<td>Present system configuration 3=pressurized, 2=depressurized, 1=off</td>
</tr>
<tr>
<td>ID</td>
<td>I</td>
<td></td>
<td>Line index of line being solved</td>
</tr>
<tr>
<td>ILTH</td>
<td>I</td>
<td></td>
<td>Length of line segments to use in line solutions</td>
</tr>
<tr>
<td>INN</td>
<td>I</td>
<td></td>
<td>Number of line segments in line ID</td>
</tr>
<tr>
<td>INTG3</td>
<td>I</td>
<td></td>
<td>Second digit in line number</td>
</tr>
<tr>
<td>JK</td>
<td>I</td>
<td></td>
<td>Number of actuators on sys IS</td>
</tr>
<tr>
<td>KEY1</td>
<td>I</td>
<td></td>
<td>Flag to determine if line ID is a return line or system IS.</td>
</tr>
<tr>
<td>KEY2</td>
<td>I</td>
<td></td>
<td>Flag to determine if line ID is first line in actuator's return line path</td>
</tr>
<tr>
<td>KEY3</td>
<td>I</td>
<td></td>
<td>Flag used in determining total flow rate in return lines</td>
</tr>
<tr>
<td>K1</td>
<td>I</td>
<td></td>
<td>Number of 16th of an inch in the line's diameter</td>
</tr>
<tr>
<td>K2</td>
<td>I</td>
<td></td>
<td>Structure node coupled to line ID.</td>
</tr>
<tr>
<td>LASTID</td>
<td>I</td>
<td>in</td>
<td>Line index for the previous line solved</td>
</tr>
<tr>
<td>LTHEND</td>
<td>I</td>
<td>in</td>
<td>Length of remainder of line after line divided into segments of length, ILTH</td>
</tr>
<tr>
<td>NAL</td>
<td>I</td>
<td></td>
<td>Number of lines to be solved for actuator,MN</td>
</tr>
<tr>
<td>NN</td>
<td>I</td>
<td></td>
<td>Actuator node number</td>
</tr>
<tr>
<td>T2</td>
<td>R</td>
<td>°R</td>
<td>Temperature of structure node that line ID is coupled to.</td>
</tr>
<tr>
<td>TI</td>
<td>R</td>
<td>°R</td>
<td>Inlet fluid temperature</td>
</tr>
<tr>
<td>TC</td>
<td>R</td>
<td>°R</td>
<td>Predicted center temperature of line segment</td>
</tr>
<tr>
<td>TO</td>
<td>R</td>
<td>°R</td>
<td>Outlet fluid temperature of line segment</td>
</tr>
<tr>
<td>TEMPZ</td>
<td>R</td>
<td>°R</td>
<td>Coefficient computed using boundary temperature and temperature at center of</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>line segment to linearize radiation coupling</td>
</tr>
<tr>
<td>TFILM</td>
<td>R</td>
<td>°R</td>
<td>Convection film temperature</td>
</tr>
<tr>
<td>Name</td>
<td>Type</td>
<td>Units</td>
<td>Description</td>
</tr>
<tr>
<td>--------</td>
<td>------</td>
<td>---------------</td>
<td>--------------------------------------------------</td>
</tr>
<tr>
<td>TBEFF</td>
<td>R</td>
<td>°R</td>
<td>Effective boundary temperature</td>
</tr>
<tr>
<td>UACOND</td>
<td>R</td>
<td>BTU/hr-°R</td>
<td>Conduction coupling coefficient</td>
</tr>
<tr>
<td>UACONV</td>
<td>R</td>
<td>BTU/hr-°R</td>
<td>Linearized convection coupling coefficient</td>
</tr>
<tr>
<td>UARAD</td>
<td>R</td>
<td>BTU/hr-°R</td>
<td>Linearized radiation coupling coefficient</td>
</tr>
<tr>
<td>UA</td>
<td>R</td>
<td>BTU/hr-°R</td>
<td>Combined coupling coefficient</td>
</tr>
</tbody>
</table>
FIGURE 6-19 FUNCTIONAL FLOWCHART FOR THERMR

- COMPUTE FLAG TO CHECK IF LINES ARE RETURN LINES FOR SYSTEM IS
- RETRIEVE NUMBER OF ACTUATORS, JK, THAT ARE ON SYSTEM IS

DO ND = 1, JK

DETERMINE ACTUATOR NODE NUMBER, NN, OF NDTH ACTUATOR ON SYSTEM IS

DETERMINE NUMBER OF LINES, NAL, SERVICING ACTUATOR NN

DETERMINE LINE INDEX AND WHETHER OR NOT LINE IS RETURN LINE FOR SYSTEM IS

DEFINE INLET FLUID TEMPERATURE AND FLOW-RATE IN LINE ID BY MIXING THE FLUID COMING FROM BRANCH LINES.

DETERMINE AREA AND CONDUCTION COUPLING COEFFICIENT OF ILTH INCH SEGMENT, CONVERT FLOW-RATE OF LINE ID, AND DETERMINE NUMBER OF LINE SEGMENTS, INN, IN LINE ID.
DO IN = 1, IN

YES

IS LINE SEGMENT LENGTH INCHES LONG?

NO

DETERMINE AREA AND CONDUCTION COEFFICIENT OF SMALLER LINE SEGMENT

DETERMINE INLET AND PREDICT CENTER TEMP OF LINE SEGMENT, ID

CALCULATE LINEARIZED RADIATION COUPLING COEFFICIENT FOR LINE SEGMENT, IN, USING TEMPERATURE AT CENTER OF LINE SEGMENT.

CALCULATE LINEARIZED CONVECTION COUPLING COEFFICIENT FOR LINE SEGMENT, IN.

- ADD UP TOTAL COUPLING FOR LINE SEGMENT, IN
- COMPUTE EFFECTIVE BOUNDARY TEMPERATURE AND OUTLET TEMP OF LINE SEGMENT, IN
- SUM HEAT LOSS RATE IN LINE, ID

D 139
ACCUMULATE HEAT LOSS RATE IN LINES

PRINTOUT LINE DATA FOR LINE ID PRINTING TEMPERATURES IN FAHRENHEIT

SET FLAGS TO SIGNAL THAT LINE CALCULATIONS WERE NOT FOR FIRST LINE IN PATH FROM ACTUATOR TO MIX NODE

ACCUMULATE CAPACITANCE HEAT SOAK RATE FOR ACTUATORS ON SYSTEM IS

ACCUMULATE TOTAL HEAT LOSS RATE, AND CALCULATE ACTUATOR COUPLING HEAT LOSS RATE

PRINTOUT, LINE AND ACTUATOR HEAT LOSS RATES, THE CAPACITANCE HEAT SOAK RATE AND TOTAL HEAT DISSIPATION RATE.

DEFINE TEMPERATURE AND FLOWRATE AT CASE DRAIN MIX NODE.

RETURN
Subroutine TRANS

Identification

Name - TRANS (GTRANS (ECLSS only))

Author/Company - FEAR/TRW

Machine/Language - UNIVAC 1108, EXEC 2 system/FORTRAN V

Purpose

To transfer flowrate and fluid temperature data from node II to node JJ.

Argument List Definition

II - Node with known flowrate and fluid temperature

JJ - Node to which to transfer data

Common Block Reference/Input-Output Variables

<table>
<thead>
<tr>
<th>Block Name</th>
<th>Input</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blank Common</td>
<td>F(II,L), C(II,3)</td>
<td>F(JJ,L), C(JJ,3)</td>
</tr>
</tbody>
</table>

No Functional Flowchart Necessary
Subroutine ZIPIT

Identification

Name - ZIPIT

Author/Company - J. L. Walker/MDTSCO

Machine/Language - UNI VAC 1108/EXEC 2 system/FORTRAN V

Purpose

To zero line flowrate, heat rate, and temperature arrays and to zero line heat loss rate arrays.

Common Block Reference/Input-Output Variables

<table>
<thead>
<tr>
<th>Block Name</th>
<th>Input</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blank Common</td>
<td>C(I, 4), I=251,253</td>
<td>FLOWL, TEMPIN, TEMPOUT,</td>
</tr>
<tr>
<td>Lines</td>
<td>FLACUM, FLOWT, QDOTL</td>
<td></td>
</tr>
</tbody>
</table>

No Functional Flowchart Necessary
APPENDIX A. PROGRAM USAGE

This appendix presents the information necessary to execute TAHAP successfully. An overall deck setup, the sequence of the input data cards, and the specific data card requirements and the format of those cards are listed and described. Differences between the ALT and OFT versions are noted where they occur.

Deck setup for TAHAP is illustrated in Figure A-1. The input data deck card sequence is summarized in Figure A-2. Data format requirements for data cards are summarized in Section A.1 and for data tapes in Section A.2.
FIGURE A-1 DECK SETUP FOR TAHAP

7/8 FIN

7/8 B PMD

7/8 EOF

INPUT DATA DECK

7/8 XQT APUHYD

PROGRAM CHANGE CARDS

TOC

TRI A

IN A

TRW A

7/8 XQT CUR

7/8 ASG P = CCP1

7/8 ASG D = LINE DATA TAPE NO. (ALT MISSION ONLY)

7/8 ASG B = MISSION TIMELINE INPUT TAPE NO.

7/8 ASG A = PCF TAPE NO.

7/8 RUN
FIGURE A-2  INPUT DATA DECK SEQUENCE

TAHAP REQUIRES THAT THE INPUT CARDS BE IN THE FOLLOWING ORDER:

1. TITLE CARD
2. MISSION CONTROL CARD
3. PLOT CONTROL CARD
4. SUMMARY TABLE CONTROL CARD
5. NODE COUPLING CARDS
6. NODE THERMAL DATA CARDS
7. PLOT INPUT CARDS
8. HEAT BALANCE TITLE CARDS
9. SYSTEM CONFIGURATION MATRIX
10. LOSS MANAGEMENT MATRIX
11. SUMMARY TABLE CONSTANTS
A.1 INPUT DATA CARD FORMAT REQUIREMENTS

The following lists summarize the card formats for each of the cards identified in Figure A-2. All integer values must be right justified.

1. Title card

<table>
<thead>
<tr>
<th>FORMAT</th>
<th>COLUMNS</th>
<th>DATA</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1 - 72</td>
<td>Any title</td>
</tr>
</tbody>
</table>

2. Mission run control card

<table>
<thead>
<tr>
<th>FORMAT</th>
<th>COLUMNS</th>
<th>DATA</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>1 - 5</td>
<td>Number of nodes</td>
</tr>
<tr>
<td>F</td>
<td>11 - 20</td>
<td>Time computation increment (hrs)</td>
</tr>
<tr>
<td>F</td>
<td>21 - 30</td>
<td>Mission start time (hrs)</td>
</tr>
<tr>
<td>F</td>
<td>31 - 40</td>
<td>Mission stop time (hrs)</td>
</tr>
<tr>
<td>F</td>
<td>41 - 50</td>
<td>Print interval (hrs)</td>
</tr>
<tr>
<td>I</td>
<td>51 - 55</td>
<td>Number of CALCOMP plot traces</td>
</tr>
<tr>
<td>I</td>
<td>56 - 60</td>
<td>Number of Coupling Data cards</td>
</tr>
<tr>
<td>I</td>
<td>66 - 70</td>
<td>Flag for type of Ambient Air Temp profile</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 = Cold Day, 3 = Hot Day, 4 = Nominal (ALT Only)</td>
</tr>
</tbody>
</table>

3. Plot control card

<table>
<thead>
<tr>
<th>FORMAT</th>
<th>COLUMNS</th>
<th>DATA</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>1 - 5</td>
<td>PLTSEQ (input the value &quot;1&quot;)</td>
</tr>
<tr>
<td>F</td>
<td>11 - 20</td>
<td>Mission stop time</td>
</tr>
<tr>
<td>F</td>
<td>21 - 30</td>
<td>X-axis length (inches)</td>
</tr>
<tr>
<td>F</td>
<td>31 - 40</td>
<td>Y-axis length (inches)</td>
</tr>
<tr>
<td>I</td>
<td>41 - 50</td>
<td>NOPLOT (ignore)</td>
</tr>
</tbody>
</table>

4. Summary Table control card

<table>
<thead>
<tr>
<th>FORMAT</th>
<th>COLUMNS</th>
<th>DATA</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>1 - 10</td>
<td>Time at end of Pre-Launch Phase (hrs)</td>
</tr>
<tr>
<td>F</td>
<td>11 - 20</td>
<td>Time at touchdown (hrs)</td>
</tr>
<tr>
<td>F</td>
<td>21 - 30</td>
<td>Time at end of Post touchdown (hrs)</td>
</tr>
<tr>
<td>F</td>
<td>31 - 40</td>
<td>Length of Mission from Takeoff (hrs)</td>
</tr>
<tr>
<td>F</td>
<td>41 - 50</td>
<td>Fudge time for long missions</td>
</tr>
</tbody>
</table>
5. Node Coupling cards (one card for each pair of nodes)

<table>
<thead>
<tr>
<th>FORMAT</th>
<th>COLUMNS</th>
<th>DATA</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>1 - 5</td>
<td>I, J</td>
</tr>
<tr>
<td>I</td>
<td>6 - 10</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>11 - 20</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>21 - 30</td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>50</td>
<td></td>
</tr>
</tbody>
</table>

NOTE: Input only one card for each pair of coupled nodes. The order is insignificant.

6. Node Thermal Data cards (one card for each node)

<table>
<thead>
<tr>
<th>FORMAT</th>
<th>COLUMNS</th>
<th>DATA</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>1 - 5</td>
<td>I</td>
</tr>
<tr>
<td>I</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>11 - 20</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>21 - 30</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>31 - 40</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>41 - 50</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>51 - 60</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>61 - 70</td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>71 - 80</td>
<td></td>
</tr>
</tbody>
</table>

7. Plot Input cards

<table>
<thead>
<tr>
<th>FORMAT</th>
<th>COLUMNS</th>
<th>DATA</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>1 - 5</td>
<td>I</td>
</tr>
<tr>
<td>I</td>
<td>6 - 10</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>11 - 20</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>21 - 30</td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>31 - 35</td>
<td></td>
</tr>
</tbody>
</table>
7. (continued)

One card is required for each trace. The cards for the traces on the same plot must be kept together.

8. Heat balance title cards (8 cards)

Titles for each value output as described in Sec. 5.1.5.

<table>
<thead>
<tr>
<th>FORMAT</th>
<th>COLUMNS</th>
<th>DATA</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1 - 12</td>
<td>Title of heat balance value</td>
</tr>
</tbody>
</table>

9. System Configuration Matrix (27 cards)

<table>
<thead>
<tr>
<th>FORMAT</th>
<th>COLUMNS</th>
<th>DATA</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>1 - 5</td>
<td>Number representing configuration of System 1</td>
</tr>
<tr>
<td>I</td>
<td>6 - 10</td>
<td>Number representing configuration of System 2</td>
</tr>
<tr>
<td>I</td>
<td>11 - 15</td>
<td>Number representing configuration of System 3</td>
</tr>
<tr>
<td>I</td>
<td>71 - 72</td>
<td>System configuration number (optional - written on card to help keep cards in order, not read).</td>
</tr>
</tbody>
</table>

3 = Pressurized, 2 = Depressurized, 1 = Off

Cards must be in numerical order for configurations 1 - 27.

10. Loss Management Matrix

<table>
<thead>
<tr>
<th>FORMAT</th>
<th>COLUMNS</th>
<th>DATA</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>1 - 5</td>
<td>Primary system for node I</td>
</tr>
<tr>
<td>I</td>
<td>6 - 10</td>
<td>1st standby system for node I</td>
</tr>
<tr>
<td>I</td>
<td>11 - 15</td>
<td>2nd standby system for node I</td>
</tr>
<tr>
<td>I</td>
<td>20</td>
<td>Input a zero</td>
</tr>
<tr>
<td>I</td>
<td>71 - 72</td>
<td>Node number (I) (optional - written on card to keep cards in order, not read)</td>
</tr>
</tbody>
</table>

Cards must be in numerical order for nodes 1 - total number of actuators, NACT. Presently there are 37 actuators for ALT model, 43 actuators for OFT model. The variable, NACT, defined by data statement in MAIN determines number of cards to be read.
11. Summary Table constants

<table>
<thead>
<tr>
<th>FORMAT</th>
<th>COLUMNS</th>
<th>DATA</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. F</td>
<td>1 - 10</td>
<td>Loading value for fuel, system 1 (lbm)</td>
</tr>
<tr>
<td>F</td>
<td>11 - 20</td>
<td>Loading value for fuel, system 2 (lbm)</td>
</tr>
<tr>
<td>F</td>
<td>21 - 30</td>
<td>Loading value for fuel, system 3 (lbm)</td>
</tr>
<tr>
<td>F</td>
<td>31 - 35</td>
<td>Loading and in-flight measurement error for fuel, system 1 (lbm)</td>
</tr>
<tr>
<td>F</td>
<td>36 - 40</td>
<td>Loading and in-flight measurement error for fuel, system 2 (lbm)</td>
</tr>
<tr>
<td>F</td>
<td>41 - 45</td>
<td>Loading and in-flight measurement error for fuel, system 3 (lbm)</td>
</tr>
<tr>
<td>F</td>
<td>46 - 50</td>
<td>Residual quantity for fuel, system 1 (lbm)</td>
</tr>
<tr>
<td>F</td>
<td>51 - 55</td>
<td>Residual quantity for fuel, system 2 (lbm)</td>
</tr>
<tr>
<td>F</td>
<td>56 - 60</td>
<td>Residual quantity for fuel, system 3 (lbm)</td>
</tr>
<tr>
<td>b. F</td>
<td>1 - 10</td>
<td>Loading value for water, system 1 (lbm)</td>
</tr>
<tr>
<td>F</td>
<td>11 - 20</td>
<td>Loading value for water, system 2 (lbm)</td>
</tr>
<tr>
<td>F</td>
<td>21 - 30</td>
<td>Loading value for water, system 3 (lbm)</td>
</tr>
<tr>
<td>F</td>
<td>31 - 40</td>
<td>Residual quantity for water, system 1 (lbm)</td>
</tr>
<tr>
<td>F</td>
<td>41 - 50</td>
<td>Residual quantity for water, system 2 (lbm)</td>
</tr>
</tbody>
</table>
### A.2 INPUT DATA TAPE FORMAT REQUIREMENTS

Data tape inputs include both mission timelines and fine data.

#### A.2.1 Mission Timeline Input Data Tape Format

Each record of the timeline input tape must contain each of the following 56 words:

<table>
<thead>
<tr>
<th>Word #</th>
<th>Type</th>
<th>Units</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>R</td>
<td>hrs</td>
<td>Time</td>
</tr>
<tr>
<td>2</td>
<td>R</td>
<td>GPM</td>
<td>SSME 1 TVC Pitch</td>
</tr>
<tr>
<td>3</td>
<td>R</td>
<td>GPM</td>
<td>SSME 1 TVC Yaw</td>
</tr>
<tr>
<td>4</td>
<td>R</td>
<td>GPM</td>
<td>SSME 1 Engine Controller</td>
</tr>
<tr>
<td>5</td>
<td>R</td>
<td>GPM</td>
<td>SSME 2 TVC Pitch</td>
</tr>
<tr>
<td>6</td>
<td>R</td>
<td>GPM</td>
<td>SSME 2 TVC Yaw</td>
</tr>
<tr>
<td>7</td>
<td>R</td>
<td>GPM</td>
<td>SSME 2 Engine Controller</td>
</tr>
<tr>
<td>8</td>
<td>R</td>
<td>GPM</td>
<td>SSME 3 TVC Pitch</td>
</tr>
<tr>
<td>9</td>
<td>R</td>
<td>GPM</td>
<td>SSME 3 TVC Yaw</td>
</tr>
<tr>
<td>10</td>
<td>R</td>
<td>GPM</td>
<td>SSME Engine Controller</td>
</tr>
<tr>
<td>11</td>
<td>R</td>
<td>GPM</td>
<td>Rudder Motor #1</td>
</tr>
<tr>
<td>12</td>
<td>R</td>
<td>GPM</td>
<td>Rudder Motor #2</td>
</tr>
<tr>
<td>13</td>
<td>R</td>
<td>GPM</td>
<td>Rudder Motor #3</td>
</tr>
<tr>
<td>14</td>
<td>R</td>
<td>GPM</td>
<td>Rudder Servo</td>
</tr>
<tr>
<td>15</td>
<td>R</td>
<td>GPM</td>
<td>Speed Brake Motor #1</td>
</tr>
<tr>
<td>16</td>
<td>R</td>
<td>GPM</td>
<td>Speed Brake Motor #2</td>
</tr>
<tr>
<td>17</td>
<td>R</td>
<td>GPM</td>
<td>Speed Brake Motor #3</td>
</tr>
<tr>
<td>18</td>
<td>R</td>
<td>GPM</td>
<td>Speed Brake Servo</td>
</tr>
<tr>
<td>19</td>
<td>R</td>
<td>GPM</td>
<td>LO Elevon</td>
</tr>
<tr>
<td>20</td>
<td>R</td>
<td>GPM</td>
<td>LI Elevon</td>
</tr>
<tr>
<td>21</td>
<td>R</td>
<td>GPM</td>
<td>RO Elevon</td>
</tr>
<tr>
<td>22</td>
<td>R</td>
<td>GPM</td>
<td>RI Elevon</td>
</tr>
<tr>
<td>23</td>
<td>R</td>
<td>GPM</td>
<td>Body Flap Motor #1</td>
</tr>
<tr>
<td>24</td>
<td>R</td>
<td>GPM</td>
<td>Body Flap Motor #2</td>
</tr>
<tr>
<td>25</td>
<td>R</td>
<td>GPM</td>
<td>Body Flap Motor #3</td>
</tr>
<tr>
<td>26</td>
<td>R</td>
<td>GPM</td>
<td>LO Brake Module</td>
</tr>
<tr>
<td>27</td>
<td>R</td>
<td>GPM</td>
<td>LI Brake Module</td>
</tr>
<tr>
<td>28</td>
<td>R</td>
<td>GPM</td>
<td>RO Brake Module</td>
</tr>
<tr>
<td>29</td>
<td>R</td>
<td>GPM</td>
<td>RI Brake Module</td>
</tr>
<tr>
<td>30</td>
<td>R</td>
<td>GPM</td>
<td>L MLG Uplock</td>
</tr>
<tr>
<td>31</td>
<td>R</td>
<td>GPM</td>
<td>R MLG Uplock</td>
</tr>
<tr>
<td>32</td>
<td>R</td>
<td>GPM</td>
<td>L MLG Strut</td>
</tr>
<tr>
<td>33</td>
<td>R</td>
<td>GPM</td>
<td>R MLG Strut</td>
</tr>
<tr>
<td>34</td>
<td>R</td>
<td>GPM</td>
<td>NLG Uplock</td>
</tr>
<tr>
<td>35</td>
<td>R</td>
<td>GPM</td>
<td>NLG Strut</td>
</tr>
<tr>
<td>36</td>
<td>R</td>
<td>GPM</td>
<td>NLG Steering</td>
</tr>
<tr>
<td>37</td>
<td>R</td>
<td>GPM</td>
<td>NLG Restrictor</td>
</tr>
<tr>
<td>38</td>
<td>R</td>
<td>GPM</td>
<td>RLG Restrictor</td>
</tr>
</tbody>
</table>
### A.2.1 (continued)

<table>
<thead>
<tr>
<th>Word #</th>
<th>Type</th>
<th>Units</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>OFT</td>
</tr>
<tr>
<td>39</td>
<td>R</td>
<td>GPM</td>
<td>LH2 ET Umbilical Retractor 1</td>
</tr>
<tr>
<td>40</td>
<td>R</td>
<td>GPM</td>
<td>LH2 ET Umbilical Retractor 2</td>
</tr>
<tr>
<td>41</td>
<td>R</td>
<td>GPM</td>
<td>LH2 ET Umbilical Retractor 3</td>
</tr>
<tr>
<td>42</td>
<td>R</td>
<td>GPM</td>
<td>LO2 ET Umbilical Retractor 1</td>
</tr>
<tr>
<td>43</td>
<td>R</td>
<td>GPM</td>
<td>LO2 ET Umbilical Retractor 2</td>
</tr>
<tr>
<td>44</td>
<td>R</td>
<td>GPM</td>
<td>LO2 ET Umbilical Retractor 3</td>
</tr>
</tbody>
</table>

Total System Flowrates for:

| 45     | R    | GPM   | System #1 |
| 46     | R    | GPM   | System #2 |
| 47     | R    | GPM   | System #3 |

Pump Shaft Horsepower for:

| 48     | R    | HP    | System #1 | not used, read and written out for |
| 49     | R    | HP    | System #2 | comparison only |
| 50     | R    | HP    | System #3 | |

System Configuration Flag

| 51     | I    | -     | APU Speed Flag for: |
| 52     | I    | -     | System #1 |
| 53     | I    | -     | System #2 |
| 54     | I    | -     | System #3 |
| 55     | R    | G     | Vehicle Load Factor |
| 56     | R    | FT    | Altitude |


A.2.2 Line Data Input Tape Format (ALT Model only)

Each record of the line data input tape must contain each of the following 53 words.

<table>
<thead>
<tr>
<th>Word #</th>
<th>Type</th>
<th>Units</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>I</td>
<td>-</td>
<td>Line number I</td>
</tr>
<tr>
<td>2</td>
<td>I</td>
<td>-</td>
<td>Landing gear flag to identify reverse flowlines</td>
</tr>
<tr>
<td>3</td>
<td>I</td>
<td>-</td>
<td>Coupling mode number (Structure mode minus 250)</td>
</tr>
<tr>
<td>4</td>
<td>I</td>
<td>-</td>
<td>Complete list of actuators whose line path includes Line I. Zeroes will be read if no more actuators.</td>
</tr>
<tr>
<td>50</td>
<td>I</td>
<td>-</td>
<td>Line number I</td>
</tr>
<tr>
<td>51</td>
<td>I</td>
<td>in.</td>
<td>Length of line I</td>
</tr>
<tr>
<td>52</td>
<td>I</td>
<td>16th in.</td>
<td>Diameter of line I in number of 16th of an inch</td>
</tr>
</tbody>
</table>
APPENDIX B. COMMON BLOCK VARIABLE DEFINITIONS

This appendix presents definitions for each of the variables appearing in each COMMON block in either the ALT or OFT version of TAHAP including the blank COMMON. Several arrays which are large general storage arrays are defined in more detail in Appendix D. For each COMMON block, each variable name, type, units and definition is provided.

Table B-1 presents a reference table for each of the COMMON blocks. On the left is a list of the COMMON blocks. On the right is a list of each of the routines, main program or subroutines, from which that COMMON block is referenced.
<table>
<thead>
<tr>
<th>Common Block:</th>
<th>Routines</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blank Common:</td>
<td>BOILP, DRAW, DRIVER, FLIP, FLOPW, FUEL, HYDACT, HYDFLD, LLOAD, LINFL, LOOP, LUBOIL, MIX, MOD, PASS, PLATE, PLATEC, PLOOT, PRINT, QBAL, RSTART, SPRAY, START, THERMP, TRANS, ZIPIT, MAIN1, MAIN2</td>
</tr>
<tr>
<td>ACT:</td>
<td>HYDACT, MAIN1, LINFL, PRINT, THERMP, THERMR, MAIN2</td>
</tr>
<tr>
<td>ALT:</td>
<td>PRINT, MAIN1</td>
</tr>
<tr>
<td>ALTD:</td>
<td>PLOOT, MAIN1, MAIN2</td>
</tr>
<tr>
<td>ARRAY:</td>
<td>BOILP, PLOOT, PRINT, QBAL, RSTART, MAIN1, MAIN2</td>
</tr>
<tr>
<td>COMEVP:</td>
<td>BOILP, PLOOT, PRINT, SPRAY, MAIN1, MAIN2</td>
</tr>
<tr>
<td>DAMMIT:</td>
<td>PLOOT, PRINT</td>
</tr>
<tr>
<td>EXTRA:</td>
<td>QBAL, START</td>
</tr>
<tr>
<td>GLOB:</td>
<td>PASS, PLATEC, QBAL, START</td>
</tr>
<tr>
<td>HYD:</td>
<td>FLOPW, FUEL, HYDACT, HYDFLD, MAIN1, MAIN2, LUBOIL, START</td>
</tr>
<tr>
<td>LINES:</td>
<td>LLOAD, LINFL, THERMP, THERMR, ZIPIT</td>
</tr>
<tr>
<td>LUMP2:</td>
<td>DRIVER, DRAW, START</td>
</tr>
<tr>
<td>PRESR:</td>
<td>FLOPW, HYDACT, HYDFLD, THERMP</td>
</tr>
<tr>
<td>PRT:</td>
<td>PRINT, START, THERMP, THERMR, MAIN1, MAIN2</td>
</tr>
<tr>
<td>PSST:</td>
<td>DRIVER, DRAW, PLOOT, START</td>
</tr>
<tr>
<td>TYME:</td>
<td>BOILP, MAIN2, FUEL, PRTTAB, RSTART, START, MAIN1</td>
</tr>
<tr>
<td>Block Name</td>
<td>Variable Name</td>
</tr>
<tr>
<td>------------</td>
<td>---------------</td>
</tr>
<tr>
<td>Blank Common</td>
<td>C</td>
</tr>
<tr>
<td></td>
<td>DUM</td>
</tr>
<tr>
<td></td>
<td>F(N, X)</td>
</tr>
<tr>
<td></td>
<td>IDUM</td>
</tr>
<tr>
<td></td>
<td>K</td>
</tr>
<tr>
<td></td>
<td>l</td>
</tr>
<tr>
<td></td>
<td>NNODES</td>
</tr>
<tr>
<td></td>
<td>P (N, X)</td>
</tr>
<tr>
<td></td>
<td>TIME</td>
</tr>
<tr>
<td></td>
<td>TSTOP</td>
</tr>
<tr>
<td>ACT</td>
<td>FLW</td>
</tr>
<tr>
<td></td>
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<tr>
<td>LUMP2</td>
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<td>TITLE</td>
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<td>WEE(J)</td>
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<td>IPRNT</td>
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<td>IPLT(J)</td>
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<td>IWRAOR</td>
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<td>JPLT(J)</td>
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<td>NOPLOT</td>
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<td>NPLPTS</td>
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TABLE B-2
(Continued)

<table>
<thead>
<tr>
<th>Block Name</th>
<th>Variable Name</th>
<th>Type</th>
<th>Units</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSST (continued)</td>
<td>NPLTS</td>
<td>I</td>
<td>-</td>
<td>Total number of traces</td>
</tr>
<tr>
<td></td>
<td>NTR</td>
<td>I</td>
<td>-</td>
<td>Number of traces on plot J</td>
</tr>
<tr>
<td></td>
<td>PLTSEQ</td>
<td>I</td>
<td>-</td>
<td>Not used</td>
</tr>
<tr>
<td></td>
<td>TSTP</td>
<td>R</td>
<td>hrs.</td>
<td>Stop time to be used as limit of X-axis</td>
</tr>
<tr>
<td></td>
<td>XAXIS</td>
<td>R</td>
<td>in.</td>
<td>X-axis length</td>
</tr>
<tr>
<td></td>
<td>YAXIS</td>
<td>R</td>
<td>in.</td>
<td>Y-axis length</td>
</tr>
<tr>
<td>TYME</td>
<td>AMSNTM</td>
<td>R</td>
<td>hrs.</td>
<td>Length of mission from takeoff (used for reinitialization capability)</td>
</tr>
<tr>
<td></td>
<td>FUDGE</td>
<td>R</td>
<td>hrs.</td>
<td>Time value to subtract from UPTIME to avoid long period of no APU/hydraulic activity</td>
</tr>
<tr>
<td></td>
<td>SUMARY</td>
<td>R</td>
<td>lbm</td>
<td>Storage array for consumables values for summary table. Described in detail in Appendix D.</td>
</tr>
<tr>
<td></td>
<td>TIMSUM</td>
<td>R</td>
<td>hrs.</td>
<td>Time values at which to divide consumables usage per mission phase on summary table</td>
</tr>
</tbody>
</table>
APPENDIX C. GENERAL STORAGE ALLOCATION

In the Thermal APU/Hydraulics Analysis Program (TAHAP), several arrays are used for general data storage. This appendix presents a detailed definition of the contents of these general storage arrays. Since this method of data storage was originally defined by FEAR (Ref. 1), large portions of the C, DUM, and IDUM arrays are used only in ECLSS consumables analyses. These areas are pointed out where they occur. The following is a list of the array names, and the COMMON blocks in which the arrays are located, whose contents are defined in Table C-1.

<table>
<thead>
<tr>
<th>Array Name</th>
<th>Common Block Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>Blank COMMON</td>
</tr>
<tr>
<td>F</td>
<td>Blank COMMON</td>
</tr>
<tr>
<td>C</td>
<td>Blank COMMON</td>
</tr>
<tr>
<td>DUM</td>
<td>Blank COMMON</td>
</tr>
<tr>
<td>IDUM</td>
<td>Blank COMMON</td>
</tr>
<tr>
<td>G</td>
<td>ARRAY</td>
</tr>
<tr>
<td>SUMARY</td>
<td>TYME</td>
</tr>
</tbody>
</table>
TABLE C-1

GENERAL STORAGE ALLOCATION

P-array description

\( P(I, X) \) - Component Temperature at node I, \( I = 1, 300 \)

F-array description

\( F(I, X) \) - Fluid Temperature at node I, \( I = 1, 249 \)

Vehicle Compartment Air temp at node I, \( I = 250, 261 \)

Ambient Air temperature for \( I = 262 \)

C-array description

For all \( I, I = 1, 300 \)

\( C(I, 1) \) - Thermal capacity
\( C(I, 2) \) - Heat transfer coefficient
\( C(I, 3) \) - Dynamic thermal capacitance
\( C(I, 4) \) - Heat rate or heat flux
\( C(I, 5) \) - Specific heat
\( C(I, 6) \) - Concentration of \( H_2O \)
\( C(I, 7) \) - Concentration of \( N_2 \)
\( C(I, 8) \) - Concentration of \( O_2 \)
\( C(I, 9) \) - Concentration of \( CO_2 \)
\( C(I, 10) \) - (varies in different routines)
\( C(I, 11) \) - Partial pressure of \( H_2O \)
\( C(I, 12) \) - Partial pressure of \( N_2 \)
\( C(I, 13) \) - Partial pressure of \( O_2 \)
\( C(I, 14) \) - Partial pressure of \( CO_2 \)
\( C(I, 16) \) - Heater energy

Used only in ECLSS Consumables analyses

In the following, only the specified portions of the array are full. The node numbers assigned for \( I \) are used for the node number requirement on the plot input card if the parameter is to be plotted. The three values for \( I \) correspond to systems 1, 2, and 3, respectively.

\( C(I, 17) \) - Accumulated Fuel used, \( I = 275, 276, 277 \)
\( C(I, 18) \) - Accumulated Energy used, \( I = 275, 276, 277 \)
\( C(I, 19) \) - Fuel remaining, \( I = 275, 276, 277 \)
TABLE C-1
(Continued)

DUM Array Description

<table>
<thead>
<tr>
<th>DUM(1)</th>
<th>DELT/2</th>
</tr>
</thead>
<tbody>
<tr>
<td>DUM(2)</td>
<td>Ambient air temperature</td>
</tr>
<tr>
<td>DUM(3)</td>
<td>not used</td>
</tr>
<tr>
<td>DUM(4)</td>
<td>not used</td>
</tr>
<tr>
<td>DUM(5)</td>
<td>Accum consum (ECLSS) 1</td>
</tr>
<tr>
<td>DUM(6)</td>
<td>Accum consum (ECLSS) 2</td>
</tr>
<tr>
<td>DUM(7)</td>
<td>Accum consum (ECLSS) 3</td>
</tr>
<tr>
<td>DUM(8)</td>
<td>Accum consum (ECLSS) 4</td>
</tr>
<tr>
<td>DUM(9)</td>
<td>Accum consum (ECLSS) 5</td>
</tr>
<tr>
<td>DUM(10)</td>
<td>not used</td>
</tr>
<tr>
<td>DUM(11)</td>
<td>not used</td>
</tr>
<tr>
<td>DUM(12)</td>
<td>not used</td>
</tr>
<tr>
<td>DUM(13)</td>
<td>not used</td>
</tr>
<tr>
<td>DUM(14)</td>
<td>not used</td>
</tr>
<tr>
<td>DUM(15)</td>
<td>not used</td>
</tr>
<tr>
<td>DUM(16)</td>
<td>Mol. weight of H₂O (ECLSS)</td>
</tr>
<tr>
<td>DUM(17)</td>
<td>Mol. weight of N₂ (ECLSS)</td>
</tr>
<tr>
<td>DUM(18)</td>
<td>Mol. weight of O₂ (ECLSS)</td>
</tr>
<tr>
<td>DUM(19)</td>
<td>Mol. weight of CO₂ (ECLSS)</td>
</tr>
<tr>
<td>DUM(20)</td>
<td>not used</td>
</tr>
<tr>
<td>DUM(21)</td>
<td>Specific heat of H₂O (gas) (ECLSS)</td>
</tr>
<tr>
<td>DUM(22)</td>
<td>Specific heat of CO₂ (gas) (ECLSS)</td>
</tr>
<tr>
<td>DUM(23)</td>
<td>not used</td>
</tr>
<tr>
<td>DUM(24)</td>
<td>not used</td>
</tr>
<tr>
<td>DUM(25)</td>
<td>start time</td>
</tr>
<tr>
<td>DUM(26)</td>
<td>not used</td>
</tr>
<tr>
<td>DUM(45)</td>
<td>not used</td>
</tr>
<tr>
<td>DUM(46)</td>
<td>A consumable 1st condensing subl</td>
</tr>
</tbody>
</table>

IDUM Array Description

<table>
<thead>
<tr>
<th>IDUM(1)</th>
<th>inlet node no. 1st evaporator called (ECLSS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IDUM(2)</td>
<td>inlet node no. 2nd evaporator called (ECLSS)</td>
</tr>
<tr>
<td>IDUM(3)</td>
<td>inlet node no. 3rd evaporator called (ECLSS)</td>
</tr>
<tr>
<td>IDUM(4)</td>
<td>inlet node no. 4th evaporator called (ECLSS)</td>
</tr>
<tr>
<td>IDUM(5)</td>
<td>inlet node no. 5th evaporator called (ECLSS)</td>
</tr>
<tr>
<td>IDUM(6)</td>
<td>No. of boilers</td>
</tr>
<tr>
<td>IDUM(7)</td>
<td>Flag used in THCAP to properly call EVAP (ECLSS)</td>
</tr>
<tr>
<td>IDUM(8)</td>
<td>Flag to prevent summing of consumables for 1st call to PRINT</td>
</tr>
<tr>
<td>IDUM(9)</td>
<td>Flag to set first guess on outlet temperature on CONSUS (ECLSS)</td>
</tr>
<tr>
<td>IDUM(10)</td>
<td>No. of turbines</td>
</tr>
<tr>
<td>IDUM(11)</td>
<td>No. of actuators on system #1</td>
</tr>
<tr>
<td>IDUM(12)</td>
<td>No. of actuators on system #2</td>
</tr>
<tr>
<td>IDUM(13)</td>
<td>No. of actuators on system #3</td>
</tr>
<tr>
<td>IDUM(14)</td>
<td>Flag for RSTART to signal if it should assign values or read in new cards - OPT only</td>
</tr>
<tr>
<td>IDUM(15)</td>
<td>not used</td>
</tr>
</tbody>
</table>
TABLE C-1
(Continued)

IDUM Array Description

IDUM(16) - No. of heaters called (ECLSS)
(17) - Time step counter
(18) - not used
(19) - Flag for BOUNDT for type of ambient air temp. 2 = Cold Day,
3 = Hot Day, 4 = Nominal (ALT Only)
(20) - Counter for number of plots to supply plot routine
(21) - not used
(22) - No. of condensing sublimators (ECLSS)
(23) - Node no. of 1st condensing sublimator called (ECLSS)
(24) - Node no. of 2nd condensing sublimator called (ECLSS)
(25) - Node no. of 3rd condensing sublimator called (ECLSS)
(26) - Node no. of 4th condensing sublimator called (ECLSS)
(27) - Node no. of 5th condensing sublimator called (ECLSS)
(28) - Flag to prevent summing consumables when THCAP is in
sensible heat region (ECLSS)
(100) - Flag set to zero when PRINT or SLEECT have written
data that timestep

G Array Description

For the G-array also, only the specified portions of the array are full.
The node numbers assigned for I are used for the node number requirement
on the plot input card if the parameters are to be plotted. The six
values for I correspond to the lube oil heat exchanger, system 1, 2, and 3,
and the hydraulic heat exchanger, system 1, 2, and 3, respectively.

G(I, 1) - Initialization and manipulation of boiler pressure (psia)
    where I = 102, 152, 202, 110, 160, 210
G(I, 2) - Ambient pressure (psia)
    where I = 102, 152, 202, 110, 160, 210
G(I, 3) - Boiling rate (1bm/min)
    where I = 102, 152, 202
G(I, 4) - Boiling rate (1bm/hr)
    where I = 102, 152, 202
G(I, 5) - Heat of vaporization
    where I = 102, 152, 202
G(I, 6) - Time derivative of the boiler pressure
    where I = 102, 152, 202
G(I, 7) - Power heat in for total of the three systems (BTU)
G(2, 7) - Turbine heat in for total of the three systems (BTU)
G(3, 7) - Total heat in for total of the three systems (BTU)
G(4, 7) - Heat out by water for total of the three systems (BTU)
G(5, 7) - Heat stored in capacitance for total of the three systems (BTU)
G(6, 7) - Heat out via coupling to structure for total of the three
    systems (BTU)
TABLE C-1
(Continued)

G Array Description (continued)

G(7, 7) - Total heat out for total of the three systems
G(8, 7) - Total BTU's error, heat in minus heat out
G(101, 7) - Power, System 1 (hp)
G(151, 7) - Power, System 2 (hp)
G(201, 7) - Power, System 3 (hp)

G(I, 8) - Pressure difference between the ambient and boiler pressures (psia)
where I = 102, 152, 202

G(I, 9) - Saturation temperature (deg)
where I = 102, 152, 202

SUMARY Array Description

For each of the following definitions, J = 1, 3, representing systems 1, 2, and 3 respectively.

SUMARY(1, J) = Present loading value for fuel
SUMARY(2, J) = Loading and in-flight measurement
SUMARY(3, J) = Residual quantity for fuel
SUMARY(4, J) = Minimum usable quantity for fuel
SUMARY(5, J) = Prelaunch requirement for fuel
SUMARY(6, J) = Flight requirement for fuel
SUMARY(7, J) = Post-landing requirement for fuel
SUMARY(8, J) = 24-hr. launch hold recycle requirement for fuel
SUMARY(9, J) = 10% Dispersion factor for fuel
SUMARY(10, J) = Usable margin for fuel

SUMARY(I, J) I = 11, 20 store the water quantities which correspond to I = 1, 10
**NODE NUMBER LIST**

**Actuators**

1 = PITCH 1
2 = YAW 1
3 = ENG CTRL 1
4 = PITCH 2
5 = YAW 2
6 = ENG CTRL 2
7 = PITCH 3
8 = YAW 3
9 = ENG CTRL 3
10 = RDR MTR 1
11 = RDR MTR 2
12 = RDR SERVO
13 = SB MTR 1
14 = SB MTR 2
15 = SB MTR 3
16 = SB SERVO
17 = LO ELEVON
18 = LI ELEVON
19 = RO ELEVON
20 = RI ELEVON
21 = BF MTR 1
22 = BF MTR 2
23 = BF MTR 3
24 = LO BRK MOD
25 = LI BRK MOD
26 = RO BRK MOD
27 = RI BRK MOD
28 = L MGL UPLK
29 = R MGL UPLK
30 = L MGL STRT
31 = R MGL STRT
32 = NMG UPLK
33 = NMG STRUT
34 = NMG STRING
35 = NMG RSTR
36 = RLG RSTR
37 = PITCH1 OUT
38 = YAW 1 OUT
39 = ENG C1 OUT
40 = PITCH2 OUT
41 = YAW 2 OUT
42 = ENG C2 OUT
43 = RDMTR2 OUT
44 = YAW 3 OUT
45 = PITCH3 OUT
46 = ENG C3 OUT
47 = RDMTR1 OUT
48 = RDMTR3 OUT
49 = RDR SR OUT
50 = SBMTR1 OUT
51 = SBMTR2 OUT
52 = SBMTR3 OUT
53 = SB SRV OUT
54 = LO ELV OUT
55 = LI ELV OUT
56 = RO ELV OUT
57 = RI ELV OUT
58 = OFMTR1 OUT
59 = OFMTR2 OUT
60 = OFMTR3 OUT
61 = LO BRK OUT
62 = LI BRK OUT
63 = RO BRK OUT
64 = RI BRK OUT
65 = LNLGUP OUT
66 = LNLGST OUT
67 = NGL UP OUT
68 = NGL ST OUT
69 = NGL RS OUT
70 = MLG ST OUT
71 = MLG OUT
72 = MLG RS OUT

**System 1**

100 = TURBINE 1
101 = GEARBOX 1
102 = BLR1 APUXH
103 = H2O TANK 1
104 = PUMP 1
105 = CASE DRN 1
106 = PUMP 1 OUT
107 = MIX HYD 1
108 = CD 1 MIX
109 = BLR1 HYD
110 = HYD1X1 OUT
111 = RSRVR1 OUT
112 = RSRVR2 OUT
113 = DUMMY

**System 2**

150 = TURBINE 2
151 = GEARBOX 2
152 = BLR2 APUXH
153 = H2O TANK 2
154 = PUMP 2
155 = CASE DRN 2
156 = PUMP 2 OUT
157 = MIX HYD 2
158 = CD 2 MIX
159 = BLR 2 BYPS
160 = BLR2 HYD
161 = HYD1X2 OUT
162 = RSRVR 2
163 = RSRVR2 OUT
164 = DUMMY

**System 3**

200 = TURBINE 3
201 = GEARBOX 3
202 = BLR3 APUXH
203 = H2O TANK 3
204 = PUMP 3
205 = CASE DRN 3
206 = PUMP 3 OUT
207 = MIX HYD 3
208 = CD 3 MIX
209 = BLR 3 BYPS
210 = BLR3 HYD
211 = HYD1X3 OUT
212 = RSRVR 3
213 = RSRVR3 OUT
214 = DUMMY

**Boundary Nodes**

250 = AFT FUSELAGE
251 = ENGINES
252 = LEFT WING
253 = RIGHT WING
254 = MID FUSELAGE
255 = BODY FLAP
256 = R WHL WELL
257 = L WHL WELL
258 = ARAIR
259 = FWD FUSELAGE
260 = N WHL WELL
261 = DUKEH
262 = FUEL ENGR
263 = FUEL ENGR
264 = FUEL ENGR

**ORIGINAL PAGE IS OF POOR QUALITY**
APPENDIX D. SUBROUTINE LISTINGS

The following are subroutine listings for the subroutines discussed in Section 6.0.
OV-101 (ALT) VERSION

```
1* COMMON K,L,DELT,TIME,TSTOP,NNODES
2* COMMON P(300,2),F(300,2),C(300,20)
3* COMMON DUM(100),IDUM(100)
4* COMMON /LUMP2/TITLE(12),BIG(25),WEE(25)
5* COMMON /PSST/NPLTS,TPLT(25),PLTSEG,TSTP(5),XAXIS(51)
6* CALL MAIN1
7* IF(IDUM(20),GT,0) CALL DRAW
```

END OF COMPILATION: NO DIAGNOSTICS.

OV-102 (OFT) VERSION

```
1* COMMON K,L,DELT,TIME,TSTOP,NNODES
2* COMMON P(300,2),F(300,2),C(300,20)
3* COMMON DUM(100),IDUM(100)
4* COMMON /LUMP2/TITLE(12),BIG(25),WEE(25)
5* COMMON /PSST/NPLTS,TPLT(25),PLTSEG,TSTP(5),XAXIS(51)
6* CALL MAIN2
7* IF(IDUM(20),GT,0) CALL DRAW
```

END OF COMPILATION: NO DIAGNOSTICS.
<table>
<thead>
<tr>
<th>VARIABLE NAME</th>
<th>DESCRIPTION</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALT</td>
<td>CURRENT ALTITUDE</td>
<td>FT</td>
</tr>
<tr>
<td>B2H0</td>
<td>AMOUNT OF WATER IN BOILER</td>
<td>LB</td>
</tr>
<tr>
<td>C(X,1)</td>
<td>THERMAL CAPACITANCE</td>
<td>BTU/DEG R</td>
</tr>
<tr>
<td>C(X,2)</td>
<td>HEAT TRANSFER COEFFICIENT</td>
<td>BTU/HR-DEG R</td>
</tr>
<tr>
<td>C(X,3)</td>
<td>DYNAMIC THERMAL CAPACITANCE</td>
<td>LBM-BTU/HR-LB- R</td>
</tr>
<tr>
<td>C(x,4)</td>
<td>HEAT LOAD OR HEAT RATE</td>
<td>BTU/HR</td>
</tr>
<tr>
<td>DATPAN</td>
<td>AMOUNT OF WATER TRANSFERRED THIS COMP</td>
<td>LBM</td>
</tr>
<tr>
<td>FL</td>
<td>ACTUATOR FLOWRATES READ IN</td>
<td>GPM</td>
</tr>
<tr>
<td>FLAW</td>
<td>TEMPORARY STORAGE FOR ACTUATOR FLOWRATES</td>
<td>GPM</td>
</tr>
<tr>
<td>FLOW</td>
<td>ACTUATOR FLOWRATES USED FOR CURRENT</td>
<td>GPM</td>
</tr>
<tr>
<td>GRAV</td>
<td>C.G. LOAD FACTOR</td>
<td></td>
</tr>
<tr>
<td>HS</td>
<td>HEIGHT OF WATER IN STANPIPE</td>
<td></td>
</tr>
</tbody>
</table>
PARAMETER NUMACT=37
DIMENSION NUM(5),IPX(5)
DIMENSION NODES(120)
DIMENSION I(2)
DIMENSION FLHUMACT,FLW(50),FLWIN(50),ISPD(3),SKIP(3),OFTACT(6)
DIMENSION TL(25),TF(25,50),TTL(25,3),TFL(3),TFLWIN(3),TFLAW(3)
DIMENSION K(2)
DIMENSION KIN(3),ITV(3)
DIMENSION TOTAL(3)
DIMENSION TK(3)
COMMON KT,TL,TSTOP,NUMODES
COMMON PP,T1,T2,T3,T4
COMMON DUN(100,100)
COMMON /PRT/ PRNT,INT,ANAME(300,2),AERROR(8,2)
COMMON /ARRAY/ G(300,10),TINIT(300),FLAG,ITER
COMMON /TIME/T,MSUM(3),AHSNT,FUDGE,SUMARY(50,3)
COMMON /CMEVP/ IWAT(10),WAT(10),DA(10),NATL(3)
COMMON /ACT/ MYD(3,50),NYD(3,50),NACT,FLW(50)
COMMON /POYN/ IPOS(27,4),MNMT(50,4),POW(3),ISPD(3),IFLAG,TFLW(3)
COMMON /ALT/ BT(20,4),TBH2OF(3),IALT
COMMON /ALT/ ALTD/ALT
EQUIVALENCE (IDUM(10),NTURBN)
DATA TOTAL/295.,295.,295./
DATA ISPD/1./
DATA CEWS/254./
DATA HPRTAT/3335/
DATA 10/999/
DATA ITV/300.
DATA FATL/30./36/
DATA NACT/NUMACT/
DATA NODES/120
* 11,61,2,62,13,63,71,4,64,15,76,5,16,66,17,4,67,18,68,19,69,20,70
* 21,71,2,62,13,63,72,5,24,74,25,26,66,27,77,28,78,29,79,30,80
* 31,81,32,62,33,82,34,84,35,85,36,86,37,87
DATA STVO/223,STVC/30,EA/2,27
DATA TXYMT/12877.
DATA AGB/17

DATA IALT/1/

C C
CALL START
CALL LLOAD
B B
DUM(1C)=3
DUM(6)=3
LAT(1)=102
LAT(2)=152
LAT(3)=292
IFLAG=27
C(275,19)=295
C(276,19)=295
C(277,19)=295
C=22 J=1,3
C=5 J=1,3
T INIT(J)=P(J,L)
B B
TO = TIME
B B
DO 15 J=1,2
B B
= IAT(J)+111
B B
G(M(J))=14.7
B B
C CONTINUE
B B
111=111+6
B B
22 CONTINUE
B B
C
C
READ FIRST TIMEPOINT
C
READ(2) UPTIME, (FLH(N)=1,29), X, FLN(30), Y, (FLN(N)=31,33),
C
* 
C
123
C
ALI=ALT2
ALI=ALT2
C
N=103
C
DO 25 J=1, NTUPDN
C
N(J)=P(J,T)
C
IF (FLN(J)*GT=5501) GO TO 25
**BEGIN TIMING SEQUENCE**

- **T(NM+1)=TIME**
- **DO 30 I=1,NTURBN**
  - **TFLAW(I)=0.**
- **DO 40 J=1,NACT**
  - **FLAG(J)=FL(J).**

**IS UP TIME-WITHIN THIS COMPUTATION-STEP**

- **IF ((TIME+DELT),LE, UPTIME) GO TO 80**
  - **T(NM+1)=UPTIME-E-T(NM).**
- **DO 60 I=1,NTURBN**
  - **TFLAW(I)=TFLAW(I).**
  - **ISPD(I)=ISPD(I).**
- **END**

**INTEGRATE TOTAL SYSTEM FLOW**

- **READ(2); END=800; UPTIME, (FL(N), N=1,29), x, FL(30); y, (FL(N), N=3:1,33);**
  - **Z, (FL(N), N=34,37), OFTACT, TFL, SKIP, IFLAG!, ISPD1, GRAY, ALT2**
- **GO TO 50**

**AVERAGE BOTH TOTAL SYSTEM-AND ACTUATOR FLOW RATES OVER TIME-STEP**

- **IF (NM+NE+1) GO TO 11C**
- **GO TO 10;**
  - **FLX(I)=TFLX(I).**
  - **IFLAG(J)=FLX(J).**
- **GO TO 180**

**JIM**

- **CC 12C M=2, NM**
  - **TFLX(1)=TFLX(1)+TTF(M,1).**
- **CONTINUE**
- **CONTINUE**
  - **CC 15C J=1, NACT**
  - **CC 14M M=2, NM**
  - **FLX(J)=FLX(J)+TTF(M, J).**
- **GO TO 180**
- **GO TO 160**
- **GO TO 170**

**END**
TFLAM(1) = (TFLAM(1) + (TIME*DELT) - T(NM)) / DELT

CONTINUE

GO TO 200

UPTIME = UPTIME + 4.6

TFLAG = 27

ST BLI I = 1, NTURBN
TFLAM(1) = 0
TFLAM(2) = 0

FLW(J) = FLW(J) - (FLW(J) - (TIME*DELT) - T(NM)) * FLW(J) / DELT

CONTINUE

GO TO 200

CALL HYDACT
CALL ZPIT

CALL ZPIT

CALL FLOWPAR(1,1)
CALL LINFLD(1)

G'MH+1,71 = POWER(I)
IF(TFLAM(1)+LT.*22C) GO TO 210

PN1+1.2 = PN1(1)
GO TO 220

CONTINUE

P(1)

C(IN(1), 9) = 0
C(IN(1), 2) = 0
C(IN(1), 4) = 0
C(IN(1), 6) = 0
GO TO 217

CONTINUE

CALL LUDOIL(1:N1)

IF(TIME < 4.5666) ITV(1) = 1
IF(TIME < 4.5666) GRAY = 1.
IF(IALTURE = 1) GO TO 217

CONTINUE

COMPUTE THERMAL CAPACITY CONSIDERING POSITION OF TRANSFER VALVE (FOR 161 ONLY)

HS(I) = 0
IF(ITV(I) > 0.1) GO TO 215
BP20(I) = ATLOD - VAT(I)
C(IN+2) = BH20(I) + 13.2
C(IN+10+1) = BP20(I) + 13.2
GO TO 217

215 BP20(I) = ATLOD + BH2OF(I) - VAT(I)

END
```plaintext
HOLD = P-2CF(1)
IF (BH20(1)+2.4 < 7.2) HS(1) = 16.0 (BH20(1)-57.8)/15.58
7.2 < BE20(1) < 40.58 BE20(1)-40.58*DELT*GRAV(14.7)*BH20(1)/60.0 - HS(1)
DH20H = BH20(1) - HOLD
P(N+2,K) = P(N1+2,K) *BH20(1) + P(N1+3,K) * DTTRAN) / (BH20(1) * DTTRAN)
7.2 < WATLD + BH20(1) - WATTL
C(N1+3,1) = TXYAT. - BH20(1)
C(N1+1,1) = 6*BE20(1) - 13.2
217 CONTINUE
N=1+50
230 CONTINUE
C IF (TIME.6E+3) CALL BOUND1
C COMPUTE ALTITUDE
C ALT = (ALT2-ALT1)/(UPTIME-T0) + (TIME-T0) + ALT1
C TIME = TIME + 2
C ALT1 = ALT
C ALT1M = ALT + 3*3048006E+3
C CONVERT ALTITUDE TO METRIC
C F = F + 12
C TEMP = ALT1M + TEMP + ACOEF(1)
C FOR CURRENT ALTITUDE
C P2 = PRESUR*14.696
C CONVERT PRESSURE FROM ATMOS. TO PSI
C THERMAL LOOP
C IF (F I) CALL PASSN
C IF TURBINE IS OFF, COMPUTE HEAT TRANSFER FROM TURBINE
C GEAR BOX LOOP
C CALL LOOP(N+1)
C CALL PLATEC(N+1,N+2)
C HYDRAULIC LOOP
C CALL LOOP(N+4)
C CALL PLATEC(N+4,N+6)
C IF (C(N+5,3) < 1.0) GO TO 784
C(N+5,1) = F(N+4,1) - 12
C(N+5,2) = F(N+4,2) - 12
C(N+5,4) = F(N+4,4) - 12
C(N+4,4) = F(N+4,4) - 12
C(N+4,4) = F(N+4,4) - 12
C(N+4,4) = F(N+4,4) - 12
784 CONTINUE
C CALL THERMP(1,N,P2)
C IF (JX.K < 0) GO TO 270
C IF (JX.K < 0) GO TO 270
C CALL PLAT6C(N6,NOO+30)
```

The code appears to be a FORTRAN program, possibly for weather or climate simulation, given the variables and functions involved. The program includes computations for altitude, pressure, and thermal loops, with various IF statements and calculations for different conditions.
CONTINUE
CALL THERMP(1,N,P2)

KP(2) = N+7
KP(1) = N+6
CALL MIX(N+8,12,KK)
IF(C(N+8,3), LE, 5) GO TO 275
IF(C(N+8,3), GT, 4379,34) GO TO 271
C(N+8,3) = C(N+8,3)
C(N+7,3) = 2.
GO TO 273
271 C(N+10,3) = 4379,34
C(N+9,3) = C(N+8,3) = 4379,34
CONTINUE
F(N+1,C,L) = F(N+2,C,L)
F(N+V,L) = F(N+3,L)
CALL HYDFLO(1,4)
CALL BOILF(N+2,N+1,N+10,N+11,P2,EA,STVC,STVO)
III(1) = N+9
III(2) = N+11
CALL MIX(N+12,2,11)
GO TO 283
275 CONTINUE
CALL TRANS(N+4,N+8)
CALL TRANS(N+4,N+9)
CALL TRANS(N+4,N+10)
CALL HYDFLO(1,1)
CALL BOILF(N+2,N+1,N+10,N+11,P2,EA,STVC,STVO)
-call TRANS(N+4,N+12)
283 CALL PASS(N+3)
CALL PLATE(N+12,N+13)
CALL TRANS(N+13,N+4)
CALL TRANS(N+13,N+14)

CALL -FUEL(TOTFUL,P2) CALL CBL
IF (ICUM(2,C), LE, 5) GO TO 350
CALL FLoot
350 CALL SELECT(123,114,INODES,10)
CALL FLIP
C
IF (ICUM+1, EG, IPRINT) WRITE(6, UPDATE)
IF (TIME, LE, TSTOP) GO TO 777
CALL PRINTAB
RETURN
END
<table>
<thead>
<tr>
<th>VARIABLE NAME</th>
<th>DESCRIPTION</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALT</td>
<td>CURRENT ALTITUDE</td>
<td>FT</td>
</tr>
<tr>
<td>SH20</td>
<td>AMOUNT OF WATER IN BOILER</td>
<td>LBm</td>
</tr>
<tr>
<td>C(X,1)</td>
<td>THERMAL CAPACITANCE</td>
<td>BTU/DEG R</td>
</tr>
<tr>
<td>C(X,2)</td>
<td>HEAT TRANSFER COEFFICIENT</td>
<td>BTU/HR/DEG R</td>
</tr>
<tr>
<td>C(X,3)</td>
<td>DYNAMIC THERMAL CAPACITANCE</td>
<td>LBm-BTU/HR-LBm</td>
</tr>
<tr>
<td>C(X,4)</td>
<td>HEAT LOAD OR HEAT RATE</td>
<td>BTU/HR</td>
</tr>
<tr>
<td>DTTRAN</td>
<td>AMOUNT OF WATER TRANSFERRED THIS COMP CYCLE</td>
<td>LBM</td>
</tr>
<tr>
<td>FL</td>
<td>ACTUATOR FLOWRATES READ IN</td>
<td>GPM</td>
</tr>
<tr>
<td>FLAW</td>
<td>TEMPORARY STORAGE FOR ACTUATOR FLOWRATES</td>
<td>GPM</td>
</tr>
<tr>
<td>FLW</td>
<td>ACTUATOR FLOWRATES USED FOR CURRENT COMP CYCLE</td>
<td>GPM</td>
</tr>
<tr>
<td>GRAY</td>
<td>CEG LOAD FACTOR</td>
<td>HSF</td>
</tr>
<tr>
<td>HS</td>
<td>HEIGHT OF WATER IN STANDPIPE</td>
<td>FT</td>
</tr>
<tr>
<td>IFLAG</td>
<td>SYSTEM CONFIGURATION FLAG</td>
<td></td>
</tr>
<tr>
<td>IO</td>
<td>FLAG USED IN PRINT TO LIMIT NODE DATA PRINTING TO C(X,1) THRU C(X,4)</td>
<td></td>
</tr>
<tr>
<td>ISPD</td>
<td>APU OPERATING SPEED FLAG</td>
<td></td>
</tr>
<tr>
<td>ISPRAY</td>
<td>FLAG TO TELL IF SPRAY BOILER HAS BEEN IN USE</td>
<td></td>
</tr>
<tr>
<td>ITV</td>
<td>TRANSFER VALVE FLAG</td>
<td></td>
</tr>
<tr>
<td>IYAT(1)</td>
<td>NODE NUMBER OF BOILER 1</td>
<td></td>
</tr>
<tr>
<td>JX</td>
<td>NUMBER OF ACTUATORS ON SYSTEM 1</td>
<td></td>
</tr>
<tr>
<td>NACT</td>
<td>TOTAL NUMBER OF ACTUATORS</td>
<td></td>
</tr>
<tr>
<td>NM</td>
<td>COUNTER FOR NUMBER OF TAPE RECORDS TO PROCESS PER COMP CYCLE</td>
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</tr>
<tr>
<td>NOD</td>
<td>ARRAY OF ACTUATOR NODE NUMBERS ON SYSTEM 1</td>
<td></td>
</tr>
<tr>
<td>NTURBN</td>
<td>NUMBER OF APU HYDRAULIC SYSTEMS</td>
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</tr>
<tr>
<td>P</td>
<td>AMBIENT AIR PRESSURE</td>
<td>PSIA</td>
</tr>
<tr>
<td>TFL</td>
<td>TOTAL SYSTEM FLOWRATES READ IN</td>
<td>GPM</td>
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<tr>
<td>TFLAW</td>
<td>TEMPORARY STORAGE FOR TOTAL SYSTEM FLOWRATES</td>
<td>GPM</td>
</tr>
<tr>
<td>TFLW</td>
<td>TOTAL SYSTEM FLOWRATES USED FOR CURRENT COMP CYCLE</td>
<td>GPM</td>
</tr>
<tr>
<td>TIME</td>
<td>CURRENT TIME</td>
<td>HRS</td>
</tr>
<tr>
<td>UPTIME</td>
<td>TIME AT WHICH TO UPDATE TIMELINE DATA</td>
<td>HRS</td>
</tr>
<tr>
<td>WAT</td>
<td>AMOUNT OF WATER USED SO FAR</td>
<td>LBm</td>
</tr>
<tr>
<td>WATLOD</td>
<td>AMOUNT OF WATER LOADED IN EACH SYSTEM</td>
<td>LBm</td>
</tr>
</tbody>
</table>

PARAMETER NUMACT=43
DIMENSION PIN(5),IXP(5)
DIMENSION INQUES1(49)
DIMENSION I(2)
DIMENSION C(11)
DIMENSION FL(HNUMACT),FLAW(50),FLW(50),ISPD(13),SK1P(13)
DIMENSION T(5),TF(25,50),TTF(25,3),TFLW(13),TFLAW(3)
DIMENSION KK(2)
DIMENSION O(12)
DIMENSION NODE(HNUMACT)
DIMENSION REFLILL(3),USED(3),ITANK(3),ISPRAY(3)
DIMENSION TOTFULL(3)
F'D I 9 PAT'-F;J) = SUMA Y#i6oJ) ^ F i7{)	 J :z	 3 10- SAYE .INITIAL COMPONENT TEMP.

INITIALIZE PRESSURE FOR BOILER ROUTINE

READ FIRST TIMEPOINT

READ(2) UPTIME, FL(N), N=1:28, X, FL(29), Y, FL(N), N=30:32, Z,
1 (FL(N), N=33:43), TFL, SKIP, IFLAG1, ISPD1, GRAY, ALT2

SET ALTITUDE TO INITIAL INPUT VALUE

SAVE INITIAL TURBINE TEMP.

TURBINE IS INITIALLY OFF

SET TURBINE TEMP EQUAL TO STRUCTURE TEMPERATURE.

SET EUBE OIL FLOW RATE TO ZERO

PRINT INITIAL NAMELIST

BEGIN TIMING SEQUENCE

IS UPTIME WITHIN THIS COMPUTATION STEP

IF (TIME*DELT) .LE. UPTIME GO TO 80

INTEGRATE TOTAL SYSTEM FLOW

CONTINUE

DO 40 J=1, NACT

T(J) = T(J) + TFLAM(J)

CONTINUE

IF (1) = IFLAG1

CONTINUE
T(NN+1) = UPTIME
NNMAX = 1

READ (2, END=802) UPTIME, (FL(N), N=1, 29), X, FL(29), Y, (FL(N), N=30, 52), Z

IF (FIRST = EQ(0,0)) GO TO 50
IF (ICHECK, EQ=1) UPTIME = UPTIME - FUDGE
IF (ICHECK, EQ=1) GO TO 50
IF (AMSMNT, GT=4., AND TIME, GT=4.) CALL RSTART(ICHECK)
IF (ICHECK, EQ=1) UPTIME = UPTIME - FUDGE
GO TO 50

C
C AVERAGE BOTH TOTAL SYSTEM AND ACTUATOR FLOW RATES OVER TIME STEP

82 IF (NMAX, EQ=1) GO TO 110
90 DU YD = 1, NTRUBN
93 TFLW(I) = TFLW(I)

100 FLW(J) = FLW(J)
GO TO 100

110 DU 13G = 1, NACT
120 DU 12G = 2, NM

TFLM(I,J) = TFLM(I,J) + TTF(M, J)

130 CONTINUE

DU 150 = J, NACT
DU 140 = M, 2, NM
FLW(J) = FLW(J) + TF(M, J)

140 CONTINUE

150 CONTINUE

DU 160 = I, NACT
TFLW(I) = (TFLW(I) + (TIME + DELT) - T(NN)) * TFLW(I) / DELT

160 CONTINUE

DU 170 = J, NACT
FLW(J) = (FLW(J) + (TIME + DELT) - T(NN)) * FLW(J) / DELT

170 CONTINUE

GO TO 200

200 UPTIME = UPTIME + 4. * G
IF (LAG = 27)
DU = 01 = 1, NTRUBN
TFLW(I) = 0.
TFLW(I) = 0.

801 PUMP(J) = 0

803 CONTINUE

804 CONTINUE

805 CALL HYDAC

" BUILD ACTUATOR ARRAYS"

N1 = 160
DU 23G = 1, NTRUBN
CALL FLOP=RI(1, N1)

" COMPUTE PUMP EFFICIENCY, POWER AND CASE DRAIN FLOW RATE"

G(N1+1, 7) = PWRH(RL)
IF (TFLW(1) LT = 200) GO TO 210

179
IAX(1)=1
P(1) = P(1) + P(1)
GOTO 220

CONTINUE
IAX(1)=0
CIN(1) = 0
CIN(2) = 0
CIN(3) = 0
GOTO 217

GO TO 210

TURBINE IS ON
SET TURBINE TEMP TO INITIAL VALUE

TURBINE IS OFF
SET GEAR BOX-HEAT LOAD
AND FLUID TEMPERATURE TO ZERO

SET HYDRAULIC HEAT LOAD
AND FLUID TEMPERATURE TO ZERO

CALL LUBOIL(1, N1)

COMPUTE THERMAL CAPACITANCE OF BOILER.

CALL TANK(1, EQ=1) GO TO 215
IF (ALT >= 10000) GO TO 215
IF (SPRAY(1, EQ=1)) TANK(1)=1

USE(1) = MAT(1) - REFILL(1)
ENDU(1) = ATLC + USED(1)
IF (ENDU(1) > Lever) ISPRAY(1) = 1
IF (ENDU(TANK) + Lev) GO TO 217
CIN(1) = B20(N) + 1
CIN(1) = B20(N) + 1
GOTO 217
CONTINUE
N1 = N1 + 1

CONTINUE
IF (CNT + 1, EQ(IPRINT)) WRITE(6, CHECK)

COMPUTE ALTITUDE

ALT = ((ALTZ - ALT1) / (UPTIME - TO)) * (TIME - TO) + ALT1
T=TIME
ALTZ = ALT + 3048006E-3
TERM = 0
DO 225 I=1, 12
TERM = ALTM + ACOEF(1)

CONTINUE

PRESUR = 1.0 / (TERM + 4)
PZ = PRESUR * 4 + 96

CONVERT PRESSURE FROM ATMUS. TO PSI

THERMAL LOOP

N=100
DU 300 I=1,NTURBN
IF (IAP(1), EQ=0) CALL PASS(N)

IF TURBINE IS OFF, COMPUTE HEAT TRANSFER FROM TURBINE

GEAR BOX LOOP

CALL LOOPS(N+1)
CALL PLATEC(N+1, N+2)

HYDRAULIC LOOP
CALL LOOP(N+4)
\[C(N+4,4) = 0\]

CALL PLATEC(N+4,N+6)
\[JK = DUM(10+1)\]

IF (C(N+1)+1 > LT +1) GO TO 784
\[F(N+6) = F(N+4) + 4\]
\[C(N+6,4) = C(N+6,1) + 4\]
\[C(N+4,4) = POWER(1) \times 25+5,-C(N+7,4)\]
\[C(N+5,4) = C(N+4,4) - C(N+6,4)\]
\[F(N+5,4) = F(N+4) + 1 + C(N+5,4)/C(N+5,3)\]

CONTINUE
IF (LT > 10) GO TO 270
\[UO \leq N \leq 1, JK\]
\[NOD = NHYD(I,NJ)\]
\[NODL(NI,J) = NHYUT(I,J)\]
\[F(NUD, L) = F(N+6,1)\]
\[CALL PLATEC(NOD, NOD+50)\]

CONTINUE
CALL MIX(N+7, JK, NODE)
\[F(N+5,1) = F(N+6,1)\]
\[KK(1) = N+5\]
\[KK(2) = N+7\]

CALL MIX(N+8,2,KK)
CALL LOOP(N+11)
IF (C(N+4)+1 > LE +1) GO TO 275
IF (ISPRAY(I)=N+1) OR (ALT + LE + 10000) GO TO 272
CALL TRANS(N+8,N+10)
CALL SPRAY(N+2,N+10, N+1, N+11)
GO TO 273

CONTINUE
IF (1NLL+G +016667) GO TO 2772
\[C(N+10,3) = 0\]
\[C(N+9,3) = C(N+8,3)\]
GO TO 2774

IF (1TTANK(I)=HE +1) GO TO 2773
\[C(N+10,3) = C(N+8,3)\]
\[C(N+9,3) = 0\]
GO TO 2774

CALL MOD(N+8,N+10,N+12, 674++,00,0,005+1,005)

CONTINUE
\[F(N+10,1) = F(N+10,4)\]
\[F(N+9,1) = F(N+9,4)\]
\[CALL HYDFLD(I1, N)\]
\[CALL BUILP(N+2,N+1,N+10,N+11,P2,EA,STVC,STV0)\]

CONTINUE
\[I(1) = N+9\]
\[I(2) = N+11\]
\[CALL MIX(N+12,2,11)\]
GO TO 280

CONTINUE
\[CALL TRANS(N+4,N+8)\]
\[CALL TRANS(N+4,N+9)\]
\[CALL TRANS(N+4,N+10)\]
\[CALL HYDFLD(I1,N)\]
\[CALL BUILP(N+2,N+1,N+10,N+11,P2,EA,STVC,STV0)\]
\[CALL TRANS(N+4,N+12)\]
\[CALL PASS(N+1)\]
\[CALL PLATEC(N+12,N+13)\]
CALL TRANS(N+13,N+4)
N = N+50
300 CONTINUE
C
CALL FUEL(TOTFUEL,P2)
CALL QBAL
CALL PLLOT
IF(DUM(20),LE.,0) GO TO 350
350 CALL SELECT(149,143,INODES,10)
CALL FLIP
C
IF(1CNT+1,EQ,1PRNT) WRITE(6,UPDATE)
IF(TIME,LE.,TSTOP) G0 TO 777
CALL PRTTAB
RETURN
END OF COMPIRATION; NO DIAGNOSTICS.
<table>
<thead>
<tr>
<th>VARIABLE NAME</th>
<th>DESCRIPTION</th>
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<tr>
<td>EA</td>
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<td>STV0</td>
<td>STEAM VALVE OPEN FLAG</td>
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<td>TEMPS</td>
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<tr>
<td>RNDOT</td>
<td>BOILING RATE</td>
<td>LBM/MIN</td>
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</table>

M1 = LUBE OIL INLET
M11 = LUBE OIL Outlet
M2 = HYDRAULIC FLUID INLET
M22 = HYDRAULIC FLUID OUTLET

DIMENSION COEF(4)
COMMON K-L, DELT, TIME, TSTOP, NNODES
COMMON P1(300,2), F(300,2), C(300,20)
COMMON DUM(100), IDUM(100)
COMMON /SCMEP/, /WAT(10), WATLT(10), DW(10), WATLFT(3)
COMMON /ARRAY/ (300,10), TINIT(300), FLAG, ITER
COMMON /TIME/TIMSUM(3), AMSNTH, FUDGE, SUMMARY(20,3)
EQUIVALENCE ( IDUM(6), NWAT )
DIMENSION KEY(125)
DATA GGRAV/32.174/A/7449.73/B/14.9285/CC/62.65/
DATA GAMMA/1.31/R/85.8507/
DATA COEF / 1.595258 D 03; -1.387541 E 00; /
CA = EA*3600
EC = GAMMA/(GAMMA+1.)
CHTPK = (2./(GAMMA+1.))*EC
ITER = 0
FLAG = 0
P10LD = 0(M1; 1)
P = P2
IF (STVO.LE.0.) GO TO 9
DELTAP = G(M1; 1) - P2
IF (10LDLAP.LE.-1.5) G1(M1; 1) = P2 - 1.5
P10LD = G(M1; 1)
DELTAP = P10LD - P2
P = P2 + STVC
IF (DELTAP,GESTVO) KEY(M1) = 1
IF (DELTAP,LTSTVC) KEY(M1) = 0.
IF (P10LD,LE21.41) KEY(M1) = 0.
IF (KEY(M1),EQ,0) GO TO 250
9 CONTINUE

C
C
C
TEMP = A/(B+ALOG(P9)) + CC
DL = 1.
DL = 1.
TERRY = ABS(C(M1,3))
IF (TERRY LT 10.) DL = 0
TERRY = ABS(C(M2,3))
IF (TERRY LT 10.) DH = 0
P = (P(M1,K),LT,TEMPS) GO TO 249
M=COEF[1]
V = 73 I = 2,4
W = M + COEF(I)*P(M1,K)*#(I-1)
TML1 = 0.
TML2 = 1.
TMLH = 0.
TMM2 = 1.
IF (P10LD,LE.0.) GO TO 2
UAMCP = C(M1,2)/C(M1,3)
TML1 = EXP(-UAMCP)
TML2 = 1./TML1
DL = C(M1,3)/TML2
2 IF (DL,LE.0.) GO TO 4
UAMCP = C(M2,2)/C(M2,3)
TML1 = EXP(-UAMCP)
TML2 = 1./TML1
DH = C(M2,3)/TML2
4 FST = (DL*(M1,L) + DH*(M2,L))/CA
E1 = (GAMMA-1.) / GAMMA
E2 = 2. / GAMMA
E3 = (GAMMA-1.) / GAMMA
E4 = (GAMMA-2.) / GAMMA
E5 = (-1./GAMMA)
ITTER=0
PGUESS = PIOLD

CONTINUE
PK=PI/PGUESS
P1=PGUESS
PART = B ALOG(P1)
BORIG = A/PART + CC
DBORIG = P1*(PART+2*)
TIMDP=C(M1,11)*I/H

CHECK CONDITIONS FOR CHOKED OR UNCHOKED FLOW

UNCHOKED FLOW
IF (PK*PK*PK*PI/2) GO TO 100
SCND = (GRAV*2*GAMMA/R)/(GAMMA-1.)*(-1./2.)
TURIG=(1/(P1**2)+(2*E1)*(P2**E2)-(P1**E1)*(P2**E3))
IF(TURIG<LT+D) GO TO 151
IF(ITTER+GO) GO TO 32
PIDOT=(FRST*CA-(DL+DH))*DBORIG-CA/SCND*SQR(TURIG/BORIG)*DBORIG/
* TIMDP
PGUESS = PIDOT+DELT+PIOLD
ITTER = ITTER + 1
GO TO 75

CONTINUE
PIDOT = (PI-PIOLD)/DELT
HMDOT=DL*(M1,L)*DH=F(M2,L)-(DL+DH)*(BORIG)-TIMDP*PIDOT/DBORIG
IF(HMDOT+LE+D) ITTER=70
IF(HMDOT+LE+D) GO TO 250
YP*SCND=SQR(TURIG/BORIG)+1/(DL+DH)*BORIG+TIMDP*PIDOT/DBORIG)*SCND/CA
DELT Y= Y/PR
ITTER = ITTER+1
Y=ABS(Y)!
IF(Y+LE+D) CHECK=1.E=5
IF(Y+LE+D) GO TO 31
CHECK=ABS(DELTY/Y)

CONTINUE
IF(CHECK+LE+DDD00) FLAG = 1;
IF(CHECK+LE+DDD00) GO TO 150
IF(ITTER+LE+DDD0) GO TO 250
DYTRIG=(1/2)*([(1/5)*SQR(TURIG/BORIG)]-DYTRIG/BORIG)
DYTRIG=(1/2)*([(1/5)*SQR(TURIG/BORIG)]-DYTRIG/A/DBORIG/(BORIG**2,))
DYTRIG=TIMDP+1/DBORIG/DELT+(2*PART)*PIDOT/PI/DBORIG/PART)
DYDP1= DYTRIG-DYTRIG2+(DYTRIG3+DYTRIG4)*SCND/CA
V=DYDP1
DELP1=DELP/YY
PGUESS=PGUESS+DELP1
GO TO 75

CHOKED FLOW
THRD=(GRAV*GAMMA/R)*(2/((GAMMA+1.)*((GAMMA+1.)/(GAMMA-1.)))
IF(ITTER+G0) GO TO 101
PIDOT=(FRST*CA-BORIG-(DL+DH)=P1*CA*SQR(THRD/BORIG))DBORIG/TIMDP
157
guess = pivot*delta*piol
158
tter = iter + 1
159
goto 75
160
continu
161
 pivot = (pi - piol)/delta
162
wmuol = dl*f(mi,1) + (piol - dm)* (borig - timop)*piol/dborig
163
if (wmuol + le = 0) go to 250
164
thmp = 1/sqrt(thmp)
165
z0 = sqrt(thmp)
166
tzorig = (pi**2) + borig
167
zmp = sqrt(tzorig) + (delta)*borig + timop*piol/dborig + thmp/c
168
veltz = 20*pr
169
iter = iter + 1
170
z0 = abs(z0)
171
if (z0*le = 0) chkz = 1.e-5
172
if (z0*le = 0) go to 91
173
chkz = abs(delta/4)
174
41 continue
175
if (chkz*le = 0.01) flag = 2
176
if (chkz*le = 0.01) go to 150
177
if (iter = ge = 500) go to 200
178
dztrm1 = (dztrm1 + (1 + sqrt(tzorig))/2)*dztrm1
179
zp = (borig*2*1)
180
dztrm2 = (delta)*borig + (delta)*borig
181
dztrm3 = timop* (delta)*borig + dztrm2 + dztrm3*thmp/c
182
zp = dztm1* (delta)*borig + dztrm2 + dztrm3*thmp/c
183
vzt = dztrm1
184
deltz = deltzm1 + deltzm2 + deltzm3
185
pguess = pguess + delta
186
goto 75
187
200 continue
188
p1 = p1 + 0.5
189
210 format (2dh, no solution in 12.12h continued)
190
90 call exit
191
cc
192
compute saturation temperature
193
150 temp = boorig
194
goto 152
195
151 continue
196
iter = -69
197
p1 = p2
198
goto 250
199
200 continue
200
p1 = temp
201
p1 = temp
202
p2 = temp
203
p3 = temp
204
v4 = wmuot
205
m = coef
206
g0 = 90, i = 2, 4
207
90 m = m + coef*(i)*temp*(i-1)
208
209 cc
210
compute water consumed
211
212
delt = wmuot*delta
213
f1(m1,1) = taml2*p(m1,1) + taml2*f(m1,1)
214
f2(m2,1) = taml2*p(m2,1) + taml2*f(m2,1)
215
95 continue
DO 160 I=1,10
IF(M1+NE.WAT(I)) GO TO 160
GO TO 160
CONTINUE
160 CONTINUE
N_WAT = N_WAT + 1
I = N_WAT
180 CONTINUE
D_W(I) = DEL_W
DU = 10 C: I = N_WAT
WAT(I) = WAT(I) + D_W(I)
185 CONTINUE
CONTINUE
C(M1,3) = C(M1,3)
G(M22,3) = G(M2,3)
P1Z=P1*P2
WDOT = WDOT/6C*
G(M1,3) = WDOT
G(M1,9) = TEMPS
G(M1,1) = P1
G(M2,1) = P2
G(M2,2) = P2
G(M1,6) = P1DOT
RETURN
240 P1L0 = P9
245 CALL PLATEC(M1,M11)
P(M2,K) = P(M1,L)
CALL PLATE(M2,M22)
P(M1,L) = P(M2,L)
P = P2
IF(STVC.GT.0) GO TO 252
IF(P(M1,L)+LE,TEMPS) GO TO 252
WDOT = C(M1,1)+[P(M1,L)-TEMPS]/H/DELT
G(M1,4) = WDOT
G(M1,51) = H
P(M1,L) = TEMPS
P(M2,L) = TEMPS
DELT = WDOT + DELT
GO TO 252
CONTINUE
252 CONTINUE
IF(STVC.LE.0+) GO TO 251
P7=P2+STVC
G(M1,1) = STVC + P2
IF(G(M1,1)+LE+2141) G(M1,1) = 2141
P9=G(M1,1)
PSTAT = MAX(P(M1,L),B)
PSTAT = EXP(PSTAT)
P7=AMAX1(PSTAT,P9)
272 CONTINUE
273  P12=P1-P2
274  G(M1:8)= P12
275  MDOT=0.
276  G(M1:4)=MDOT
277  G(M1:8)= P12
278  MDOT = MDOT
279  G(M1:9)= TEMPR
280  G(M1:13)=P1
281  G(M2:11)=P1
282  G(M1:2)=P2
283  G(M2:2)=P3
284  G(M1:3)= C
285  G(M1:6)=1.E-6*(G(M1,1)/DELT*1.)
286  RETURN
287  END

END OF COMPI LATION: NO DIAGNOSTICS.
DATA X/1/2

WRITE(6,200)

200 FORMAT(1H0,24X,19HREST, PLOTTING TIMES )

CALL CDATE(TITLE(12))

TSTRT(1) = DUN(25)

CALL SCAL(TSTP(1),TSTRT(1),XAXIS(1),DTIME,IT,ERR)

KTRL = 20

IF (XAXIS(1) + GT. 9) KTRL = 10

KTRL = 10

ISAVAD = 1 IRADAR

NPLTS = NPLTS + 1

DIV = 0

Determine if any data points are to be skipped

NIP =1

63 IF (NPLPTS / NIP . LT. 1500) GO TO 89

DIV = DIV + 1

IF (DIV .GT. 8160) GO TO 50

NIP = NIP + 2

65 WRITE(6,255) X,NIP

GO TO 83

84 NIPM = NIP - 1

MD = INT((NPLPTS*DTIME)/(NIP*200*(TSTP(1)-TSTRT(1)))*DTIME))

IF (MD .LT. 1) MD = 1

Determine number of parameters to read

100 NTRC = NTR(X)

GROUP OF B (MAX)

4 IF (NTRC .EQ. 5) GO TO 2

1 NSAV = NTRC

IF (INTRC+X),EQ.0,1) GO TO 2

NTRC = NTRC+INTRC+X)

GO TO 4

3 NTRC=NSAV

2 CONTINUE

READ DATA

J = 0

44 J = J + 1

CALL RREAD (INRADR,REST,NPLTS,ISTAT)

48 IF (ISTAT .EQ. 1) GO TO 48

10 IF (REST(1) .LT. TSTRT(1)) GO TO 49

STIME(J) = REST(1)

NIP = NTRC

DO 7 IR = 0, N1

7 DATUM(1500+1R+J) = REST(X+IR+1)

IF (STIME(J) .GE. TSTP(1)) GO TO 77 & HAVE ARRIVED AT END OF PLOT RANGE

49 INRADR = INRADR + NPLTS

IF (INRADR .GE. IRRAD) GO TO 77 & HAVE ARRIVED AT END OF DATA

190
GO TO 44

1RDADR = ISAVAD

PREPARE Y SCALING

DO 8 JJ=1,NTRC
  KI=X-1+JJ
  IF (ABS(BIG(KI)) .GT. 1.E-10 .OR. ABS(WEE(KI)) .GT. 1.E-10) GO TO 20
  AMAX(JJ) = 100000.
  XMIN(JJ) = 100000.
  DO 5 JJ=1,J
  JN1=JJ-1
  AMAX(JJ) = AMAX1(XMAX(JJ),DATUM(JM1 *1500+11))
  AMIN(JJ) = AMIN1(XMIN(JJ),DATUM(JM1 *1500+11))
5 CONTINUE
GO TO 101
20 AMAX(JJ) = BIG(KI)
  AMIN(JJ) = WEE(KI)
101 CONTINUE
CALL SCAL(XMAX(JJ),XMIN(JJ),YAXIS(1),DPAR(JJ),PARU(JJ),ERK)
8 CONTINUE

PREPARE Y AXIS TITLES

DO 70 IZ=1,NTRC
  NUL=JPLT(X-1+IZ)
  YTILE(5,NUL) = ICNVRT(IPLT(X-1+IZ))
  DO 70 IY=1,7
  TITEL1(Y,IZ) = YTILE1(Y,NUL)
70 CONTINUE

PLACE DATA FOR ONE PLOT ON TAPE

NSET = NTR(X)
  NSET5V = NSET
68 GO TO (11,12,13,14,15),NSET
11 CALL CCP1,KTRL,TO,DTIME,STIME,DPAR(1),PARU(1),0,0,ALPHA
  ,72, TITLE,20,20H TIME (HRS.),54,TITEL1(1,1))
69 GO TO 18
12 CALL CCP1,KTRL,TO,DTIME,STIME,DPAR(1),PARU(1),1,4,ALPHA
  ,72, TITLE,20,20H TIME (HRS.),54,TITEL1(1,1))
63 GO TO 18
70 CALL CCP1,KTRL,TO,DTIME,STIME,DPAR(1),PARU(1),1,4,BETA
  ,72, TITLE,20,20H TIME (HRS.),54,TITEL1(1,1))
65 GO TO 18
71 CALL CCP1,KTRL,TO,DTIME,STIME,DPAR(1),PARU(1),2,16,ALPHA
  ,72, TITLE,20,20H TIME (HRS.),54,TITEL1(1,1))
66 GO TO 18
72 CALL CCP1,KTRL,TO,DTIME,STIME,DPAR(1),PARU(1),2,16,BETA
  ,72, TITLE,20,20H TIME (HRS.),54,TITEL1(1,1))
67 GO TO 18
73 CALL CCP1,KTRL,TO,DTIME,STIME,DPAR(1),PARU(1),7,20,ALPHA
  ,72, TITLE,20,20H TIME (HRS.),54,TITEL1(1,1))
68 GO TO 18
74 CALL CCP1,KTRL,TO,DTIME,STIME,DPAR(1),PARU(1),7,20,BETA
  ,72, TITLE,20,20H TIME (HRS.),54,TITEL1(1,1))
69 GO TO 18
75 CALL CCP1,KTRL,TO,DTIME,STIME,DPAR(1),PARU(1),12,32,ALPHA
  ,72, TITLE,20,20H TIME (HRS.),54,TITEL1(1,1))
70 GO TO 18
76 CALL CCP1,KTRL,TO,DTIME,STIME,DPAR(1),PARU(1),12,32,BETA
  ,72, TITLE,20,20H TIME (HRS.),54,TITEL1(1,1))
72 GO TO 18
77 CALL CCP1,KTRL,TO,DTIME,STIME,DPAR(1),PARU(1),18,64,ALPHA
  ,72, TITLE,20,20H TIME (HRS.),54,TITEL1(1,1))
78 GO TO 18
79 CALL CCP1,KTRL,TO,DTIME,STIME,DPAR(1),PARU(1),18,64,BETA

W NUMBER OF TRACES ON THIS PLOT
W TOTAL NUMBER OF TRACES IN THIS GROUP
OF 5 (MAX)

191
180* GO TO 18
181* 15 CALL CCP(1,KTL,TIME,TIME,0..55,PARA(1),UPAR(1),1,14+MU,ALPHA
182* PARA(2),UPAR(2),2,16+MU,BETA
183* PARA(3),UPAR(3),7,20+MU,GAMMA
184* PARA(4),UPAR(4),6,22+MU,PHI
185* PARA(5),UPAR(5),3,26+MU,THETA
186* TIME (MRS.): 54, TITEL(1,2)
187* 54, TITEL(1,3)
188* 54, TITEL(1,4)
189* 54, TITEL(1,5)
190* CONTINUE
191* CALL CCP(2,J,1)
192* CALL CCP(5,32767,PLOTIM)
193* WRITE(6,202) PLOTIM
194* 202 FORMAT(22X,F7.2,5X,HIN*)
195* IF((X-1+NSETV)+GE.+NPLTS) GO TO 500
196* IF(NSETV+NTR(NSETV+X)+GT.+NTRC) GO TO 80
197* MOVE REMAINING DATA, SCALING AND TITLE INTO POSITION FOR PLOTTING
198* N1=1500*(5-NSETV)
199* N2=5-NSETV
200* DU 66 IR=1,N1
201* DU 67 IR=1,N2
202* N3=NSET +IR
203* PARA(IR)=PARA(N3)
204* UPAR(IR)=UPAR(N3)
205* DU 67 IS=1
206* TITEL(IS,IR)=TITEL(IS,N3)
207* CONTINUE
208* NSET=NTR(NSETV+X)
209* NSETV=NSETV+NSET
210* GO TO 58
211* CHECK FOR MORE PLOTS
212* X=X+NTRC
213* GO TO 100
214* CALL CCP(6)
215* CALL EXIT
216* END

END OF COMPILATION: NO DIAGNOSTICS.
SUBROUTINE FLOPWR \( I, N \)

SUBROUTINE FLOPWR CALCULATES:

PART A: POWER AS A FUNCTION OF SYSTEM FLOWRATE IN GPM

PART B: POWER AS A FUNCTION OF SYSTEM FLOWRATE IN GPM

PART C: CASE DRAIN FLOWRATE AS A FUNCTION OF SYSTEM FLOWRATE IN GPM

PART D: CONVERTS VOLUMETRIC FLOWRATE TO MASS FLOWRATE

VARIABLE NAME | DESCRIPTION | UNITS
--- | --- | ---
\( C(N+4,3) \) | FLOWRATE INTO PUMP | LBM-BTU/HR-LBM-R
\( CDFLW \) | CASE DRAIN FLOWRATE | GPM
\( COE1 \) | PRESSURIZED, 100\% | FLOW RATE<10 GPM
\( COE2 \) | PRESSURIZED, 100\% | FLOW RATE<10 GPM
\( COE3 \) | PRESSURIZED, 100\% | FLOW RATE<10 GPM
\( COE4 \) | PRESSURIZED, 100\% | FLOW RATE<10 GPM
\( COE5 \) | DEPRESSURIZED | FLOW RATE<10 GPM
\( COE6 \) | DEPRESSURIZED | FLOW RATE<10 GPM
\( COE7 \) | PRESSURIZED, 105 DEG F | FLOW RATE<10 GPM
\( COE8 \) | PRESSURIZED, 240 DEG F | FLOW RATE<10 GPM
\( I \) | SYSTEM NUMBER | -
\( ICNFIG \) | CURRENT SYSTEM CONFIGURATION | -
\( IDO \) | SYSTEM CONFIGURATION | -
\( PDRP \) | PRESSURE DROP IN CURRENT CONFIGURATION | PSID
\( PEFF \) | PUMP EFFICIENCY | -
\( TFLP \) | PUMP SHAFT HORSEPOWER | HP
\( TFLR \) | PUMP DISCHARGE FLOWRATE | GPM

DIMENSION COEF(17), COEF2(17), COEF3(17), COEF4(17), COEF5(17)

DATA COEF(17)
1 23789028E-3, 1012577E-4, 0
2 24398098E-1, 4350098E-1, 1321502E-2, 14183407E-4
3 12586157E-6, -3864727E-8, -2253327E-10
4 15472021E-2, -9864602E-4, 2497738E-2, -26934014E-2
5 13982190E-4, -3, 0
6 2360945401, 4217201E-1, 1171359E-2, 1168629E-4
7 1084019E-6, -3350218E-8, 1982743E-10
8 2274319E-3, 6328513E-1, 4400191E-2, 1907086E-3
9 6573444E-6, -3387870E-8, 162783E-1
10 83406717E-2, -143595590E1, 23879447E-3
11 202717959E-4, 4.6, 526222337E-7, 7.2, 702823085E-10
12 91503020E-6, -25616662E-2, 2.2, 16334989E-3, -4.1
13 34702696E-7, 2634049214E-9, 1.670254927E-11
14 34086431E-5, 6.1, 441905327E-3
15 2.7777364735E-4, -7, 106378892E-8, 9.7, 105226309E-8, 4.5
16 100419158E-10

ICNFIG=1, IPDO=1, IFLAG=1

M=1SPD(11)
0=TFNL(1)
60 TO (20,30), M

193
PART A

100% SPEED

20 GO TO (22, 22, 24) * ICNFIG
22 PEFF = FUNC(COEFl, Q)  \* DEPRESSURIZED

70 GO TO 50
71 IF ITFLW(I) > GT, IG \* GO TO 25
72 PEFF = FUNC(COEFl, Q)
73 GO TO 50
74 PEFF = FUNC(COEFl, Q)
75 GO TO 50
76
77
78
79 IF ITFLW(I) > GT, IG \* GO TO 35
80 PEFF = FUNC(COEFl, Q)
81 GO TO 50
82 PEFF = FUNC(COEFl, Q)

PART B

50 \* POWER(I) = TFLW(I) * DPLR/(ICNFIG)/(PEFF = 1714.)
51 GO TO (60, 70, 100) * ICNFIG

PART C

SYSTEM OFF

60 \* CDFLW(I) = 0.
61 GO TO 100

DEPRESSURIZED MODE

70 \* CDFLW(I) = FUNC(COEFl, Q)
71 GO TO 100

72 \* PRESSURIZED MODE

80 \* CDL = FUNC(COEFl, Q)
81 CDH = FUNC(COEFl, Q)
82 \* CDFLW(I) = CDL + (CDH - CDL) * (F(N+4, K) - 565.) / 595.
83 CONTINUE
84
85
86
87
88
89
90
91
92
93
94
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96
97
98
99
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101
102
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113
114

\* PART D

C(N+6, 3) = TFLW(I) \* 220,
C(N+5, 3) = CDFLW(I) \* 220,
C(N+4, 3) = C(N+5, 3) + C(N+6, 3)
RETURN
END

END OF COMPILATION: NO DIAGNOSTICS.
**SUBROUTINE FUEL(TOTFUL,P2)**

**VARIABLE NAME** | **DESCRIPTION** | **UNITS**
--- | --- | ---
BAND | INTERVAL AROUND TIME TO CHECK FOR SAVING VALUES FOR SUMMARY TABLE | LBM/HR
FRATE1 | FUEL USAGE RATE AT SEA LEVEL | LBM/HR
FRATE2 | FUEL USAGE RATE IN SPACE | LBM/HR
FURATE | FUEL USAGE RATE AT CURRENT ALTITUDE | LBM/HR
ISP0 | APU OPERATING SPEED FLAG | LMD
PU | FUEL USED THIS COMP CYCLE | LMD

**DIMENSION TOTFUL(3)**
COMMON K,L,DELT,TIME,TSTOP,NNODES
COMMON P(300,2),F(300,2),C(300,20)
COMMON DUH(100),IDUH(100)
COMMON N/O/Y/IPX(27,3),LMTRX(50,4),POW(3),ISP(3),IFL(3),TFL(3)
COMMON NL/1(10),NTURB

**COMMON 274**
DU=100 I=1,NTURB
PWR=POWER(1)
IF(PWR.LE.0.) GO TO 100
M=ISP(1)

**GO TO (10,20),M**

*** 100% ***

**10 CONTINUE**
FRATE1= 5.554* PWR + 69.55 | W SEA LEVEL 100%
FRATE2= 4.593* PWR + 33.29 | W SPACE 100%

**GO TO 30**

*** 110% ***

**20 CONTINUE**
FRATE1= 5.554* PWR + 69.55 | W SEA LEVEL 110%
FRATE2= 4.593* PWR + 33.29 | W SPACE 110%

**PU=FURATE-DELT**
C(N+1,17)= C(N+1,17)+PU
C(N+1,19)= TOTFUL(1)-C(N+1,17)
ENERGY=POWER(1)-DELT
C(N+1,16)= C(N+1,16)+ENERGY

**PREPARE FUEL USAGE INFORMATION FOR SUMMARY TABLE**

**BAND = 6 * DELT**
**IF (TIME.GE.(TIMSUM(1)+BAND).AND.TIME.LE.(TIMSUM(1)+BAND))**
**SUMARY(5,1)=C(N+1,17)**
**IF (TIME.GE.(TIMSUM(2)+BAND).AND.TIME.LE.(TIMSUM(2)+BAND))**
**SUMARY(6,1)=SUMARY(5,1)-SUMARY(5,1)**
**IF (TIME.GE.(TIMSUM(3)+BAND).AND.TIME.LE.(TIMSUM(3)+BAND))**
**SUMARY(7,1)=SUMARY(6,1)**

**100 CONTINUE**
**RETURN**

**END**

**END OF COMPILATION:** NO DIAGNOSTICS. 195
### SUBROUTINE HYDACT

<table>
<thead>
<tr>
<th>VARIABLE NAME</th>
<th>DESCRIPTION</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>C(N1+7,1)</td>
<td>THERMAL CAPACITANCE OF HYDRAULIC SYSTEM 1</td>
<td></td>
</tr>
<tr>
<td>C(N1+7,4)</td>
<td>HEAT LOAD ON SYSTEM 1</td>
<td></td>
</tr>
<tr>
<td>ICNF1G</td>
<td>SYSTEM CONFIGURATION</td>
<td></td>
</tr>
<tr>
<td>IFLAG</td>
<td>SYSTEM CONFIGURATION FLAG</td>
<td></td>
</tr>
<tr>
<td>JK</td>
<td>COUNTER FOR NUMBER OF ACTUATORS ON EACH SYSTEM</td>
<td></td>
</tr>
<tr>
<td>LM</td>
<td>COLUMN OF MMTRX BEING CHECKED</td>
<td></td>
</tr>
<tr>
<td>LMC</td>
<td>OPERATING MODE OF COLUMN OF MMTRX</td>
<td></td>
</tr>
<tr>
<td>LMTRX</td>
<td>LOSS MANAGEMENT MATRIX</td>
<td></td>
</tr>
<tr>
<td>NACT</td>
<td>TOTAL NUMBER OF ACTUATORS</td>
<td></td>
</tr>
<tr>
<td>NHYD</td>
<td>ARRAY OF INLET NODE NUMBERS FOR ACTUATORS</td>
<td></td>
</tr>
<tr>
<td>NHYOUT</td>
<td>ARRAY OF OUTLET NODE NUMBERS FOR ACTUATORS ON SYSTEM 1</td>
<td></td>
</tr>
<tr>
<td>PDRP</td>
<td>PRESSURE DROP FOR CURRENT SYSTEM</td>
<td>PSID</td>
</tr>
</tbody>
</table>

- COMMON K,L,DELT,TIME,TSTOP,NNODES
- COMMON P(300,2),F(350,2),C(300,20)
- COMMON DUM(100),IDUM(100)
- COMMON /ACT/,NHYD(3,50),NHYOUT(3,50),NACT,FLM(50)
- COMMON /FRESK/,SPH(3),DENS(3),PDRP(3)
- COMMON /HYD/,IPDO(37,3),LMTRX(50,9),POWEK(3),ISP(3),IFLAG
- EQUIVALENCE(IDUM(11),NTURBN)
- DATA PDRP/0,1740/,3000*

10 CONTINUE
DO 60 J=1,JACT
LM = 0
20 LM = LM + 1
IF(LMMTRX(J,LM),EQ,0) GO TO 30
ISYS = LMMTRX(J,LM)
LMC = IPDO(IFLAG,ISYS)
IF(LMC+LT,3) GO TO 20
GO TO 50
30 LM = 0
40 LM = LM + 1
IF(LMMTRX(J,LM),EQ,0) ISYS=LMMTRX(J,LM)
IF(LMMTRX(J,LM),EQ,0) GO TO 50
ISYS = LMMTRX(J,LM)
LMC = IPDO(IFLAG,ISYS)
IF(LMC+LT,2) GO TO 40
50 IDUM(10+ISYS) = IDUM(10+ISYS) + 1
Jk = IDUM(10+ISYS)
54 NMDOUT(ISYS,JK) = J
55 CONTINUE
60 CONTINUE
Nj = 100
DO 80 J=1,NTRBN
70 JL=IDUM(10*1)
C(J)+7;1=0
C(J)+7;4=0
80 IF(JL,60+1,JL)
GO TO 79
69 NOD=NHYD(1,ND)
IF(NOD,LE,9) GO TO 65
C(J)+7;1=C(N)+7;1+C(NOD,1)
65 CONTINUE
ICNFIG=1PD0(IFLAG,1)
C(NOD,4)=FLX(NOD)*PDRT(1CNFIG)*1.98483
C(J)+7;4=C(N)+7;4+C(NOD,4)
C(NOD,3) = FLX(NOD)*220.
70 CONTINUE
79 N1=N1+50
74 CONTINUE
50 RETURN
76 END

END OF COMPILATION:  NO DIAGNOSTICS.
SUBROUTINE LLOAD

<table>
<thead>
<tr>
<th>VARIABLE NAME</th>
<th>DESCRIPTION</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>KNODE</td>
<td>COUPLING NODE</td>
<td></td>
</tr>
<tr>
<td>LINDEX</td>
<td>LINE NUMBER INDEX</td>
<td></td>
</tr>
<tr>
<td>LINUM</td>
<td>ARRAY OF ACTUATOR AND THEIR LINE PATHS</td>
<td></td>
</tr>
<tr>
<td>NODE</td>
<td>ACTUATOR-LINE MATRIX</td>
<td></td>
</tr>
<tr>
<td>NUCOUNT</td>
<td>COUNTER FOR NUMBER OF ACTUATORS</td>
<td></td>
</tr>
</tbody>
</table>

This S/R loads the LINE data, constructs the ACTUATOR X LINE matrix, and loads the line x actuator vector from the line data. It computes the capacitance and loads the data into the line data array.
```
SUBROUTINE LINFLO(IS)

<table>
<thead>
<tr>
<th>VARIABLE NAME</th>
<th>DESCRIPTION</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>FLOWL</td>
<td>FLOW RATE IN THE HYDRAULIC LINES</td>
<td>GPM</td>
</tr>
<tr>
<td>ID</td>
<td>POSITION OF LINE NUMBER IN THE LINE ARRAYS</td>
<td></td>
</tr>
<tr>
<td>INTG3</td>
<td>SECOND DIGIT OF THE LINE NUMBER</td>
<td></td>
</tr>
<tr>
<td>1=PRESSURE LINE SYS 1</td>
<td>2=RETURN SYS 1</td>
<td></td>
</tr>
<tr>
<td>3=PRESSURE LINE SYS 2</td>
<td>4=RETURN SYS 2</td>
<td></td>
</tr>
<tr>
<td>5=PRESSURE LINE SYS 3</td>
<td>6=RETURN SYS 3</td>
<td></td>
</tr>
<tr>
<td>LLL</td>
<td>NUMBER OF LINES ON ACTUATOR NN</td>
<td></td>
</tr>
<tr>
<td>NN</td>
<td>ACTUATOR NUMBER ON SYS IS</td>
<td></td>
</tr>
</tbody>
</table>

COMMON X,L,DEL,TIME,TSTOP,NNODES
COMMON P(300,2),F(300,2),S(300,20)
COMMON DUM(100),IDUM(100)
COMMON/LINES/ LINUM(260),KNODE(260),LTH(260),IG(260),FLOWL(260),
 TEMP(260),TEMPOT(260),LDGF(260),SPACE(20,2),
 NODLIN(50,75),NLCNT(50),DDOTL(260),SHAPL,EMISS,
 TEMP(1,2),FLACUM(260),FLOU(260)

KLY1 = 2+IS -1
KLY2 = 2+IS
JK = IDUM(10+IS)
DO 1 ND=1,JK
IN = NNYD(IS,NO)
LLL=NLCNT(ND)
DO 2 LL=1,LLL
IDO=NODLIN(IN,LLL)
LINE= LINUM(ID)
INTG1 = LINE/100
INTG2 = LINE/100
INTG3 = INTG1 - INTG2
INTG4 = INTG3 - INTG2
IF(LDGF(ID),ST,0) INTG3 = 2
IF(I)(INTG3+KEY) FLOWL(ID) = FLOWL(ID) + FLOWL(NN)2 CONTINUE
1 CONTINUE RETURN
END

END OF COMPILED: NO DIAGNOSTICS.

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```
SUBROUTINE LUBOIL(I,N)

VARIABLE NAME DESCRIPTION UNITS

C(N+1,4) HEAT LOAD ON GEARBOX BTU/HR
C(N+1,3) LUBE OIL FLOWRATE LBM-BTU/HR-LBM-K
C(N+2,2) HEAT TRANSFER COEFFICIENT FOR LUBE OIL BTU/HR-DEG
TBAR AVERAGE OF INLET AND OUTLET TEMPS DEG

DIMENSION SPHL(3), DENS(3)
COMMON X1,DEL,T,TIME,TSTOP,NNODES
COMMON P(300,2),F(300,2),C(300,20)
COMMON DUM(100), IDUM(100)
COMMON/HTD/D(27,3),LMTRX(50,4),POWER(3),ISPDL(3),IFLAG,IFL(3)

TBAR=(F(N+1,1)+F(N+2,1))/2
SPHL(1)=.0004*TBAR+.228
DENS(1)=C19008*TBAR+.7069
IF(ISPD(1)=0) GO TO 10
C(N+1,4) = 19997.2 + 26.514 * POWER(1)
C(N+1,3)= SPHL(1) * DENS(1) * 26.468
GO TO 20
HP=.494+.024*POWER(1)
C(N+1,3)= SPHL(1) * DENS(1) * 33.668
20 CONTINUE

TBAR=TBAR+.960

FLHL=(520,114,*) * C(N+1,3)/SPHL(1) LUBE OIL HEAT EXCHANGER

END OF COMPILATION: NO DIAGNOSTICS.
SUBROUTINE MOD(N,I,J,M,TC,R,MIN,MAX)

N = NODE TO SPLIT
I = SPLIT N INTO I, FLOW XM
J = SPLIT N INTO J, FLOW X1=XM
M = CONTROL NODE
TC = CONTROL TEMP.
R = XM CHANGE PER DEGREE
MAX = MAX+ VAL OF XM
MIN = MIN+ VAL OF XM

REAL MAX, MIN
COMMON K, L, DELT, TIME, TSTOP, NNODES
COMMON P(300:2), F(300:2), C(300,20)
COMMON DUM(I:100), IDUM(I:100)

GO TO 101
ENTRY MOD(N,I,J,M,TC,R,MIN,MAX)
BAD1 = C(I,10)
BAD2 = C(J,10)
DO 102 I=5,14
C(I,I) = C(N,I)
C(J,I) = C(N,1)
102 CONTINUE
C(I,10) = BAD1
C(J,10) = BAD2
101 IF (F(N,L),LT,TC) XM=0
IF (F(N,L),LT,TC) GO TO 13
290 IF (F(I+1,L),GT,TC) XM=1
IF (F(I+1,L),GT,TC) GO TO 13
XM = XM + 0.05
G = MAX + 0.05
IF (XM,GE,MM) GO TO 15
XM = H
GO TO 18
15 IF (XM,LE,GG) GO TO 18
XM = GG
18 C(I,3) = XM * C(N,3)
C(J,3) = C(N,3) - C(I,3)
30 F(I,L) = F(N,L)
F(J,L) = F(N,L)
RETURN
END OF COMPILATION; NO DIAGNOSTICS.
SUBROUTINE PLATE(M,N)

M = INLET
N = OUTLET

VARIABLE NAME DESCRIPTION UNITS

ICUF = FLAG TO SIGNAL THAT PLATO WAS CALLED
F(N,L) = OUTLET FLUID TEMPERATURE
P(N,L) = COMPONENT TEMPERATURE

COMMON K, L, DELT, TIME, TSTOP, NNODES
COMMON P1(300,2), F1(300,2), C1(300,20)
COMMON DUM1(100), IDUM1(100)
EQUIVALENCE (DELT02, DUM1(1))
C(N,1) = C(M+3)
GO TO 100
ENTRY PLATO(M,N)
C(N,3) = C(M,3)
SAVEQ = C(M,4)
SAVEV = F(N,L)
ICUF = 1
IF(C(M,3),LE.0) GO TO 100
F(M,L) = C(M,4) / (C(M,3) / 2) + SAVET
C(M+4) = 0
GO TO 100
ENTRY CPLT(M,N)
C(N,5) = C(M,5)
PM = C(M,12) * DUM1(17) + C(M,13) * DUM1(18)
GO TO 110
C(N+1) = C(N,1)
C(N+1X) = C(N,1X)
101 C(N+1X-5) = C(N,1X) * DUM1(1X+5) / PM
C(N+3) = C(M,3)
C(M+3) = (C(N,6) * DUM2(1) + C(N,9) * DUM2(2) + C(M,5)) * C(M,3) / C(M,5)
ICUF = 1
CONTINUE
78 TM1=EXP(-UAWCP)
TM3=DELT02*TRM2*C(M,3)
TM3=TRM2/2,
TUFML=2.*P(M,L)
C1T(L)=C(M,1)+TRM3
P(M,L) = C(M,4) * DELT1 * (P(M,K) * T0FML) * TRM3 * C(M,3) * P(M,K) / C(M,RM3
PML1K=P(M,L) * P(M,K)
F(N,L) = TRM5 * PML1K * TRM1 * F(M,L)
C(M+3) = C(M,3)
IF (ICUF,EQ,0) RETURN
C(M+4) = SAVEQ
F(N,L) = SAVET
IF (C(M,3),LE.0) GO TO 102
F(M,L) = F(N,L) * C(M,4) / C(M,3) / 2,
102 ICUF=0
RETURN
END
SUBROUTINE PLATE(I,J)

<table>
<thead>
<tr>
<th>VARIABLE NAME</th>
<th>DESCRIPTION</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>NSTRT</td>
<td>LOCATION OF FIRST NODE IN IBIG COUPLED TO NODE M</td>
<td></td>
</tr>
<tr>
<td>NTRY</td>
<td>LOCATION OF LAST NODE IN IBIG COUPLED TO NODE M</td>
<td></td>
</tr>
<tr>
<td>SUM</td>
<td>TOTAL HEAT CLOSED TO STRUCTURE OR OTHER COMPONENTS</td>
<td></td>
</tr>
</tbody>
</table>

COMMON K, L, DELT, TIME, TSTOP, NNODES
COMMON P(300, 2), F(300, 2), C(300, 20)
COMMON DUM(100), IDUM(100)

AA = C(I, 4)
GO TO 44
ENTRY PLATEC(I, J)
AA = C(I, 4)
GO TO 44
ENTRY GPLETC(I, J)
BAD = C(J, 10)
DO 44 IX = 5, 19
44 CI(J, IX) = C(I, IX)
C(J, 10) = BAD
CONTINUE
NSTRT = KEEP(I) + 1000
NTRY = KEEP(I) - NSTRT + 1000 + NSTRT - 1
IF (NSTRT + EQ 0) GO TO 150
SUM = 0
DO 100 I = NSTRT, NTRY
NUM = IBIG(I)
TEMP = P(I, K) - P(NOW, K)
SUM = SUM + TEMP
100 CONTINUE
C(I, 4) = C(I, 4) + SUM
150 NSTRT = KEEP(I) / 1000
NTRY = KEEP(I) - NSTRT + 1000 + NSTRT - 1
IF (NSTRT + EQ 0) GO TO 200
SUM = 0
14 = P(I, K) + 4
DO 44 I = NSTRT, NTRY
NUM = JBIG(I)
TEMP = T4 - P(NOW, K) + 4
SUM = SUM + RVAL(I) + TEMP
44 CONTINUE
C(I, 4) = C(I, 4) + SUM
200 IF (ICUP + EQ 1) CALL PLATEC(I, J)
IF (ICUP + EQ 1) GO TO 202
CALL PLATEC(I, J)
202 ICUP = 0
C(I, 4) = AA
RETURN
END
**SUBROUTINE PLOOT**

SUBROUTINE PLOOT PUTS THE INFORMATION FROM EACH COMP CYCLE FOR EACH DESIRED PLOT INTO HIGH SPEED DRUM TO BE RETRIEVED LATER BY THE ROUTINE DRAW.

<table>
<thead>
<tr>
<th>VARIABLE NAME</th>
<th>DESCRIPTION</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>IPLT</td>
<td>NODE NUMBER OF PLOT</td>
<td></td>
</tr>
<tr>
<td>INADR</td>
<td>ADDRESS ON DRUM AT WHICH TO WRITE DATA</td>
<td></td>
</tr>
<tr>
<td>JPLT</td>
<td>TYPE OF PLOT</td>
<td></td>
</tr>
<tr>
<td>NIA</td>
<td>COUNTER FOR NUMBER OF PLOTS</td>
<td></td>
</tr>
</tbody>
</table>
C NNPLTS NUMBER OF PLOTS PLUS 1 FOR A
C COUNTER FOR NUMBER OF POINTS ON EACH PLOT
C PLANET ARRAY OF VALUES TO PUT ON ONE RECORD OF
C DRUM (1)=TIME (1), I=2, NNPLTS=ONE POINT FOR EACH PARAMETER BEING PLOTTED

DIMENSION PLANET(25)
COMMON K, L, DELT, TIME, TSTOP, NNODES
COMMON P1(300,2), F1(300,2), C1(300,20)
COMMON DUM(160), IDUM(160)
COMMON ARRAY/PSST/NPLTS, IPLOT(25), JPLT(25), PLTSET, TSTOP15, XAXIS(5),
 COMMON/UAMMIT/ERG(12), ERG(12), OH(12)
COMMON /ALTD /ALT
COMMON /COMEVPS/ IATT10, IATT10, DW(10), MATLFT(10)
COMMON /CONV/ ALTM
DATA CONVF/22-1
DATA CONVENT/19-1
DATA CONV/16-1
DATA CONVG/13-1
C * * * FLUID TEMPERATURE (DEGREES R)
XX = F1(MUG, L) - 460
GO TO 400
C * * * COMPONENT TEMPERATURE (DEGREES R)
XX = P1(MUG, L) - 460
GO TO 400
C * * * FLOW RATE (LBS/HR)
XX = C1(MUG, 3)/C1(MUG, 5)
GO TO 400
C * * * FLOW RATE (GPM)
XX = C1(MUG, 3)/CONVF
GO TO 400
C * * * HEAT (BTU/HR)
XX = C1(MUG, 4)
GO TO 400
C * * * WATER REMAINING (LBS)
DO 54 IM = 1, 10
IF (MUG .EQ. IMAT1) GO TO 56
C * * * CONC. OF H2O (LB/LB DRY GAS)
XX = C1(MUG, 6)
GO TO 400
C * * * CONC. OF O2 (LB/LB DRY GAS)
XX = C1(MUG, 7)
GO TO 400
END
C *** CONC OF N2 (LB/LB DRY GAS)
    80  XA = C(MUG,8)
GO TO 400
C *** CONC OF CO2 (LB/LB DRY GAS)
    90  XA = C(MUG,9)
GO TO 400
C *** HEATER POWER (BTU/HR)
   100  XA = C(MUG,10)
GO TO 400
C *** PARTIAL PRESSURE OF H2O (PSI)
   110  XA = C(MUG,11)
GO TO 400
C *** PARTIAL PRESSURE OF O2 (PSI)
   120  XA = C(MUG,12)
GO TO 400
C *** PARTIAL PRESSURE OF N2 (PSI)
   130  XA = C(MUG,13)
GO TO 400
C *** PARTIAL PRESSURE OF CO2 (MMHG)
   140  XA = C(MUG,14) *51.70068
GO TO 400
C *** HEATER ENERGY (BTU)
   150  GO 155 IN, H, NERG
IF(MUG.EQ.1)ERG(1) GO TO 156
CONTINUE
   156  XA = ENG(1) + DH(1)
GO TO 400
   160  XA = C(MUG,16)
GO TO 400
C *** ACCUM FUEL (LBS)
   170  XA = C(MUG,17)
GO TO 400
C *** ACCUM ENERGY (HP-HR)
   180  XA = C(MUG,18)
GO TO 400
C *** FUEL REMAINING (PERCENT USABLE)
   190  XA = C(MUG,19)
GO TO 400
C *** AMBIENT PRESSURE (PSIA)
   200  XX=6(MUG,2)
GO TO 400
C *** BUILDER PRESSURE (PSIA)
   210  XA = G(MUG,1)
GO TO 400
C *** MISCELLANEOUS PLOT
   220  XA = G(MUG,3)
IF(MUG.EQ.35) XX=ALT
GO TO 400
C *** MISCELLANEOUS PLOT
   230  XA = G(MUG,4)
CONTINUE
   240  PLANET(INX+1) = XX
   250  IF(INX.LT.NNPLTS) GO TO 450
   260  NNPLTS=NNPLTS+1
   270  CALL RRITE(INRADR,PLANET,NNPLTS,ISTAT)
   280  IF(ISTAT.EQ.1) GO TO 450
   290  INRADR = INRADR + NNPLTS
END
SUBROUTINE PRINT

<table>
<thead>
<tr>
<th>VARIABLE NAME</th>
<th>DESCRIPTION</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>AERROR</td>
<td>ARRAY OF TITLES FOR HEAT BALANCE VALUES</td>
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</tr>
<tr>
<td>G(1:7)</td>
<td>ARRAY OF HEAT BALANCE VALUES</td>
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</tr>
<tr>
<td>G(1:J)</td>
<td>I=1,3, J=1,2,3,8,9 - OUTPUT FROM BOILP</td>
<td></td>
</tr>
<tr>
<td>IALT</td>
<td>FLAG TO LIMIT PRINTING OF ALT OUTPUT</td>
<td></td>
</tr>
<tr>
<td>ICNT</td>
<td>COUNTER FOR NUMBER OF COMP CYCLES BETWEEN PRINT CYCLES</td>
<td></td>
</tr>
<tr>
<td>IP</td>
<td>FLAG TO SIGNAL WHICH ROUTINE WAS CALLED</td>
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</tr>
<tr>
<td>IPRN</td>
<td>NUMBER OF COMP CYCLES PER PRINT CYCLE</td>
<td></td>
</tr>
<tr>
<td>ISKP</td>
<td>FLAG TO PREVENT WRITING NODE DATA</td>
<td></td>
</tr>
<tr>
<td>IWHAT</td>
<td>NODE NUMBER OF BUTLER</td>
<td></td>
</tr>
<tr>
<td>NODE</td>
<td>ARRAY OF INLET NODES ON EACH SYSTEM</td>
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<tr>
<td>NMP</td>
<td>NUMBER OF NP FOR WHICH TO PRINT THERMAL DATA</td>
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</tr>
<tr>
<td>NMP1</td>
<td>FIRST NODE NUMBER USED FOR FUEL USAGE</td>
<td>LBM</td>
</tr>
<tr>
<td>NMP6</td>
<td>LAST NODE NUMBER USED FOR ENERGY USAGE</td>
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</tr>
<tr>
<td>NODES</td>
<td>TOTAL NUMBER OF NODES IN MODEL</td>
<td></td>
</tr>
<tr>
<td>NP</td>
<td>TOTAL NUMBER OF NODES IN IPART ARRAY</td>
<td></td>
</tr>
<tr>
<td>NUP</td>
<td>TOTAL NUMBER OF BOILERS</td>
<td></td>
</tr>
<tr>
<td>NWHAT</td>
<td>NUMBER OF CYCLES PRINTED</td>
<td></td>
</tr>
<tr>
<td>TTINIT</td>
<td>START TIME</td>
<td></td>
</tr>
<tr>
<td>TSTOP</td>
<td>AMOUNT OF WATER USED</td>
<td></td>
</tr>
</tbody>
</table>

COMMON K,L,DELT,TIME,TSTOP,NODES
COMMON P(300,2),T(300,2),C(300,20)
COMMON U(100),IPART(100)
COMMON V(12),ERG(12),ERG(12),OH(12)
COMMON TYME,TIMSUM(3),AMNT,MET,FUDGE,SYMD(20,3)
COMMON ARRAY, G(300,10),TIMT(300),FLAG,ITER
COMMON /PRNT/ IPRN,ICNT,NAME(300,2),AERROR(2),J
COMMON ACT, HWYP(3,30),NYUX(30,30),NACT,FLA(30)
COMMON /ALT/ BI(20(3),H2CF(3),IALT
COMMON /COMESP/ IWHAT(10),WAT(T10),DW(10),MATLT(13)
DIMENSION NAD(37),NADE(37)
DIMENSION I(10),IPART(10)
DIMENSION ICON(5),CON(5),UC(5)
EQUIVALENCE /CONUM(10),NTURBN|
EQUIVALENCE (IDUM(16),NERG), (IDUM(17),NUP), (IDUM(25),TTINIT)
EQUIVALENCE (IDUM(15),NUP), (IDUM(25),TTINIT)
EQUIVALENCE (IDUM(15),NUP), (IDUM(25),TTINIT)
EQUIVALENCE (IDUM(15),NUP), (IDUM(25),TTINIT)
DATA ISKP/0/ |
IP=1 |
GO TO 199 |
ENTRY SELECT(NP,NMP,IPART,10) |
IP=2 |
199 CONTINUE
111  WRITE(6,2)I,PI,L, F(I,L),(C(I,M),M=1,4ENY)
112  2 FORMAT(1X,14,3(2X,F10.5,2X),2X,F7.1,5(2X,F11.5),/)
113  10 CONTINUE
114  GO TO 82
115  402 N=1
116  DO 83 I=1,NMP
117  INDEX=IPART(I)
118  IF(INDEX+NE*10(N)) GO TO 403
119  INDEX=14
120  NMP=NMP+1
121  403 CONTINUE
122  P(INDEX,L)=P(INDEX,L)-460.*
123  F(INDEX,L)=F(INDEX,L)-460.*
124  WRITE(6,49)INDEX,ANAME(INDEX,J),J=1,2,P(INDEX,L),F(INDEX,L),
125  *(C(INDEX,M),M=1,INDEX)
126  49 FORMAT(1X,14,3(2X,F10.5,2X),2X,F7.1,5(2X,F11.5),/)
127  F(INDEX,L)=P(INDEX,L)-460.*
128  63 CONTINUE
129  GO TO 82
130  81 CONTINUE
131  IF(DUM(8),EQ,1) GO TO 20
132  IF(INDEX+LE*10(I)) GO TO 75
133  DO 40 I=1,NMP
134  INDEX=IPART(I)
135  WRITE(6,3) INDEX,INDEX
136  3 FORMAT(10X,4X,INDEX,13,5X,26HACCUMULATED CONSUMABLES = 1PE11.4)
137  40 CONTINUE
138  IF(DUM(8),EQ,1) GO TO 20
139  SUM=0.
140  NMP1 = NMP+1
141  NMP2 = NMP+3
142  DO 60 I=NMP1,NMP3
143  INDEX=IPART(I)
144  WRITE(6,13) INDEX,INDEX
145  13 FORMAT(10X,4X,INDEX,13,5X,26HACCUMULATED FUEL (LBM) = 1PE11.4)
146  60 CONTINUE
147  NMP4 = NMP+4
148  NMP6 = NMP+6
149  DO 81 I=NMP4,NMP6
150  INDEX=IPART(I)
151  WRITE(6,15) INDEX,INDEX
152  15 FORMAT(10X,4X,INDEX,13,5X,26HACCUMULATED ENERGY (HP-HK) = 1PE11.4)
153  81 CONTINUE
154  IF(ENERGY+LE*1) GO TO 20
155  DO 80 I=1,ENERGY
156  SUM=SUM+ENERGY
157  80 CONTINUE
158  61 CONTINUE
159  IF(ENERGY+EQ,1) GO TO 80
160  WRITE(6,3) ENERGY,ENERGY
161  IF(ENERGY,ERG(I)) GO TO 80
162  WRITE(6,3) ENERGY,ENERGY
163  33 FORMAT(10X,4X,INDEX,13,5X,9HENERGY = 1PE11.4)
164  80 CONTINUE
165  85 WRITE(6,4) SUM
166  44 FORMAT(1X,15HTOTAL ENERGY = 1PE11.4)
167  20 CONTINUE

209
169* IF(IDUM(8),EQ,1) GO TO 36
170* IF(NCON.LE.0) GO TO 36
171* DO 55 I=1,NCON
172* WRITE(6,53) (CON(I),CON(I))
173* 53 FORMAT(10A,4HNODE,13,5X,21HCONSUSB,19HCONSUSB,19HCUSMABLES = $1PE11.4)
174* 55 CONTINUE
175* 36 CONTINUE
176* NUP=NUP+1
177* X=XUP
178* TIME = TTINIT * X*DELT
179* 100 CONTINUE
180* IDUM(100) = ICNT
181* RETURN
182* END

END OF COMPILATION: NO DIAGNOSTICS.
SUBROUTINE PRTTAB

SUBROUTINE PRTTAB GATHERS THE SUMMARY TABLE
INFORMATION PREPARED IN OTHER ROUTINES, COMPUTES
THE OTHER NECESSARY VALUES, AND PRINTS OUT THE
CONSUMABLES SUMMARY TABLE.

COMMON /TYME,TIMSUM(3),AMSNTM,FUDGE,SUMARY(20,3)

DO 938 J=1,3
938 SUMARY(8,J)=SUMARY(5,J)
SUMARY(18,J)=SUMARY(18,J)
PARI=0,
PART2=0,
DO 939 I=5,8
939 CONTINUE
PARI=PART1+SUMARY(1,J)
PART2=PART2+SUMARY(1+10,J)
I=10
I=10
I=1
I=1
SUMARY(10,J)=SUMARY(4,J) = (PART1 * SUMARY(4,J))
SUMARY(20,J)=SUMARY(14,J) = (PART2 * SUMARY(14,J))
CONTINUE
CONTINUE
1000 FORMAT(1H1,4X,9H,FUEL, LBM,22X,10H,WATER, LBM,1/35X,3(2X,7H,SYSTEM,1))
WRITE(6,1001) ((SUMARY(1,J),J=1,3),(SUMARY(1+10,J),J=1,3),I=1,10)
1001 FORMAT(1H77X,PRESENT LOADING,17X,3F10,1,12X,3F10,1/10H,UNUSABLES//4
X,23H,MEASUREMENT ERROR (RSS),6X,3F10,1,2X,3F10,1//4X,9H,RESIDUALS,
20X,3F10,1,2X,3F10,1//16H,MÍNIMUM USABLE,17X,3F10,1,2X,3F10,1/7/9
H, USABLE REQUIREMENTS//2X,22H,PRELAUNCH REQUIREMENT,8X,3F10,1,1X,
3F10,1//3X,19H,FLIGHT REQUIREMENT,11X,3F10,1,2X,3F10,1//4X,24H,POST
LANDING REQUIREMENT,5X,3F10,1,2X,3F10,1//4X,27H,24H,LAUNCH HUL
CYCLE//4X,11H,REQUIREMENT,18X,3F10,1,2X,3F10,1//4X,17H,1S,PERS,10N
5(10X),12X,3F10,1,2X,3F10,1//14H,USABLE MARGIN,14X,3F10,1,2X,3F10
RETURN
END

END OF COMPILATION: NO DIAGNOSTICS.
SUBROUTINE GBAL

<table>
<thead>
<tr>
<th>VARIABLE NAME</th>
<th>DESCRIPTION</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>G(1,7) 1=1,3</td>
<td>HEAT IN</td>
<td>BTU</td>
</tr>
<tr>
<td>G(4,7) 1=4,7</td>
<td>HEAT OUT</td>
<td>BTU</td>
</tr>
<tr>
<td>G(8)</td>
<td>BTU'S ERROR</td>
<td></td>
</tr>
<tr>
<td>IBIG</td>
<td>ARRAY OF CONDUCTION/CONVECTION COUPLING NODES</td>
<td></td>
</tr>
<tr>
<td>JBIG</td>
<td>ARRAY OF RADIATION COUPLING NODES</td>
<td></td>
</tr>
<tr>
<td>NSTRT</td>
<td>LOCATION OF FIRST NODE IN IBIG OR JBIG</td>
<td></td>
</tr>
<tr>
<td>NTRY</td>
<td>LOCATION OF LAST NODE IN IBIG OR JBIG</td>
<td></td>
</tr>
<tr>
<td>RVAL</td>
<td>ARRAY OF RADIATION COUPLING COEFFICIENTS</td>
<td></td>
</tr>
<tr>
<td>TOTCUP</td>
<td>TOTAL HEAT OUT VIA COUPLING TO STRUCTURE BTU/HR FOR ONE SYSTEM FOR ONE COMP CYCLE</td>
<td></td>
</tr>
<tr>
<td>TOTCUP</td>
<td>TOTAL HEAT OUT VIA COUPLING TO STRUCTURE BTU/HR FOR ALL THREE SYSTEMS PLUS LINE AND COMPONENT LOSSES FOR ONE COMP CYCLE</td>
<td></td>
</tr>
<tr>
<td>VAL</td>
<td>ARRAY OF CONDUCTION/CONVECTION COUPLING COEFFICIENTS</td>
<td></td>
</tr>
</tbody>
</table>

COMMON K,L,DELT,TIME,TSTOP,NNODES
COMMON P(300,2);F(300,2);C(300,20)
COMMON DUM(100),10DUM(100)
COMMON /ACT/ /HYD(3,50),/NHYD(3,50),/NACT,FLN(50)
COMMON /ARRAY/ G(300,10),TINIT(300),FLAG,ITERR
COMMON/GLOB/KEEP(300),IBIG(2000),VAL(2000),
COMMON/EXTRAY/COPUP(300)
COMMON/EQUIVALENCE(NTURBN,1DUM(10))
G(1,7)=0.
DO 15 M=1,NACT
   15 G(5,7)+G(5,7)+C(M,1)*(P(M,L)+TINIT(M)) OF ACTUATORS -ADD IN LATER
   N=100
   DO 150 I=1,NTURBN
   POWER HEAT IN
      G(1,7)=G(1,7)+(C(N+1,4)+C(N+4,4)+C(N+7,4))*DELT
      C(249+1,2)=C(249+1,2)+(C(N+1,4)*DELT) APU HEAT PER SYSTEM
   TURBINE HEAT IN
      G(2,7)=D.*
   TOTAL HEAT IN
      G(3,7)=G(1,7)+G(2,7)
HEAT OUT BY H2O

G(4,7) = G(4,7) + G(N-2,4) * DELT * (G(N+2,5) + (P(N+2, L) - TINIT(N+2))

C(252+1, 2) = C(252+1, 2) + G(N-2,4) * DELT * (G(N+2,5) + (P(N+2, L) -

HEAT STORED IN CAPACITANCE

DUMMY = 0

DO 25 N = 1, 14

25 DUMMY = DUMMY + C(N+1, 1) * (P(N+1, L) - TINIT(N+1))

DUMMY2 = C(N+10, 1) * (P(N+10, L) - TINIT(N+10))

G(5, 7) = G(5, 7) + DUMMY - DUMMY2

HEAT OUT VIA CONDUCTANCE TO STRUCTURE

DO 75 N1 = 1, 12

75 NSTRT = LEEP(N+1)/1000

HCYX = LEEP(N+10) * NSTRT = 1000 * NSTRT - 1

SUM = 0

IF (NSTRT = EQ. 0) GO TO 65

DO 50 J = NSTRT, NTRY

NOW = BIG(J)

TEMP = P(NOW, L) - P(NOW, L)

50 SUM = SUM + VAL(J) * TEMP * ICOUP(J)

CONTINUE

75 NSTRT = LEEP(N+1)/1000

NTRY = LEEP(N+10) * NSTRT = 1000 + NSTRT - 1

SUMR = 0

IF (NSTRT = EQ. 0) GO TO 60

60 T4 = P(N+11, L) * 4

60 DO 65 M = NSTRT, NTRY

65 NOW = JBIG(M)

TEMP = P(NOW, L) * 4

SUMR = SUMR + RV4L(M) * TEMP * ICOUP(M)

CONTINUE

85 CONTINUE

75 TCCUP = TCCUP + SUM + SUMR

C(255+1, 2) = C(255+1, 2) + C(250+1, 4) * 60 * DELT

C(258+1, 2) = C(258+1, 2) + (C(256+1, 4) * 60 + TCCUP) * DELT

TCCUP = TCCUP + (C(1+250+4) + C(1+256+4)) * 60

TOTAL HEAT OUT

G(6, 7) = G(6, 7) + TOTCUP * DELT

TOTCUP = 0

HEAT IN = HEAT OUT

G(6, 7) = G(6, 7) + G(7, 7) - G(7, 7)

HEAT IN = HEAT OUT

G(6, 7) = G(6, 7) - G(7, 7)

END OF COMPILATION: NO DIAGNOSTICS.
<table>
<thead>
<tr>
<th>VARIABLE NAME</th>
<th>DESCRIPTION</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>IBIG</td>
<td>ARRAY OF CONDUCTION/CONVECTION COUPLING NODES</td>
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<tr>
<td>JBIG</td>
<td>ARRAY OF RADIATION COUPLING NODES</td>
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</tr>
<tr>
<td>G(1,7)</td>
<td>1=1,3 HEAT IN</td>
<td>BTU</td>
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<tr>
<td>G(1,7)</td>
<td>1=4,7 HEAT OUT</td>
<td>BTU</td>
</tr>
<tr>
<td>C8</td>
<td>BTU'S ERROR</td>
<td></td>
</tr>
<tr>
<td>NSTRT</td>
<td>LOCATION OF FIRST NODE IN IBIG OR JBIG</td>
<td></td>
</tr>
<tr>
<td>NTRY</td>
<td>LOCATION OF LAST NODE IN IBIG OR JBIG</td>
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</tr>
<tr>
<td>RVAL</td>
<td>ARRAY OF RADIATION COUPLING COEFFICIENTS</td>
<td></td>
</tr>
<tr>
<td>TCCUP</td>
<td>TOTAL HEAT OUT VIA COUPLING TO STRUCTURE BTU/HR</td>
<td></td>
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<tr>
<td>TOTCUP</td>
<td>TOTAL HEAT OUT VIA COUPLING TO STRUCTURE BTU/HR</td>
<td></td>
</tr>
<tr>
<td>VAL</td>
<td>ARRAY OF CONDUCTION/CONVECTION COUPLING COEFFICIENTS</td>
<td></td>
</tr>
</tbody>
</table>

COMMON X: L, DELT, TIME, TSTOP, NODES
COMMON P(300, 2), T(300, 2), C(300, 20)
COMMON DUM(100), T(300, 100)

COMMON/EXTRA/ICOU/P(300)
COMMON/ACT/NMD(3, 50), NHOUT(3, 50), NACT, FL(150)
EQUIVALENCE(NURB, DUM(100))

DO 15 M = 1, NACT
   15 G(5, 7) = G(5, 7) + C(M, 1) * (P(M, L) - TINIT(M)) \% OF ACTUATORS + ABD IN LATER
   N#100
   DO 100 I = 1, NURB
   POWER HEAT IN
   G(1, 7) = G(1, 7) + (C(N+1, 4) + C(N+4, 4) + C(N+7, 4)) * DELT
   C(249+1, 2) = C(249+1, 2) + (C(N+1, 4) * DELT) \% APU HEAT PER SYSTEM
   TURBINE HEAT IN
   G(2, 7) = 0*
   TOTAL HEAT IN
   G(3, 7) = G(1, 7) + G(2, 7)
HEAT OUT BY H2O

G(4+7)+G(4+7)+G(N+2,4)+DELT*(G(N+2.5)+(P(N+2,L)-TINIT(N+2)))

C(252+1,2)=C(252+1,2)+G(N+2,4)*DELT*(G(N+2.5)+(P(N+2,L)-TINIT(N+2)))

HEAT STORED IN CAPACITANCE

DUMMY=0

DO 25 N1=1,14

25 DUMMY=DUMMY+C(N+N1,1)+(P(N+N1,L)-TINIT(N+N1))

G(15+7)=G(5+7)+DUMMY=DUMMY

HEAT OUT VIA CONDUCTANCE TO STRUCTURE

DO 75 N1=1,12

75 N1=KEEP(N+N1)/1000

DO=N1-1000+NSRT-1

SUM=0

IF(NSRT.EQ.0) GO TO 65

DO 90 J=NSRT,NTRY

90 TEMP=P(N+N1,L)-P(NOW,L)

50 SUM=SUM+VAL(J)*TEMP*ICOUPL(J)

CONTINUE

MOD=KEEP(N+N1)/1000

MTRY=KEEP(N+N1)-NSRT*1000+NSRT+1

SUM=0

IF(NSRT.EQ.0) GO TO 60

10 TYP=P(N+N1,L)*4

DO 80 M=NSRT,NTRY

80 TEMP=P(NOW,L)*4

SUM=SUM+VAL(N)*TEMP*ICOUPL(M)

CONTINUE

85 CONTINUE

80 CONTINUE

75 CONTINUE

TCCUP=TCCUP+SUM+SUMR

TUTCUP=TUTCUP

TCCUP=0

G(16,7)=G(6,7)+TUTCUP*DELT

TUTCUP=0

TOTAL HEAT OUT

G(7,7)=G(4,7)+G(5,7)+G(16,7)

HEAT IN=HEAT OUT

G(8,7)=G(3,7)-G(7,7)

END OF COMPIIATION: NO DIAGNOSTICS.
SUBROUTINE RSTART(ICHECK)

<table>
<thead>
<tr>
<th>VARIABLE NAME</th>
<th>DESCRIPTION</th>
<th>UNITS</th>
</tr>
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<tbody>
<tr>
<td>I</td>
<td>NODE NUMBER AT WHICH TO START DU-LOOP FOR EACH SYSTEM</td>
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</tr>
<tr>
<td>ICHECK</td>
<td>FLAG SHOWING THAT RSTART HAS BEEN CALLED</td>
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</tr>
<tr>
<td>I</td>
<td>NODE NUMBER AT WHICH TO STOP DU-LOOP FOR EACH SYSTEM</td>
<td></td>
</tr>
<tr>
<td>IRST</td>
<td>FLAG FOR TYPE OF REINITIALIZATION</td>
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<tr>
<td></td>
<td>1=DEFINE NEW VALUE, 2=READ IN NEW VALUE</td>
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</tbody>
</table>

COMMON K, L, DELT, TIME, STOP, NNODES
COMMON P(300, 2), T(300, 2), C(300, 20)
COMMON DUM(100, 1, 0)
COMMON /TYPE/ /TMSUM(3), ARSNTM, FUDGE, SUMARY(20, 3)
COMMON /ARRAY/ G(300, 10), TINIT(300), /FLAG/ /ITER|

EQUIVALENCE (DUM(10, NTURBN))

EQUIVALENCE (DUM(14, IRST))

GO TO (2, 402), (1, 1)

REINITIALIZE ACTUATOR TEMPERATURES

2 CONTINUE
DO 102 M=1, 50
P(M, K)=560 *
P(M, L)=560 *
TINIT(M)=560 *
102 CONTINUE

REINITIALIZE THERMAL NODE TEMPERATURES

I=100
II=120
DO 302 N=1, NTURBN
DO 202 M=1, 111
P(M, K)=560 *
P(M, L)=560 *
TINIT(M)=560 *
202 CONTINUE
I=1+50
II=I+20
302 CONTINUE
RETURN

READ NEW INITIALIZATION TEMPS

402 DO 602 I=1, NNODES
READ(5, 502) NODE, P(NODE, 1), P(NODE, 2)
502 FORMAT(1, 5X, 2F10.0)
P(NODE, 1)= P(NODE, 1)+460 *
P(NODE, 2)= P(NODE, 2)+460 *
504-continue
RETURN

END
<table>
<thead>
<tr>
<th>Variable Name</th>
<th>Description</th>
<th>Units</th>
<th>Start Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>AEROK</td>
<td>ARRAY OF TITLES FOR ERROR CALCULATIONS</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>AMSNTM</td>
<td>LENGTH OF MISSION</td>
<td>HR</td>
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<tr>
<td>BIG</td>
<td>MAX VALUE DESIRED ON PLOT</td>
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<tr>
<td>DA</td>
<td>DELTA VALUE OF PARAMETER PER INCH</td>
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<tr>
<td>FUDGE</td>
<td>TIME FUDGE FOR LONG MISSION</td>
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<tr>
<td>IUG</td>
<td>ARRAY OF CONDUCTION/CONVECTION COUPLING NODES</td>
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</tr>
<tr>
<td>IDUM(8)</td>
<td>FLAG USED TO RESTRICT PRINTING DONE IN FIRST CALL TO PRINT</td>
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</tr>
<tr>
<td>IFLAG</td>
<td>SYSTEM CONFIGURATION CODE</td>
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<tr>
<td>IPD</td>
<td>SYSTEM CONFIGURATION MATRIX</td>
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<tr>
<td>IPLT</td>
<td>NODE NUMBER FOR PLOT DESIRED</td>
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<tr>
<td>IRADR</td>
<td>INITIAL DRUM ADDRESS FOR READING</td>
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<tr>
<td>IWRADR</td>
<td>INITIAL DRUM ADDRESS FOR WRITING</td>
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<tr>
<td>JGIG</td>
<td>ARRAY OF RADIATION COUPLING NODES</td>
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<tr>
<td>JPLT</td>
<td>TYPE OF PLOT DESIRED FOR IPLT</td>
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<tr>
<td>LMTRX</td>
<td>LOSS MANAGEMENT MATRIX</td>
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<tr>
<td>NSC</td>
<td>NUMBER OF NODE COUPLING CARDS</td>
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</tr>
<tr>
<td>NTR</td>
<td>NUMBER OF TRACES ON THIS PLOT</td>
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<tr>
<td>RVAL</td>
<td>ARRAY OF RADIATION COUPLING COEFFICIENTS</td>
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<tr>
<td>TIMSUM</td>
<td>TIMES FOR DIVISION OF ACCUMULATED CONSUMABLES VALUES PER PHASE IN SUMMARY TABLE</td>
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<tr>
<td>VAL</td>
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<td>WEE</td>
<td>MIN VALUE DESIRED ON PLOT</td>
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<tr>
<td>WORDS</td>
<td>ARRAY OF ALPHA CHARACTERS USED FOR GREETING</td>
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<tr>
<td>WORK</td>
<td>COUPLING COEFFICIENTS FOR NODES IN IWORK</td>
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<td>XI</td>
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<td>XE</td>
<td>ERROR VALUE (USED INTERNALLY)</td>
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<tr>
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<td>STARTING VALUE OF PARAMETER ON PLOT</td>
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<td>XMAX</td>
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<td>XMIN</td>
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<tr>
<td>YAXIS</td>
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INTEGER PLTSEW
DIMENSION IWORK(100,2), WORK(100,2), ICoupl(100)
DIMENSION WORDS(79), ZER0(7406)
COMMON K, L, DETL, TIME, TSTOP, NNOD3ES
COMMON PL(300,2), F(300,2), C(300,20)
COMMON DUM(100), IDUM(100)
COMMON /EXTRA/ ICoupl(300)
COMMON HYD/PFD(27,3), LMTRX(50,4), POWER(3), ISPDT(3), IFLAG, TFLw(3)
COMMON /ACT/HYD(3,50), NOUT(3,50), NACT, FLDW(50)
COMMON /TYME/TIMSUM(3), AMSNTM, FUDGE, SUMMARY(20,3)
COMMON /IPRT/ IPRT, ANAME(1200), IDIM(00), AERRR(9,2)
COMMON /LUMP2/ TITLE(12), D16(25), WE(25)
COMMON /PSTS/ NPLTS, IPLT(125), JPLT(125), PLTSW, TSTOP(5), XAXIS(5),
  YAXIS(5), NPLOP(15), NPLTS, NTR(25), IWRADR, IMDAHR
EQUIVALENCE (DELTOZ, DUM(11))
EQUIVALENCE (IDUM(35), IPFREQ)

K = PREVIOUS VALUE
L = PRESENT VALUE
NNODES = NO. OF NODES
TIME = START TIME INITIALLY, CURRENT TIME THEREAFTER
C

STOP = STOP TIME
DEL = TIME STEP
PRINT = PRINT AT THIS INCREMENT
T(J+1) = PLATE TEMPERATURE J = NODE \nPREVIOUS OR PRESENT

EQUATION [ZERO,K]
DATA WORDS/378HIP DIGITAECS DOKIT ECTOM SWECS PKEET EDRA
*I = 3 TO ENDGRAM PROGRAM PM SLID PROGRESSIFIC SECS PK ALL ENDGRAM PRESENT
*MS = OUTPUT CS PROS \nSIMULTANEOUS PKSANDUR

DO 24 I = 1,7406
24 I=KORK(I)=0
CALL CLICK(CLICK)
LOCK=CLICK*1000
LOCK=MODE(LOCK,7)+1
READ(I+1) TITLE
1 FORMAT(12A6)
WHITE(0,1) = (ROWS*LK;1),I=1;9;CLICK,TITLE
READ(I+3) NNODES,TIME,STOP,PRINT,NPLTS,NSC,MOREY,IDUM(19)
3 FORMAT(I5;5X;19D10.0;4/5)
READ(I+19) TPLS0,TSTP(I),AAXIS(I),YAXIS(I),NUPLOT(I)
9 FORMAT(I5;5X;39D10.0;1/0)
DUM(25)=TIME
READ(I+20) TPLS(I),TSTP(I),AAXIS(I),YAXIS(I),NUPLOT(I)
20 FORMAT(5F10.3)
IDUM(20) = NPLTS
IF(NSC+LT,1) GO TO 707
1000 NCON=0
NRAD=0
MAX=1
1010 DO 300 I = 1;NSC
READ(I+5;26) (WORK(I,J),J=1;2),(WORK(I,J),J=1;2),ICLPL(I)
26 FORMAT(I25;16D10.10+I) FLX+O;10X+F10.0;1/0)
90 I=WORK(I,1)
N=WORK(I,2)
IF (ABS(WORK(I,1);LT+1.E-25) GO TO 310
10 KEEP(NJ)=KEEP(NJ)+1
11 KEEP(NK)=KEEP(NK)+1
12 NCON=1+NCON
13 IF (ABS(WORK(I,2);LT+1.E-25) GO TO 300
14 KEEP(NJ)=KEEP(NJ)+1
15 KEEP(NK)=KEEP(NK)+1
16 MAX=MAX(MAX,NJ,NK)
17 JJ=1
18 JJ=1
19 DO 360 I = 1;MAX
IF (KEEP(I);EE+0) GO TO 370
20 MESS=KEEP(I)
21 KELP(I)=KEEP(I)+J=1000
22 M=0
23 DO 360 J=1;NSC
24 DIARY 2 of 5
IF (ABS(WORK(J,1)) .LT. 1.E-25) GO TO 350

DO J=1,N
  IF (I .NE. IWORK(J,M)) GO TO 340
  YY=MOD(M+2)*I
  JJJ=IWORK(J,NN)
  I(JJJ)=IWORK(J,1)
  IC(JJJ)=IC(J)
  JJ=JJ+1
  MM=MM+1
END

IF (MM+1 .LE. MESS) GO TO 370

CONTINUE

350 CONTINUE

IF (IKEEP(1) .EQ. 0) GO TO 360

MESS=IKEEP(1) .LT. LL+1000
MN=0
DO 380 J=1,NSC
  IF (ABS(WORK(J,2)) .LT. 1.E-25) GO TO 380
  DO M=1,2
    IF (I .NE. IWORK(J,M)) GO TO 390
    NN=MOD(M+2)*I
    JJJ=IWORK(J,NN)
    RV(JJJ)=IWORK(J,2)
    LL=LL+1
    MN=MN+1
  END
390 CONTINUE

CONTINUE

360 CONTINUE

IF (INCON .EQ. 0) GO TO 627

WRITE(*,727)

727 FORMAT(IOK,15X,18HCOP/Coupling / 15X,19MNODE HOOKED TO NODE

400 CONTINUE

DO 600 J=1,MAX
  IF (IKEEP(J) .EQ. 0) GO TO 600
  NSTRT=IKEEP(J)/1000
  NTRY=IKEEP(J)-NSTRT*1000-1
  WRITE(*,602) I,JBIG(NSTRT),VAL(NSTRT)

602 FORMAT((1X,5X,15X,15X,5X,1P2E15.6))

IF (INTRY .EQ. 0) GO TO 600

DO 610 J=1,NTRY
  WRITE(*,610)
  NTRY=NTRY-J

610 FORMAT(1X,5X,15X,5X,1P2E15.6))

600 CONTINUE

627 IF (INRAD .EQ. 0) GO TO 629

WRITE(*,627)

729 FORMAT(IOK,15X,12HRAD COUPLING / 15X,19MNODE HOOKED TO NODE / 1)

710 CONTINUE

DO 620 J=1,MAX
  IF (IKEEP(J) .EQ. 0) GO TO 620
  NSTRT=IKEEP(J)/1000
  NTRY=IKEEP(J)-NSTRT*1000-1
  WRITE(*,602) J,JBIG(NSTRT),RVAL(NSTRT)

620 CONTINUE

615 WRITE(*,603) J,JBIG(M),RVAL(M)

610 CONTINUE
627 CONTINUE

70 DO 126 I=1,100

80 DO 125 J=1,2

90 DO 126 J=1,2

126 WRITE(9,122) NNODES,DELT,TIME,TSTOP,FRINT

122 FORMAT(4X,1H4,1H,1H NODE PROBLEM / 5X,10DELT,7H T = ,F10.4,4H HRS

97 ! 5X, 9HSTART AT ;F10.4, 4H HRS / 5X, BMSTOP AT ;F10.4,4H HRS/

192 ! 5X, 9HPRINT AT ;F10.4, 4H HRS/

192 DO 10 I=1,NNODES

195 READ(5+I,5) NODE,MORE,(C(NODE,J),J=1,4),P(NODE,1),F(NODE,1),

200 ! (NAME(NODE,J),J=1,2)

201 DO 10 I=1,NNODES

202 ! (NAME(NODE,J),J=1,2)

203 ! (NAME(NODE,J),J=1,2)

4 FORMAT(4X,14.3H = ,2A5,6F15.3)

206 ! 5 (P(NODE,1) = P(NODE,1) + 460

207 ! (NAME(NODE,J),J=1,2)

208 IF (MORE,LT=1) GO TO 100

210 READ(5,5) (C(NODE,J),J=5,9)

213 ! (NAME(NODE,J),J=1,2)

215 ! (NAME(NODE,J),J=1,2)

100 CONTINUE

219 IF (NPLTS,LT=1) GO TO 102

220 IFREQ=(TSTOP-TIME)/DELT

221 IFREQ=IFREQ*99D

222 READ(15,7) NPLT(1),PLT(1),BIG(1),WEE(1),N;K(1),1=1,NPLTS

227 ! 7 (PLT(1),BIG(1),WEE(1),NTRT(1),1=1,NPLTS)

232 WRITE(6,8) NPLT(1),PLT(1),BIG(1),WEE(1),NTRT(1),1=1,NPLTS

233 ! 8 (PLT(1),BIG(1),WEE(1),NTRT(1),1=1,NPLTS)

234 CALL RINIT(INIAU,NNDS)

235 NADR= NADR

236 IINADR= IINADR

239 ! 102 CONTINUE

240 DO 490 IERROR=1,8

243 READ(15,11) ERROR(IERROR,J),J=1,2

11 FORMAT(2A6)

244 CONTINUE

247 DO 410 IFLAG=1,27

251 READ(15,12) IPDO(IFLAG,J),J=1,3

256 WRITE(6,12) IPDO(IFLAG,J),J=1,3

257 ! 12 (IPDO(IFLAG,J),J=1,3)

260 CONTINUE

269 DO 420 NSYSUP=1,NACT

279 READ(15,13) LMINTRX(1),1=1,4

221
241 *  **WHITE(6,13)(LMMTRX(NSYSUP,1),J=1,4)**
242 *  **FORMAT(4,15)**
243 *  **CONTINUE**
244 *  **READ(5,14)(SUMARY(I,J),J=1,3),I=1,3)**
245 *  **READ(5,15)(SUMARY(1,J),J=1,3),SUMARY(3,J),J=1,3)**
246 *  **FORMAT(3,F10.1)**
247 *  **FORMAT(2,F10.1)**
248 *  **DO 430 J=1,3**
249 *  **SUMARY(4,J)=SUMARY(1,J)+SUMARY(2,J)+SUMARY(3,J)**
250 *  **SUMARY(14,J)=SUMARY(11,J)+SUMARY(13,J)**
251 *  **CONTINUE**
252 *  **WHITE(6,2)(WORDS(LOCK,1),I=1,9),CLICK,TITLE**
253 *  **K=2**
254 *  **L=1**
255 *  **IPKNT=IPKNT+99999999/DELT**
256 *  **IF(IPKNT.LE.0)IPKNT=2**
257 *  **LCNT=IPKNT+1**
258 *  **TSTOP=TSTOP+DELT/TSTOP**
259 *  **I=I+1**
260 *  **IDUM(8)=I**
261 *  **DUM(16)=18.915**
262 *  **DUM(17)=28.013**
263 *  **DUM(18)=31.999**
264 *  **DUM(19)=44.339**
265 *  **DUM(21)=44.549**
266 *  **DUM(22)=44.853**
267 *  **DUM(23)=44.934**
268 *  **CALL PRINT**
269 *  **IDUM(9)=2**
270 *  **RETURN**
271 *  **ENDD

END OF COMPILATION: NO DIAGNOSTICS.
<table>
<thead>
<tr>
<th>VARIABLE NAME</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>AREA</td>
<td>AREA OF LINE SEGMENT</td>
</tr>
<tr>
<td>FLACUN</td>
<td>ACCUMULATOR OF FLOW RATE IN LINE FROM EACH ACTUATOR SERVICING IT</td>
</tr>
<tr>
<td>ID1G</td>
<td>NUMBER OF 16THS IN+ IN DIAMETER</td>
</tr>
<tr>
<td>ID</td>
<td>LINE INDEX OF LINE BEING SOLVED</td>
</tr>
<tr>
<td>LTH</td>
<td>LENGTH OF LINE SEGMENT IN</td>
</tr>
<tr>
<td>INTG</td>
<td>NUMBER OF LINE SEGMENTS IN LINE (ID)</td>
</tr>
<tr>
<td>INTG3</td>
<td>SECOND DIGIT OF LINE NUMBER, TELLS WHETHER LINE IS PRESSURE OR RETURN AND ON</td>
</tr>
<tr>
<td>JK</td>
<td>TOTAL NUMBER OF ACTUATORS SERVICING SYSTEM</td>
</tr>
<tr>
<td>KNOE</td>
<td>BOUNDARY NODE NUMBER</td>
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<tr>
<td>LGDF</td>
<td>FLAG TO DISTINGUISH BETWEEN FORWARD AND REVERSE FLOW IN SYSTEM</td>
</tr>
<tr>
<td>LTHEND</td>
<td>LENGTH OF LINE SEGMENT REMAINING AFTER EVEN DIVISION INTO STANDARD LENGTH SEGMENT</td>
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<tr>
<td>NAL</td>
<td>NUMBER OF LINES SERVICING ACTUATOR NN</td>
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<td>NACTU</td>
<td>ACTUATOR NUMBER SERVICING SYSTEM</td>
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<tr>
<td>QDOL</td>
<td>HEAT LOSS RATE IN LINE (ID)</td>
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<tr>
<td>T0EFF</td>
<td>EFFECTIVE BOUNDARY TEMPERATURE</td>
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<tr>
<td>T0</td>
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</tr>
<tr>
<td>U0</td>
<td>COMBINED HEAT TRANSFER COEFFICIENT</td>
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THIS S/R COMPUTES THE INLET AND OUTLET TEMP OF SYSTEM(S) PRESSURE LINES.
C  COMPUTE CONDUCTION UA/INCH
  K1 = IBIG(ID)
  K2 = KNODE(ID)
C  ASSUME *DI BTU/HR=DEGF/SUPPORT* SPACE = SUPPORT DENSITY PER IL SSP/Y+4-10
  AREA = 19634953*ILTH*K1
  WCP = 220. * FLOW(I)
  INNL = LTHM(ID)/ILTH
  LTHEND = LTHM(ID) - ILTH*INNL
  IF(LTHEND*GT+0) INNL = INNL + 1
  IF(INNL.LT.1) INNL = 1
  DO 4 INNL=1,INNL
  IF(INNL.LE.INN) GO TO 29
  IF(LTHEND.EQ+0) GO TO 29
  AREA = AREA + LTHEND*ILTH
  UACOND = UACOND + LTHEND/ILTH
29  CONTINUE
C  CALCULATE RADIATION UA/IN = HULTZMAN = 1.1897E-11(BTU/HR/IN**2/DEGF**4)
C  LINEARIZE TEMPERATURE TO CENTER POINT FORWARD DIFFERENCE PREDICTION
  T1 = TC
  T2 = P(K2,1)
  TEMPZ = T1 + T2
  UAADV = SHAPE*AREA*TEMPZ*1.1897E-11*EMISS
C  CALCULATE CONVECTION UA/IN = SHAPE*AREA*TEMPZ*1.1897E-11*EMISS
C  CHEMICAL ENGINEERING HANDBOOK: FOURTH EDITION; BASE FACTOR FOR AIR IS 15.
C  LINEARLY INTERPOLATED BETWEEN 0 AND 200 F. NOMOGRAM MAPPING FUNCTIONS ARE
C  WITHIN EYEBALL RESOLUTION FOR DT/DO FROM 10 TO 400 AND FOR PRESS FROM 14.7 TO
394.7 PSIA.
  TFLM = T1*F(K2,1)/2
  RATIO = T1*F(K2,1)/K1*16*
  IF(RATIO.GE.1.*E.-5) RATIO = 1.*E.-5
  YOTDO = 9.666*ALOG10(RATIO) - 3.227220*4+RATIO) * 6.947
  FLOG = +1227*YOTDO + 3655*YPM + 11765
  CFAC= 10.*FLOG
  BASE = 0.69 - 1.*TFLM - 460.* 1.*E.-4
  FILM = CFAC*BASE
  UACOND = FILM*AREA*144.
  UA = UACOND + UAADV + UAcDiv
  TBEF = 1.0/(UACOND+UARD+UAcDIV)+PI(K2,1) *UAcDiv*F(K2,1)/UA
  IF(T1.TE.TBEF) EXP(-1.A/UAC)+TBEF
  UDOTT(I) = QDOTT(I) + UA/60.*111*1.TU/2 + -TBEF
4  CONTINUE
C  IS*250.4 = CISS*250.4 + QDOTT(I)
IF(IICT+1,NEEPNNT) GO TO 300
  TEPINT(I) = TEPINT(I) - 460.0
  TEPOT(I) = TEPOT(I) - 460.0
  TBEF = TBEF + 460.0
  IF(IZNT+1.LEE.PNNT) WRITE(6,199) INNL, LINE, KNODE(ID), LTH(ID),
              TEPINT(I), TEPOT(I), TBEF, QDOTT(I), FLOW(I), NLCNT(NN)
  FORMAT(2X,13,1X,17.5X,15.2X,15.5F10.3,15)
199  TEPINT(I) = TEPINT(I) + 460.0
196  TEPOT(I) = TEPOT(I) + 460.0
197  TBEF = TBEF + 460.0
224
300 CONTINUE
122 CONTINUE
123 LASTID = 10
124 KEY2 = 10
125 CONTINUE
126 C CALCULATE ACTUATOR INLET AND OUTLET EQUILIBRIUM TEMPERATURES CONSIDERING TOTAL
127 C PRESSURE DROP AT ACTUATOR = NO ACTUATOR HEAT LOSS OR INERTIA.
128 FINNL = TEMPOT(LASTID)
129 CONTINUE
130 RETURN
131 END

END OF COMPILATION: NO DIAGNOSTICS.
SUBROUTINE THERM(15,N1,PAMB)

<table>
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<tr>
<th>VARIABLE NAME</th>
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<td>FLACUM</td>
<td>ACUMULATOR OF FLOW RATE IN LINE FROM</td>
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<td>EACH ACTUATOR SERVICING IT</td>
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<td>IO</td>
<td>LINE INDEX OF LINE BEING SOLVED</td>
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<tr>
<td>LLTH</td>
<td>LENGTH OF LINE SEGMENT IN</td>
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<td>NUMBER OF LINE SEGMENTS IN LINE(IO)</td>
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<td>SECOND DIGIT OF LINE NUMBER, TELLS WHETHER</td>
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<td>VA</td>
<td>COMBINED HEAT TRANSFER COEFFICIENT</td>
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</table>

THIS S/R COMPUTES THE INLET AND OUTLET TEMP OF SYSTEM(15) RETURN LINES STARTING AT THE ACTUATOR OUTLETS AND GOING TO THE WATER BOILER.

COMMON K,L,DEL,TIME,TSSTOP,NNODES
COMMON P(300,2),F(300,2),C(130,2)
COMMON DUM(100),IDUM(100)
COMMON/LINES/ LNUM(260),KNODE(260),LTH(260),I16G(260),FLACUM(260),
               TEMP1(260),TEMP2(260),LUDGF(260),SPACE(20,2),
               NODLIN(50,70),NLNTS(50),IDOTL(260),SCALE(EM125),
               TEMP(11.2),FLACUM(260),FLON(260),
COMMON/ACT/ NHYD(3,50),NHYOUT(3,50),HACT,FLAM(50),
COMMON/PRT/ IPRT,ICNT,NAME(300,2),AERRR(10,2)
COMMON/PRES/ SPH(13),DENS(31),PDRP(3)
COMMON/HYD/ IPD(27,3),LMMTRA(50,9),POWER(3),ISPU(3),ILAM
DATA ILTH/10/
CAPH=0,
YPF=1.42,ALOGIC(PAMB) = 1.45759
KYL1 = 15
JX = IDUM(10+15)
DO 1 10=1,JK
KYL2=0
KYL3 = 0
N= NHYD(15,NO)
IF(FLAM(30),LT/-1,E-4) GO TO 1
N=NLNTS(N)
DO 2 10=1,NAL
IO = NODLIN(NA,LL)
LINE = LNUM(15)
INTG = LINE/100
```
INTG2 = LINE/100
INTG2 = 10*INTG2
INTG3 = INTG1*INTG2
IF(LDGFL(ID) > 10.0) INTG3 = 2
IF (INTG3 > KEY1) GO TO 0 2
IF (KEY3.EQ.0) GO TO 100
FLACUM(ID) = FLACUM(ID) + FLW(NN)
GO TO 2
CONTINUE

IF (KEY2.EQ.0) TEMPINI(ID) = FLW(NN) + FLW(NN)
IF (FLACUM(ID) .LT. FLTOM(ID)) KEY3 = 10
IF (KEY2 .EQ.1) FLW(ID) = FLTOM(ID) * FLW(NN) * FLW(NN)
IF (KEY3 .NE. 0) GO TO 2
TEMPINI(ID) = FLOWT(ID)/FLOWL(ID)

IF (INR .EQ. 1) K1 = 1
IF (INR .EQ. 1) K2 = K1
VACOND = VACOND + 1
AREA = VACOND + LTH ENG/ILTH
AAA = 1861.96 + 15.0
INN = LTH(ID)/ILTH
LTHENG = LTH(ID) - ILTH * INN
IF (LTHENG .LT. 0) INN = INN + 1
IF (INR .LT. 1) INN = 1
DO 4 INN = 1, INN
4 IF (INR .LE. INN) GO TO 29
4 IF (LTHENG .EQ. 0) GO TO 29
4 AREA = AREA + LTHENG/ILTH
4 VACOND = VACOND + LTHENG/ILTH

CONTINUE

IF (INR .EQ. 1) TC = TEMPINI(ID)
IF (INR .EQ. 1) TC = TEMPINI(ID)
IF (INR .EQ. 1) TC = (TO - T1) / 2 + T0
92 IF (INR .EQ. 1) TC = T0
93 T1 = TC
94 T2 = P(K2, L)
95 TEMPZ = T1**3 + T1**2 * T2 + T1 * T2**2 + T2**3
96 VARAD = SHAPE * AREA * EM155 * TEMPZ + 1.897E-11
97 N10 = (TC - F(K2, L))/K1*1.1*
98 FILM = (TC - F(K2, L))/2*
99 IF (RATIO .EQ. 1E-5) RATIO = 1E-5
100 TTD0 = .9086 + ALUG(10) + (2.27/22 + 0.9*RATIO) - .9493
101 FLUG = .2227 + YD(TD0 + 3.655*YP)*.01765
102 CFACT = 1D**10**FLUG
103 BASE = 89*(FILM - 49.0) + 1E-4
104 FILM = CFACT*BASE
105 UACOND = FILM*AINT - 144*
106 UA = UACOND + VARAD + UACOND
107 WC = WC/20*D*FLOWL(ID)
108 TBEFF = (UACOND + VARAD) + PIK2, L) + UACOND + F(K2, L))/UA
109 U = T1 - TBEFF + EXP(-UA/0.1*0.1)*1.9 + TBEFF
110 UQOIL 10) + QOQTL(ID) + UA/60. + (U + T1)/2 + TBEFF
111 IF (INR .LE. INN) TEMPO(T) = 0
112 CONTINUE
113 C15 = 250.0*4 = C15 + 250.0*4 + QOQTL(ID)
114 IF (INR .EQ. 1) INN .EQ. 1") GO TO 300
115 TEMPINI(ID) = TEMPINI(ID) + 40*
116 TEMPOT(ID) = TEMPOT(ID) + 40*
```

```plaintext
TBEFF = TBEFF - 460.

IF (ICNT+1*EQ*1PRNT) WRITE(6,197) NN,L,KNODE(ID),LTH(ID),
197 FORMAT(2X,13*I1,1X,17.5A),15*2A,15.5F10.3,15)

TEMP(In(ID), TEMPOT(ID), TBEFF, QDOT(I), FLOWL(ID), NCH(I,NN))

TEMP(ID) = TEMP(ID) + 460.

TEMPOT(ID) = TEMPOT(ID) + 460.

CONTINUE = TBEFF = 460.

CONTINUE = CONTINUE = 10

LASTID = ID

CONTINUE = CONTINUE = 1

CAPHR = CAPHR + (P(NN,L) - P(NN,K)) - C(NN,1)/60.0/DLT

1 CONTINUE

C CAPHR = SYSTEM(IS) CAPACITANCE HEAT SUAK RATE (BTU/MIN)

C SYSTEM(IS) LINE HEAT LOSS RATE (BTU/MIN)

C SYSTEM(IS) TOTAL HEAT LOSS RATE

C SYSTEM(IS) ACTUATOR COUPLING HEAT LOSS RATE (BTU/MIN)

CONFIG = 1000 (IFLAG, IS)

C(1S+253,4) = FLOWL(LASTID) = (F(N1+6,L) - TEMPOT(LASTID)) / 3.9609*

200 FLOW L=LW, SYSTEM(IS), 12, 36H HEAT LOSS RATES (BTU/MIN) = LINES

3.9609*CAPPH = F(N1+6,L) - TEMPOT(LASTID)

RETURN

END
```
APPENDIX E. SAMPLE OUTPUT

The following are examples of the tabular data printout and plot output from TAHAP.
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Output from THERMP and THERMR
### Output from THERMP and THERMR (Cont.)

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### THERMP and THERMR Output

The table above shows the heat loss rates for System 2 and System 3, with corresponding coupling values. The total heat loss for System 2 is calculated as 21.503 BTU/min, while System 3 has a footing of 29,307 lines with a coupling value of 21.1, resulting in a total of 384.56 BTU/min.
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|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
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## Accumulated Consumables

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REFERENCE

1. FORTRAN Environmental Analysis Routines (FEAR) User's Guide,