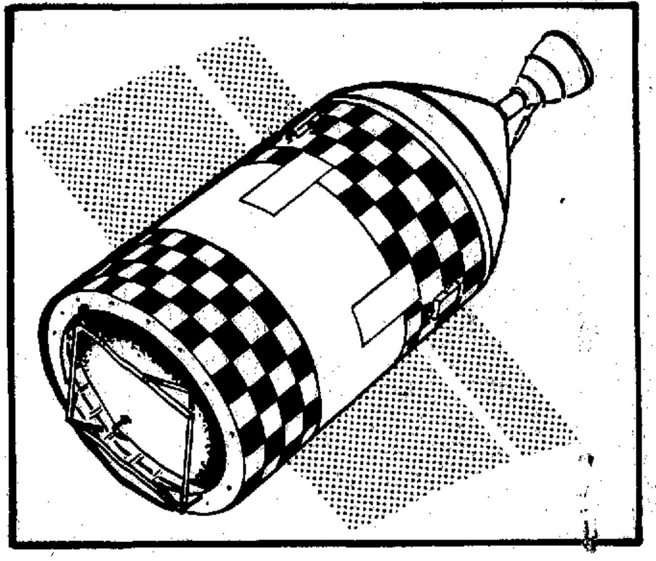
MCR-74-144
Contract NAS8-29670

25

Catalogue
User's Guide

April 1974

Space Tug Thermal Control Equipment Thermal Requirements, Characteristics, and Constraints



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MCR-74-144

SPACE TUG THERMAL CONTROL
EQUIPMENT THERMAL REQUIREMENTS
CHARACTERISTICS AND
CONSTRAINTS CATALOGUE
USERS GUIDE

April 1974

Prepared for

National Aeronautics and Space Administration
George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama 35812

by

Terry L. Ward
Program Manager

Martin Marietta Corporation
P. O. Box 179
Denver, Colorado 80201

FOREWORD

This document describes the user input instructions for the use of a component cataloging technique developed by Martin Marietta Corporation, Denver Division under Contract NAS 8-29670.

The program was developed in satisfaction of two cataloging tasks under the above contract titled Space Tug Thermal Control for the National Aeronautics and Space Administration's George C. Marshall Space Flight Center. Mr. Jack D. Loose of the Astronautics Laboratory, Propulsion and Thermal Branch served as the Technical Monitor.

The program provides the thermal designer of spacecraft a means of documenting components in a standardized manner and serves as a reference to obtain necessary thermal design information. The catalogue which was prepared during the study was published as a separate document, Reference 1.

Mr. Solomon H. Eichenbaum was the major contributor in the development of the catalogue.

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INTRODUCTION

The Space Tug Equipment Data Bank was developed under the Space Tug Thermal Control Study Contract NAS8-29670. This manual details the input instructions to the data bank, an explanation of the program and its output. The data bank was developed in satisfaction of two of the study tasks, the equipment thermal requirement catalog and the equipment characteristics and constraints catalog. The data bank contains 109 components within Space Tug Avionics system. Other systems were not included in the data bank due to the available information, however, with some program modification, other systems could be incorporated into the data bank program. The data bank was developed and checked out and is compatible with the Univac 1108, and the CDC 6500 operating systems.

The data contained within the data bank is general in content with emphasis on the component thermal design. The data is applicable to any spacecraft program where the components contained in the data bank can be applied in satisfaction of the system and subsystem requirements.

Section 1 - Inputing Equipment Catalogue

Space Tug Equipment Data Bank Input Procedure

A preprinted form for inputing raw data to the equipment catalog data bank was developed to enable an easy input method. The preprinted form was used with corresponding prepunched cards so that once the raw data was filled in on the data sheets it was submitted for key punch with the prepunched cards and the data was punched to the cards.

Table 1 shows the line and field length that corresponds to the raw data to be incorporated. The area is darkened to indicate the allocated space. Table 2 is a sample of a completed data sheet from the data bank.

The following are instructions to be followed in filling in the data sheets with input data. While following these instructions one should keep Table 1 in view for reference.

1) Starting with page 1, line 1, field 69 through 72, fill in the page number in chronological order. This corresponds to the chronological order of the components being incorporated into the data bank. The field allows component numbers from 1 through 9999 and is right hand justified (bbbl, b102 etc.).

2) Line 4, field 8 through 49 - fill in the system that component i is a part of e.g. AVIONICS SYSTEM, etc; input is left hand justified.

TABLE 1

SPACE TUG EQUIPMENT DATA BANK RAW DATA

NAME ____________________ PHONE EXT ____________ PAGE 1 OF 2

1 1 SPACE TUG EQUIPMENT DATA BANK RAW DATA PAGE [redacted]

2 THERMAL REQUIREMENTS, PHYSICAL CHARACTERISTICS, AND CØNSTRAINTS

3 --

4 [redacted]

6 ***********************************

7 [redacted]

8 DESIGN ØPERATING CASE TEMPERATURE [redacted] . TØ [redacted] . DEG. F

9 NØN-ØPERATING AND STØRAGE CASE TEMPERATURE [redacted] . TØ [redacted] . DEG. F

10 ACCEPTANCE TEST TEMPERATURE REQUIREMENTS [redacted] . TØ [redacted] . DEG. F

11 QUALIFICATIØN TEST TEMPERATURE REQUIREMENTS [redacted] . TØ [redacted] . DEG. F

12 PACKAGE SHAPE [redacted]

13 PACKAGE SIZE * LENGTH [redacted] . [redacted] * WIDTH [redacted] . [redacted] * HEIGHT [redacted] . [redacted] (INCHES)

14 CASE MATERIAL [redacted]

15 CASE WEIGHT [redacted] . [redacted] PØUNDS

16 TØTAL WEIGHT [redacted] . [redacted] PØUNDS

17 SURFACE PRØPERTIES ALPHA = 0. [redacted] * EMISSIVITY = 0. [redacted]

18 INPUT STEADY STATE PØWER [redacted] . WATTS ** [redacted]

19 [redacted] . [redacted] AT [redacted] . DEG, [redacted] . [redacted] AT [redacted] . DEG (WATTS AT DEG. FAHRENHEIT)

20 ØUTPUT PØWER [redacted] . [redacted] WATTS ** [redacted]

21 THERMAL DESIGN [redacted] * [redacted]

22 **

23 PHYSICAL CHARACTERISTICS AND CØNSTRAINTS REMARKS

24 NØN MISSIØN ØN-TIMES *PRELAUNCH [redacted] * ASCENT [redacted] * REENTRY [redacted]

25 MISSIØN ØN-TIMES * SHUT/TUG [redacted] * TUG/ØRBIT [redacted] * TUG/PAY [redacted]

26 [redacted]

TABLE 1 (CONCLUDED)

SPACE TUG EQUIPMENT DATA BANK RAW DATA

NAME ______________ PHONE EXT ________ PAGE 2 OF 2

	1–80
1	
2	
3	**
4	THE
5	
6	
7	THE DATA CØNTAINED HEREIN WAS ØBTAINED FRØM
8	PHONE - - EXTENSIØN
9	
10	
11	
12	
13	
14	
15	
16	
17	
18	
19	
20	
21	
22	
23	
24	
25	
26	END***

TABLE 2
SPACE TUG EQUIPMENT DATA BANK RAW DATA

NAME ______________ PHONE EXT ______________ PAGE 1 OF 2

```
1     SPACE TUG EQUIPMENT DATA BANK   RAW DATA                 PAGE 44
      THERMAL REQUIREMENTS, PHYSICAL CHARACTERISTICS, AND CØNSTRAINTS
 ----------------------------------------------------------------------
      AVIØNICS SYSTEM
      GUIDANCE NAVIGATION AND CONTROL SUBSYSTEM
     *****************************************************
    ST 7 OMA ATM STAR TRKR. BENDIX CORPORATION P/N-2125000-3 GIMBAL
      DESIGN ØPERATING CASE TEMPERATURE                -15. TØ 90. DEG. F
     .NØN-ØPERATING AND STØRAGE CASE TEMPERATURE       -40. TØ 130. DEG. F
      ACCEPTANCE TEST TEMPERATURE REQUIREMENTS           0. TØ 90. DEG. F
      QUALIFICATIØN TEST TEMPERATURE REQUIREMENTS        0. TØ 90. DEG. F
      PACKAGE SHAPE       RECTANGULAR
      PACKAGE SIZE * LENGTH 17.1 * WIDTH 12.6 * HEIGHT 22.0 (INCHES)
      CASE MATERIAL       ALUMINUM
      CASE WEIGHT            6.0   PØUNDS
      TØTAL WEIGHT          40.0   PØUNDS
      SURFACE PRØPERTIES      ALPHA = 0.250 * EMISSIVITY = 0.90
      INPUT STEADY STATE PØWER  8.6 WATTS ** THERE ARE 3 HEATERS
      20.0 AT -10.0DEG, 10. AT 5. DEG (WATTS AT DEG. FAHRENHEIT)
      ØUTPUT PØWER              0.0 WATTS **
      THERMAL DESIGN       PASSIVE * PASSIVE
      ******************************************************************
      PHYSICAL CHARACTERISTICS AND CØNSTRAINTS REMARKS
        NØN MISSIØN ØN-TIMES *PRELAUNCH OFF* ASCENT OFF* REENTRY OFF
        MISSIØN ØN-TIMES * SHUT/TUG OFF* TUG/ØRBIT INT* TUG/PAY INT
      THE OMA ATM STAR TRACKER IS A GIMBALLED UNIT THE ABOVE DIMENSIONS
      ARE EXTERIOR LIMITS SEE REF FOR MORE DETAIL DESCRIPTION. UNIT IS
      MARRIED TO ATM STAR TRACKER ELECTRONICS UNIT. UNIT HAS 3 INTERNAL
      HEATERS OF 10 WATTS EACH TWO OF THE HEATERS HAVE SET POINTS OF -23
      .3 TO -15.0 (-9.9 TO 5.0 DEG.F) AND THE THIRD HEATER HAS SET POINT
```

TABLE 2 (CONCLUDED)
SPACE TUG EQUIPMENT DATA BANK RAW DATA

NAME ______________ PHONE EXT ______________

OF -15.3 TO -6.7 DEG C (5.5 TO 22.5 DEG. F). UNIT IS THERMALLY ISO
LATED, IS PAINTED WHITE, AND HAS A SUPERINSULATION BLANKET COVERING
****
THE SKYLAB ATM OMA GIMBALLED STAR TRACKER IS DESIGN AND BUILT
BY THE BENDIX CORPORATION NAVIGATION AND CONTROL DIVISION.
TETERBORO, NEW JERSEY 07608.
THE DATA CONTAINED HEREIN WAS OBTAINED FROM
MR. JIM TONGE PHONE 201-288-2000 EXTENSION 6111
THE APOLLO TELESCOPE MOUNT (ATM) STAR TRACKER SYSTEM CONSIST OF
THE OPTICAL MECHANICAL ASSEMBLY (OMA) AND A STAR TRACKER ELECTRO-
NICS (STE). THE UNIT WAS DESIGN AND BUILT FOR NASA-MARSHALL SPACE
FLIGHT CENTER AND IS AT PRESENT ON BOARD THE SKYLAB. THE OMA CON-
SISTS OF A REFRACTIVE TELESCOPE MOUNTED IN A DOUBLE GIMBAL SUSPEN-
SION. EACH GIMBAL IS DRIVEN BY A DIRECT DRIVE D.C. TORQUER. WITH
GIMBAL RATE CONTROL PROVIDED BY D.C. TACHOMETERS. THE TELESCOPE
HAS A SCANNED FIELD-OF-VIEW OF 1 DEGREE SQUARE AND AN INSTANTANE-
OUS FIELD-OF-VIEW OF A 10 ARC MINUTE SQUARE. A COMBINATION SUN
AND EARTH ALBEDO SHADE IS PROVIDED WHICH ALLOWS TRACKING OF STARS
WITHIN 45 DEGREES OF THE SUN AND 5 DEGREES OF EARTH. THE STAR
TRACKER ELECTRONICS PROVIDES THE 28 VDC POWER SUPPLY, SERVO AMPLI-
FIERS, DIGITAL LOGIC UNIT, ENCODER PROCESSING ELECTRONICS, TELE-
METRY AND OTHER FUNCTIONS. THE ATM STAR TRACKER IS CAPABLE OF 3
MODES OF OPERATION, MANUAL, SEARCH, AND TRACK.
REF. OPTICAL STELLAR PLANET AND SOLAR TRACKING SENSING DEVICES BY
THE BENDIX CORP., NAVIGATION AND CONTROL DIVISION. APRIL 1973.
END***

3) Line 5, field 8 through 49 - fill in the subsystem that component i is part of e.g. DATA MANAGEMENT, etc; input is left hand justified.

4) Line 7, field 3 through 6 - fill in the component identifier (see Appendix I). Appendix I lists the available component names and their corresponding identifiers. These equipment identifiers are right hand justified. Note: if the identifier is mispunched in columns 3 through 6 or not included in appropriate allocated space, the program will stop at that component and will print an output message indicating "xxxx is not a defined equipment item." Section 3.0 discusses modifying the program to add additional equipment identifiers for component names not included in program list.

5) Line 7, field 7 through 9 - fill in the numerical order of component i, subject space is right hand justified, and available code is from 1 through 999 per component i e.g. IMU bb3 or COMP b29, etc.

6) Line 7, field 11 through 28 - fill in the component name or title e.g. SKN-2400 IMU etc. Title is left hand justified.

7) Line 7, field 31 through 48 - fill in if available, component i manufacturer(part number)e.g. SINGER COMPANY etc. Variable is left hand justified.

8) Line 7, field 51 through 72 - fill in if available, component i manufacturer part number e.g. P/N-bPD9450027-005; item is left hand justified. Note: not all components have manufacturer part number and if item is not included, no problem occurs in the program.

9) Lines 8, 9, 10 and 11, field 54 through 56 - fill in the minimum temperature value per each of the specified items. Temperature is in degrees F to the nearest integer, range is from -99 to 999°F. Note: do not include plus sign if temperature has a positive value.

10) Lines 8, 9, 10 and 11, field 62 through 64 - fill in the maximum temperature value per each of the specified items. Temperature as indicated is in degrees F to the nearest integer, range of the program is from -99 to 999°F and is right hand justified.

11) Line 12, field 26 through 42 - fill in component i package shape. There are 3 acceptable shapes in the program CYLINDRICAL RECTANGULAR or SPHERICAL. The first 4 letters in each case CYLI, RECT and SPHE are used to identify the package shape. The program will accept the full package shape name or just the first 4 letters as long as the variable is left hand justified, e.g. CYLIbbbbb or CYLINDRICAL. Note: to add other package shapes to the program will require some additional program modifications.

12) Line 13, field 29 through 33 - fill in the rectangle or cylinder length in inches to the nearest tenth of an inch. If package is a sphere, leave field blank.

Field 43 through 47 - fill in for rectangular package the width, for a cylindrical or spherical package - fill in the radius to the nearest tenth of an inch.

Field 58 through 62 - fill in only for a rectangular package the height in inches to the nearest tenth of an inch. Note: for cylindrical and spherical packages this field is left blank. All three dimensions are right hand justified.

13) Line 14, field 26 through 42, fill in the case material. The program accepts only 5 materials with the first 4 letters of each being the identifying flag for the material. The variables are ALUMINUM, STAINLESS STEEL, MAGNESIUM, BERYLLIUM AND EPOXY. The addition of other materials will require program modifications. The above variables are left hand justified.

14) Lines 15 and 16, field 28 through 33 - fill in the corresponding weights in pounds to the nearest tenth of a pound, case weight on line 15 and the total weight on line 16 as indicated on data sheet. Note: items are right hand justified.

15) Line 17, field 42 through 44 - fill in component *i* case solar absorbtivity. Variable is left hand justified, e.g. .900.

Field 64 through 66 - fill in component i case surface emissivity. Variable is left hand justified, e.g. .900.

16) Line 18, field 33 through 37 - fill in component i input steady state power (or average power) dissipated, in watts to the nearest 10th of a watt.

Line 18, field 47 through 72 - fill in comments relative to variable power, e.g. 28 VDC power source or HAS VARIABLE HEATER POWER. Note: if comments are placed in this field, data must be placed on line 19 to indicate what the control power is, and if no control or variable power is needed enter a zero on line 19.

17) Line 19, field 7 through 11 - fill in component maximum control power in watts to nearest tenth of a watt, and in field 16 through 18 - fill in the corresponding minimum temperature (in degrees F) for the above control power. These variables are right hand justified.

Line 19, field 26 through 30 - fill in the component i minimum control power in watts to the nearest 10th of a watt, and in field 35 through 37 - fill in the corresponding maximum temperature (in degrees F) for the above control power. (Note: If there is no control power for component i leave line 19 blank, unless line 18 column 47 through 72 has a comment, which will require the control power to be zeroed out. In addition note that data can be inputted to represent watts load per watts power etc, as long as the input data is within the above prescribed field length, and unit is a battery or fuel cell.

18) Line 20, field 33 through 37 - fill in component i output power in watts to the nearest 10th of a watt. For most components this is usually zero.

Field 47 through 72 - comment concerning output power may be added.

19) Line 21, field 32 through 38 - fill in component i thermal design for ground operation active or passive. Field 45 through 51 - fill in component i thermal design for flight operation active or passive. Note: above variables are left hand justified.

20) Line 24, fields 41 through 43, 53 through 55 and 66 through 68 - fill in the non-mission on time requirement for component i for the three indicated time periods. No requirement of the component to be on indicate OFF, for component requirement to be on during above periods indicate YES.

21) Line 25, field 37 through 39, 52 through 54 and 65 through 67. Fill in component i mission on-time requirements for the 3 indicated time intervals. The options available are ON for continuously on, OFF for off requirement and INT for intermittent. Note: variables are left hand justified, e.g. OFF, INT and ON.

22) Lines 26 through 30, field 7 through 72, and page 2, line 1 and 2, field 7 through 72. The 7 lines are available for a narrative description of component i with emphasis on the unit physical characteristics and constraints and a more detail description of the thermal design and constraints, e.g. see Table 2 sample form.

23) Page 2, line 4, field 14 through 72 and lines 5 and 6, field 7 through 72. The available space is to be used to list component i title, manufacturer and address. See Table 2 sample form.

24) Page 2, line 8 field 7 through 38 - fill in the name of the individual that supplied the information on component i, usually it is the manufacturer personnel but may be other individuals with knowledge of the particular component.

25) Line 8, field 46 through 57 - fill in the area code and telephone of the individual that supplied the information on component i. Field 69 through 72 - fill in the individual extension number.

26) Page 2, lines 9 through 25, field 7 through 72. This allocated space of 17 lines is provided for general narrative information and detail description of the component. Reference to any printed material may also be made here. See Table 2 for sample. Note: if component i has control power included in

page 1, line 19, then the general description on page 2 must be reduced by one line to enable the data to be on one printed sheet.

27) Having supplied the various input data the following option card is required after the last data card separated by an end of record card. Format for the card is as follows: Raw starting in column 1 - gives the raw data output; final starting in column 11, gives the final data output; Thereq starting in column 21 gives the Thermal Requirement Catalog and Char starting in column 31 gives the characteristics and constrains catalog. Note all or any of the four routines can be called as per user's need.

28) Control Cards - See Section 2.7 for deck setup and control card requirements.

Section 2 - Program Description

2.1 Introduction

The Space Tug catalogue program is a Fortran 4 computer program consisting of 5 major subroutines. The subroutines are Page, RAW, Final, Thereq and CHAR, in addition there are 3 minor subroutines that are part of CHAR subroutines and they are Convrt, Sink and Timcon. Figure 1 presents a block diagram of the program.

2.2 Page Subroutine

This subroutine modifies the page numbers from the data bank for both the printed raw data into a consistent and ordered set of pages. There should be no modifications made in this part of the program.

2.3 Raw Subroutine

Subroutine RAW provides the user a means of listing the information contained within the data bank for checkout and verification purposes. The main reason for including the routine was to enable the user to get a listing of the data in the event that off line listing devices are not available. The routine is called after subroutine Page is called. Hence, the only change in the data is that the page numbers have been ordered.

2.4 Final Subroutine

Subroutine final takes the input data and converts it to international units for output in a similar format as the

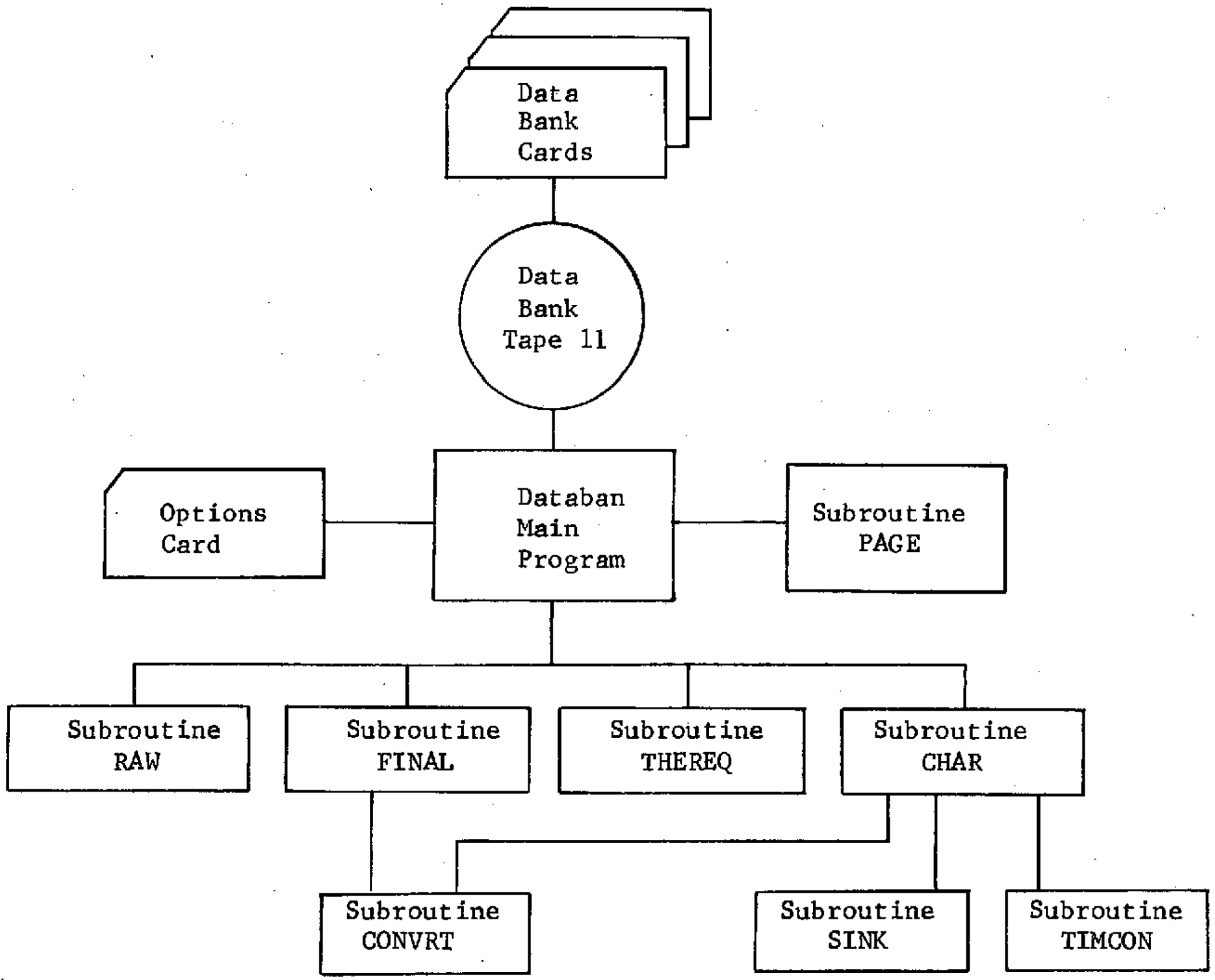

FIGURE 1 - DATA BANK FLOW CHART

raw data, with the English system of units printed in parenthesis. A sample of the Space Tug Equipment Data Bank Final data is shown in Table 3. The subroutine calls on subroutine CONVERT to do the actual temperature conversion from Fahrenheit to Kelvin. Subroutine Final calculates the package surface area and volume and converts the dimension to the international system of units.

2.5 Thereq Subroutine

Subroutine Thereq is the section of the program that builds the equipment thermal requirements catalogue, a sample of this catalogue is shown in Table 4. The subroutine generates a table of all components in which the following variables are indicated: thermal design, ground and orbital (active or passive), power requirements in watts, minimum and maximum mission phase thermal requirement and temperature limits in degrees Kelvin (Fahrenheit) minimum and maximum. The last item correlate on and off mission requirements with temperature range.

The program uses the following equation to calculate minimum and maximum power usage for Q_{min} = SSP + CPC - OP

for Q_{max} = SSP + CPH - OP

The minimum power is equal to steady state power (SSP) + minimum control power (CPC) - output power (OP). The maximum power is equal to steady state power (SSP) + maximum control power (CPH) - output power (OP).

Table 3

AVIONICS SYSTEM
GUIDANCE NAVIGATION AND CONTROL SUBSYSTEM

****

ST 7 OMA ATM STAR TRKR. BENDIX CORPORATION P/N-2125000-3 GIMBAL

DESIGN OPERATING CASE TEMPERATURE	247 TO 305 DEG. K	(-15 TO 90 DEG. F)
NON-OPERATING AND STORAGE CASE TEMPERATURE	233 TO 328 DEG. K	(-40 TO 130 DEG. F)
ACCEPTANCE TEST TEMPERATURE REQUIREMENTS	255 TO 305 DEG. K	(0 TO 90 DEG. F)
QUALIFICATION TEST TEMPERATURE REQUIREMENTS	255 TO 305 DEG. K	(0 TO 90 DEG. F)

PACKAGE SHAPE RECTANGULAR
PACKAGE SIZE * LENGTH 43.4 * WIDTH 32.0 * HEIGHT 55.9 CENTIMETERS
LENGTH 17.1 * WIDTH 12.6 * HEIGHT 22.0 INCHES
PACKAGE AREA 11211.1 SQ. CENTIMETERS * 1737.7 SQ. INCHES
PACKAGE VOLUME 77675.6 CU. CENTIMETERS * 4740.1 CU. INCHES
CASE MATERIAL ALUMINUM
CASE WEIGHT 2.7 KILOGRAMS * 6.0 POUNDS
TOTAL WEIGHT 18.1 KILOGRAMS * 40.0 POUNDS
SURFACE PROPERTIES ALPHA = 0.250 * EMISSIVITY = 0.90
INPUT STEADY STATE POWER 8.6 WATTS ** THE ARE 3 HEATERS
10.0 AT 258 DEG, 20.0 AT 261 DEG (WATTS AT DEG. KELVIN)
10.0 AT 5 DEG, 20.0 AT 10 DEG (WATTS AT DEG. FAHRENHEIT)
OUTPUT POWER 0.0 WATTS **
THERMAL DESIGN PASSIVE * PASSIVE

****

PHYSICAL CHARACTERISTICS AND CONSTRAINTS REMARKS
NON MISSION ON-TIMES *PRELAUNCH OFF* ASCENT OFF* REENTRY OFF
MISSION ON-TIMES * SHUT/TUG OFF* TUG/ORBIT INT* TUG/PAY INT
THE OMA ATM STAR TRACKER IS A GIMBALLED UNIT. THE ABOVE DIMENSIONS ARE EXTERIOR LIMITS SEE REF FOR MORE DETAIL DESCRIPTION. UNIT IS MARRIED TO ATM STAR TRACKER ELECTRONICS UNIT. UNIT HAS 3 INTERNAL HEATERS OF 10 WATTS EACH TWO OF THE HEATERS HAVE SET POINTS OF -23 .3 TO -15.0 (-9.9 TO 5.0 DEG.F) AND THE THIRD HEATER HAS SET POIN OF -15.3 TO -6.7 DEG C (5.5 TO 22.5 DEG.F). UNIT IS THERMALLY ISO-LATED, PAINTED WHITE, AND HAS A SUPERINSULATION BLANKET COVERING

****

THE SKYLAB ATM OMA GIMBALLED STAR TRACKER IS DESIGN AND BUILT BY THE BENDIX CORPORATION NAVIGATION AND CONTROL DIVISION TETERBORO, NEW JERSEY 07608.
THE DATA CONTAINED HEREIN WAS OBTAINED FROM
MR. JIM TONGE PHONE 201-288-2000 EXTENSION 6111
THE APOLLO TELESCOPE MOUNT (ATM) STAR TRACKER SYSTEM CONSISTS OF THE OPTICAL MECHANICAL ASSEMBLY (OMA) AND A STAR TRACKER ELECTRO-NICS (STE). THE OMA CONSISTS OF A REFRACTIVE TELESCOPE MOUNTED IN A DOUBLE GIMBAL SUSPENSION. EACH GIMBAL IS DRIVEN BY A DIRECT DRIVE D.C. TORQUER, WITH GIMBAL RATE CONTROL PROVIDED BY D.C. TACH OMETERS. THE TELESCOPE HAS A SCANNED FIELD-OF-VIEW OF 1 DEG SQUARE AND AN INSTANTANEOUS FIELD-OF-VIEW OF 10 ARC MINUTE SQUARE. A COM-BINATION SUN AND EARTH ALBEDO SHADE IS PROVIDED ALLOWING TRACKING OF STARS WITHIN 45 DEG OF THE SUN AND 5 DEG OF THE EARTH. THE STAR TRACKER ELECTRONICS, SEE STE 1, PROVIDES OTHER FUNCTIONS IN SUPPORT OF THE OMA. THE ATM STAR TRACKER IS CAPABLE OF 3 MODES OF OPERATION, MANUAL, SEARCH, AND TRACK.

REF. OPTICAL STELLAR PLANET AND SOLAR TRACKING SENSING DEVICES BY THE BENDIX CORP. NAVIGATION AND CONTROL DIVISION. APRIL 1973.

TABLE 4

EQUIPMENT THERMAL REQUIREMENTS CATALOGUE

GUIDANCE NAVIGATION AND CONTROL SUBSYSTEM

EQUIPMENT ITEM STAR TRACKERS

REF. NO.	DESCRIPTION AND MANUFACTURE	THERMAL DESIGN GROUND/ ORBITAL	POWER WATTS MIN/ MAX	MISSION PHASE THERMAL REQUIREMENTS AND TEMPERATURE LIMITS DEGREES KELVIN / (FAHRENHEIT) - MIN / MAX						REMARKS
				PRELAUNCH	SHUTTLE CARRY	MANEUVERS SHUTTLE TUG	MANEUVERS TUG ORBITAL	PAYLOAD TUG	REENTRY AND LANDING	
ST 1	CT-401 SENSOR BBRC	PASSIVE PASSIVE	5/ 5	OFF 243/333 (-22/140)	OFF 243/333 (-22/140)	OFF 243/333 (-22/140)	ON 243/333 (-22/ 0)	ON 243/333 (-22/140)	OFF 243/333 (-22/140)	ON DURING PRELAUNCH FOR CHECKOUT
ST 2	STAR TRACKER HONEYWELL	PASSIVE PASSIVE	3/ 3	OFF 255/302 (0/ 85)	OFF 255/302 (0/ 85)	OFF 255/302 (0/ 85)	INT 255/ 50 (-22/ 50)	INT 255/283 (0/ 50)	OFF 255/302 (0/ 85)	ON DURING PRELAUNCH FOR CHECKOUT
ST 3	MMOS ITT GILFILLAN	PASSIVE PASSIVE	20/ 20	YES 293/323 (68/122)	OFF 288/323 (60/122)	OFF 288/323 (60/122)	ON 293/323 (68/122)	ON 293/323 (68/122)	OFF 288/323 (60/122)	ON DURING PRELAUNCH FOR CHECKOUT
ST 4	569B STAR TRACKER EMR PHOTOELECTRIC	PASSIVE PASSIVE	3/ 3	OFF 218/348 (-67/167)	OFF 218/348 (-67/167)	OFF 218/348 (-67/167)	INT 218/113 (68/113)	INT 218/318 (-67/113)	OFF 218/348 (-67/167)	ON DURING PRELAUNCH FOR CHECKOUT
ST 5	574 STAR CAMERA EMR PHOTOELECTRIC	PASSIVE PASSIVE	4/ 4	OFF 218/343 (-67/158)	OFF 218/343 (-67/158)	OFF 218/343 (-67/158)	INT 218/104 (68/104)	INT 218/313 (-67/104)	OFF 218/343 (-67/158)	ON DURING PRELAUNCH FOR CHECKOUT
ST 6	OAO STAR TRACKER BENDIX CORPORATION	PASSIVE PASSIVE	6/ 6	OFF 238/327 (-30/130)	OFF 238/327 (-30/130)	INT 238/310 (-30/100)	INT 238/100 (68/100)	INT 238/310 (-30/100)	OFF 238/327 (-30/130)	ON DURING PRELAUNCH FOR CHECKOUT
ST 7	OMA ATM STAR TRKR. BENDIX CORPORATION	PASSIVE PASSIVE	18/ 28	OFF 233/327 (-40/130)	OFF 233/327 (-40/130)	OFF 233/327 (-40/130)	INT 233/ 90 (68/ 90)	INT 233/305 (-40/ 90)	OFF 233/327 (-40/130)	ON DURING PRELAUNCH FOR CHECKOUT
ST 8	KS-199 STAR TRKR KOLLSMAN INSTR.	PASSIVE PASSIVE	8/ 18	OFF 272/310 (30/100)	OFF 272/310 (30/100)	OFF 272/310 (30/100)	INT 272/ 70 (68/ 70)	IN 272/310 (30/100)	OFF 272/310 (30/100)	ON DURING PRELAUNCH FOR CHECKOUT

The minimum and maximum power levels correspond to the temperatures associated with the variable power and temperature data derived from card 19. The temperature data listed under each mission phase is derived from the design operating case temperature and non-operating and storage case temperature data derived from cards 8 and 9 depending upon whether or not the component is on or off respectively.

2.6 Char Subroutine

Subroutine CHAR is used in building the equipment physical characteristics and constraints catalogue, a sample of this catalogue is shown in Table 5. The program builds a table on all the components in which the following variables are included: component i, its manufacturer and Remarks, weight, package shape, surface area, volume, case solar absorbtivity and emissivity, minimum and maximum power. The unit power density in watts per unit area (M^2 and ft^2) and time constant in hours for maximum and minimum power are calculated. The adiabatic rise rate minimum and maximum in degrees K/hr (^oF/hr) are also presented. The unit thermal mass in W-hr/K (BTU/F) and the allowable sink temperature for both design and qual maximum and minimum and the operation mode are presented.

The Char subroutine uses subroutine Convrt, Sink and Timcon to perform some of the calculations. CONVRT subroutine is used to convert degrees Fahrenheit to degrees Kelvin. SINK subroutine

TABLE 5

GUIDANCE NAVIGATION AND CONTROL SUBSYSTEM

EQUIPMENT ITEM STAR TRACKERS

REF. NO.	DESCRIPTION MANUFACTURER AND REMARKS	WEIGHT KG (LBS)	PACKAGE SHAPE	SURFACE AREA SQUARE CM (FT)	VOLUME CUBIC CM (FT)	RAD. ALPHA/ EMISS	POWER WATTS MIN/ MAX	POWER DENSITY Q/A W/ M2 (W/FT2)	TIME CONST. HOURS MIN MAX	ADIABATIC RISE RATE DEG K/HR DEG F/HR MIN	MAX	THERMAL MASS W-HR/K BTU/F	ALLOWABLE SINK TEMP. DEG K/(F) DESIGN MIN	DESIGN MAX	QUAL MIN	QUAL MAX	OPERATION MODE
ST 6	OAO STAR TRACKER	7.3	RECT	2877	9832	.70/	6/	20/ 20	1.00	1	1	5.3	236	307	236	307	INT
	BENDIX CORPORATION	(15.0)		(3.1)	(.35)	.85	6	(1/ 1)	1.00	2	2	2.6	-33	93	-33	93	

THE OAO-IV STRAPDOWN STAR TRACKER HAS A PASSIVE THERMAL CONTROL HEAT IS REJECTED BY CONDUCTION TO A RADIATION SHIELD HAVING A PERMISSIBLE TEMPERATURE EXCURSION OF -29 TO 38 DEG.C(-20 TO 100 DEG F). NO HEATERS ARE REQUIRED WITHIN THIS RANGE. UNIT IS HARD MOUNTED TO VEHICLE MOUNTING FLANGE. UNIT REQUIRE CLEAR UNOBSTRACTED VIEW TO OPERATE PROPERLY

REF. NO.	DESCRIPTION MANUFACTURER AND REMARKS	WEIGHT KG (LBS)	PACKAGE SHAPE	SURFACE AREA SQUARE CM (FT)	VOLUME CUBIC CM (FT)	RAD. ALPHA/ EMISS	POWER WATTS MIN/ MAX	POWER DENSITY Q/A W/ M2 (W/FT2)	TIME CONST. HOURS MIN MAX	ADIABATIC RISE RATE DEG K/HR DEG F/HR MIN	MAX	THERMAL MASS W-HR/K BTU/F	ALLOWABLE SINK TEMP. DEG K/(F) DESIGN MIN	DESIGN MAX	QUAL MIN	QUAL MAX	OPERATION MODE
ST 7	OMA ATM STAR TRKR.	18.1	RECT	11211	77677	.25/	18/	16/ 25	.62	1	2	12.9	236	302	247	302	INT
	BENDIX CORPORATION	(40.0)		(12.1)	(2.74)	.90	28	(1/ 2)	.61	2	4	6.8	-30	84	-14	84	

THE OMA ATM STAR TRACKER IS A GIMBALLED UNIT. THE ABOVE DIMENSIONS ARE EXTERIOR LIMITS SEE REF FOR MORE DETAIL DESCRIPTION. UNIT IS MARRIED TO ATM STAR TRACKER ELECTRONICS UNIT. UNIT HAS 3 INTERNAL HEATERS OF 10 WATTS EACH TWO OF THE HEATERS HAVE SET POINTS OF -23.3 TO -15.0 (-9.9 TO 5.0 DEG.F) AND THE THIRD HEATER HAS SET POIN OF -15.3 TO -6.7 DEG C (5.5 TO 22.5 DEG.F). UNIT IS THERMALLY ISOLATED, PAINTED WHITE, AND HAS A SUPERINSULATION BLANKET COVERING.

REF. NO.	DESCRIPTION MANUFACTURER AND REMARKS	WEIGHT KG (LBS)	PACKAGE SHAPE	SURFACE AREA SQUARE CM (FT)	VOLUME CUBIC CM (FT)	RAD. ALPHA/ EMISS	POWER WATTS MIN/ MAX	POWER DENSITY Q/A W/ M2 (W/FT2)	TIME CONST. HOURS MIN MAX	ADIABATIC RISE RATE DEG K/HR DEG F/HR MIN	MAX	THERMAL MASS W-HR/K BTU/F	ALLOWABLE SINK TEMP. DEG K/(F) DESIGN MIN	DESIGN MAX	QUAL MIN	QUAL MAX	OPERATION MODE
ST 8	KS-199 STAR TRKR	9.1	RECT	4842	22184	.20/	8/	17/ 38	.43	3	6	3.0	247	290	226	307	INT
	KOLLSMAN INSTR.	(20.0)		(5.2)	(.78)	.75	18	(1/ 3)	.42	5	11	1.6	-14	62	-51	93	

THE KS-199 STAR TRACKER WAS BUILT FOR THE MOL PROGRAM. ONE ENGINEERING MODEL WAS BUILT AND FUNCTIONAL TESTED. THE GIMBAL SENSOR IS COUPLED TO AN ELECTRONIC UNIT. THE TRACKER HAS INTERNAL HEATERS TOTALING 10 WATTS AND ARE SUED FOR FAST WARM UP WHEN UNIT IS BELOW -11.8 DEG C(10 DEG. F). THE UNIT THERMAL DESIGN IS PASSIVE WITH UNIT THERMALLY ISOLATED FROM MOUNTING, AND COVERED BY SUPER-INSULATION BLANKET TO MAINTAIN PROPER OPERATING TEMPERATURE.

calculates component allowable sink temperatures for both the design and qual base temperature levels using minimum and maximum temperature and power values. If the sink calculation determines that 100% of the dissipated heat cannot be radiated at the design and qual maximum case temperatures, a message is printed indicating the quantity of heat which must be conducted way at the above temperature levels assuming an absolute zero temperature radiation sink environment. TIMCON subroutine calculates the component time constant in hours using both minimum and maximum power values. The time constant is defined as the time required to achieve 67 percent of the delta temperature defined by the design operating temperature from room ambient temperature.

2.7 Control Cards and Deck Setup

The Data Bank Program was developed on the CDC 6500 SCOPE 3.4 system and was modified for use on the 1108 EXEC 8.

1108 Input Instructions System

Figure 2 presents the deck setup required for running on the 1108 system. The deck as delivered is complete except for the first card shown a run card, and a charge card. The remainder of the deck was setup per Figure 2. Appendix 2 contains a listing of the control cards and Fortran IV program. Further, input instructions may be obtained by contacting the appropriate computer lab personnel at MSFC.

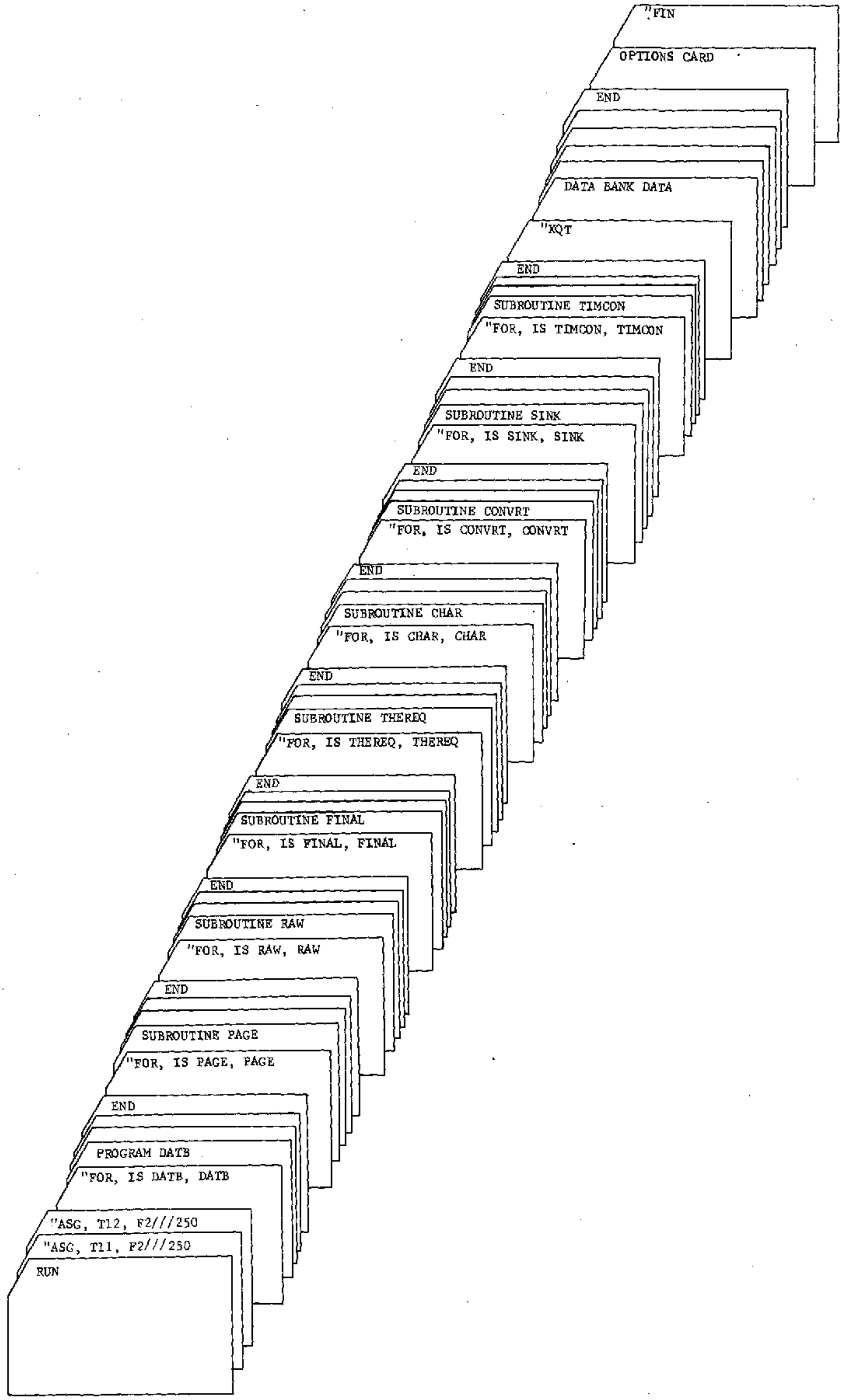

FIGURE 2 - UNIVAC 1108 DECK ARRANGEMENT

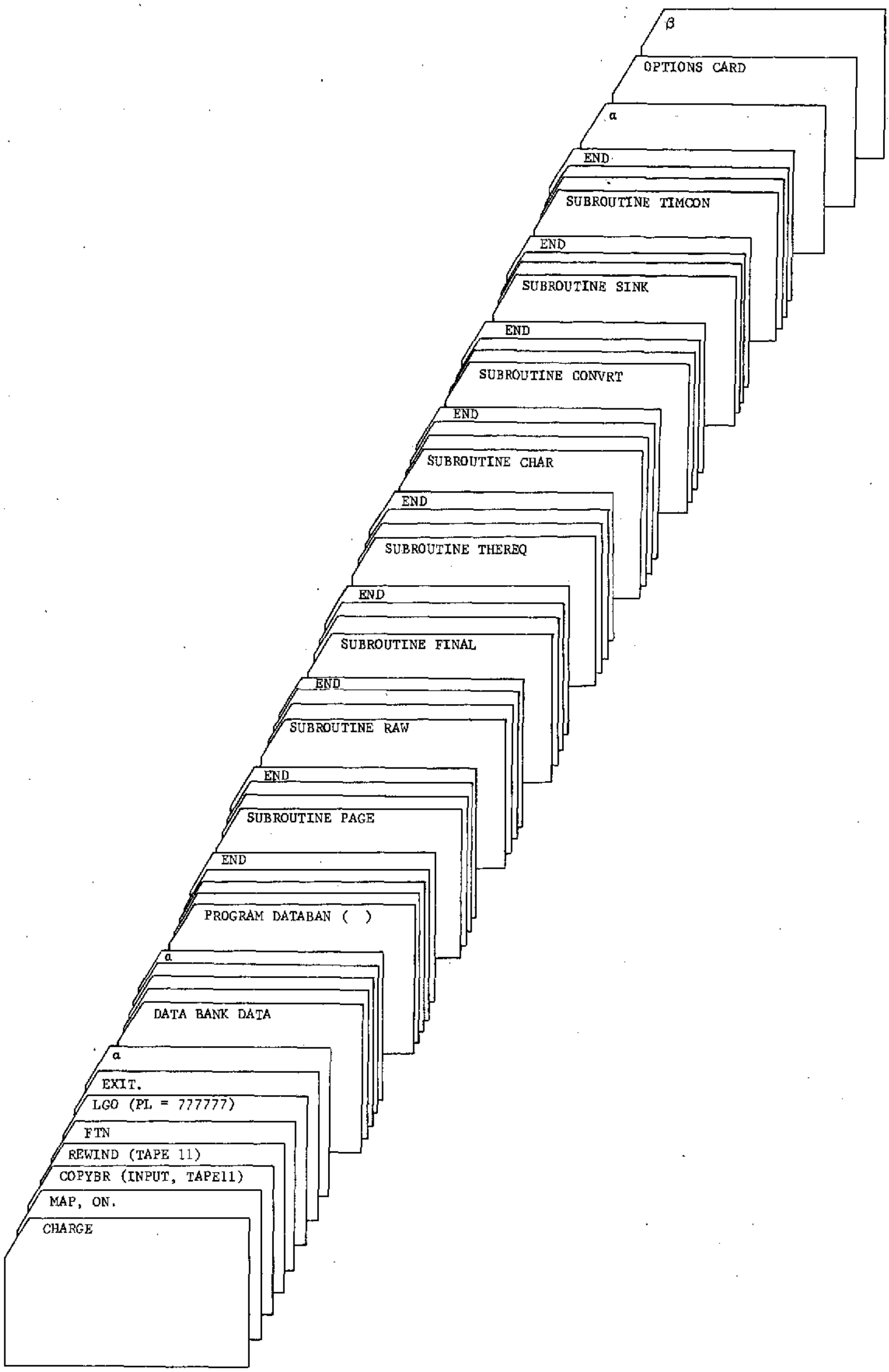

FIGURE 3 - CDC 6500 DECK ARRANGEMENT

CDC 6500 Input Instructions

Figure 3 presents the deck setup for running on the SCOPE 3.4 operating system. Note: the data bank data is loaded on Tape 11 prior to execution requiring COPYBR control card. The options card is loaded after the last subroutine. The α cards are end of record cards, 7-8-9 in Column 1 and the β card is the end-of-file card, 6-7-8-9 in Column 1. The CDC 6500 requires 40000_8 cells of core to run in and approximately 90 decimals seconds of time to execute the 4 basic subroutines.

Section 3.0 Program Modification

3.1 Addition of New Components to Components List

The Thereq and Char subroutines have identifical components listing, therefore, whatever is modified in one has to be duplicated in the other routine. The components listed are in the form of statements and formats statements that start with Format statement number 1010 and ends in Format statement number 1048. Note all new components will have to have format statements numbers larger than 1048 and be placed after statement 1048.

To add new components to the program list the following steps should be followed: (see Appendix II program listing for reference).

1) Write format statement 1049 or higher similar to the other components format statements, e.g. 1049 FORMAT (41X, 'EQUIPMENT ITEM XXXXX etc through column 72').

2) Locate the following card in the program "WRITE (6,1003) DATA(I), I = 1, 7". Go down the list of IF statement cards that follows the above write card.

3) Punch and place at this location the new IF statement card that identified the new component, e.g. "IF (IEQUIP.EQ.4H XXXX) GØ TO 49" Note: XXXX can be from one to four letters identifying the new component i.

4) Punch the new write statement card that is called by the above IF statement (statement 49) and place it after the last previous write statement in the program (statement 48) e.g. 49 write (6, 1049) etc.

5) Add a "GO TO 100" card prior to the new write statement.

In addition to the above procedure, locate the title page of the subsystem of the new component and add the appropriate information in this area. Note: the subsystem title page is simply printed as is and has no program modifications requirements.

REFERENCES

1. T. L. Ward, "Space Tug Thermal Control Equipment Thermal Requirements Characteristics and Constraints Catalogue." MCR-74-145, Martin Marietta Corporation, April 1974.

APPENDIX I

Listing of Components & Corresponding Identifier

Inertial Measurement Units	IMU
STAR Tracker	ST
STAR Tracker Electronics	STE
Horizon Scanner	HS
Horizon Scanner Electronics	HSE
Laser Rader	LR
Laser Rader Electronics	LRE
Television	TV
ACS Electronics	ACSE
Autocollimator	AUTO
Computers	COMP
Tape Recorders	TR
Data Acquisition Unit	DAU
Telemetry Formators	TF
Data Bus Controllers	DBC
Transponder PM	TPM
Transmitter FM	TFM
Power Amplifiers	PA
Hybrid Junction	HJ
RF Multiplexer	RFM

APPENDIX I (Continued)

Filters	F
Decoder	DEC
Modulation Processors	MP
Omni Antennas	OA
Pressure Transducers	PRES
Temperature Transducers	TEMP
Position Indicators	POS
Voltage Measurements	VOLT
Current Measurements	CURR
Flow Measurements	FLOW
Liquid Level Measurements	LLEV
Discrete Measurements	DISC
Fuel Cell Power System	FC
Batteries	BAT
Power Distribution Units	PDU
Power Conversion Units	PC
Sun Sensor	SS
Rate Gyros	RS

APPENDIX II

```
"ASG,T 11,F2///250
"ASG,T 12,F2///250
"ASG,T 13,F2///250
"FOR,IS DATAB,DATAB
C
C        THIS PROGRAM CONTAINS THE NECESSARY LOGIC TO SATISFY THE
C                      SPACE TUG THERMAL CONTROL STUDY
C                             NAS 8-29670
C        CATALOGING REQUIREMENTS.  THE DATA CONTAINED IN THE DATA
C        BANK DEFINES THOSE EQUIPMENT ITEMS CONSIDERED APPLICABLE
C        TO THE SPACE TUG.  THE SPECIFIC DATA CONTAINED HEREIN DEFINES
C
C                      1)  EQUIPMENT THERMAL REQUIREMENTS
C                      2)  EQUIPMENT PHYSICAL CHARACTERISTICS
C                      3)  EQUIPMENT CONSTRAINTS
C
C        BY DEFINITION ALL EQUIPMENT ITEMS ARE CONSIDERED TO BE
C        FUNCTIONALLY COMPATIBLE WITH SUBSYSTEM REQUIREMENTS.
C
C
C
C
      COMMON/BLANK/  IPAGE
      DIMENSION  DATA(12)
      DIMENSION DATA1(20)
      REWIND 11
   10 READ(5,11,END=20)DATA1
   11 FORMAT(20A4)
      WRITE(11,11)DATA1
      GO TO 10
   20 END FILE 11
      REWIND 11
C
 1001 FORMAT(5(A6,4X))
C
      IPAGE=1
C
      CALL PAGE
C        READ THE OPTIONS CARD
C
      READ(5,1001) IRAW, IFINAL, ITHRQ, ICHAR
      IF(IRAW.EQ.3HRAW)                    GO TO 100
    1 IF(IFINAL.EQ.5HFINAL)                GO TO 200
    2 IF(ITHRQ.EQ.6HTHEREQ)                GO TO 300
    3 IF(ICHAR.EQ.4HCHAR)                  GO TO 400
      GO TO 1000
C
  100 CALL RAW
      GO TO 1
  200 CALL FINAL
      GO TO 2
  300 CALL THEREQ
      GO TO 3
  400 CALL CHAR
 1000 CONTINUE
      CALL EXIT
      END
```

```
@FOR,IS PAGE,PAGE
      SUBROUTINE PAGE
C
C  THIS SUBROUTINE UPDATES THE PAGE NUMBERS FOR THE DATA BANK FOR
C  OUTPUT OF RAW AND FINAL
C
      COMMON/BLANK/  IPAGE
      DIMENSION  DATA(12)
C
 1001 FORMAT(A1,A5,11A6)
 1002 FORMAT(A1,A5,10A6,'GE'I4)
C
      J=0
      REWIND 11
      REWIND 12
    1 READ(11,1001,END=1000)I, DATA(1), (DATA(K),K=2,12)
      IF(I.EQ.1H1)                         GO TO 3
      WRITE(12,1001)I, DATA(1), (DATA(K),K=2,12)
      GO TO 1
    3 J=J+1
      IF(J.GT.2)                           GO TO 4
      WRITE(12,1001) I, DATA(1), (DATA(K),K=2,12)
      GO TO 1
    4 IPAGE=IPAGE+1
      WRITE(12,1002) I, DATA(1), (DATA(K),K=2,11), IPAGE
      GO TO 1
 1000 CONTINUE
      RETURN
      END
```

```
"FOR,IS RAW,RAW
      SUBROUTINE RAW
C  THIS SUBROUTINE WRITES THE DATA BANK TO OUTPUT IN A RAW FORM
      DIMENSION DATA(12)
C
 1001 FORMAT(12A6)
C
      REWIND 12
    1 READ(12,1001,END=1000) (DATA(I),I=1,12)
      WRITE(6,1001) (DATA(I),I=1,12)
      GO TO 1
 1000 CONTINUE
      RETURN
      END
```

```
@FOR,IS FINAL,FINAL
      SUBROUTINE FINAL
C
C THIS SUBROUTINE CONVERTS THE RAW DATA ON TAPE 12 TO SI UNITS AND
C
      DIMENSION DATA(12)
C
 1001 FORMAT(12A6)
 1003 FORMAT(7A6,' FINAL DATA'7X,2A6)
 1004 FORMAT(1X,8A6,3X,F5.0,3X,F5.0)
 1005 FORMAT(1X,8A6,2X,F5.0,' TO'F5.0,' DEG. K'/50X,'('F5.0,' TO'F5.0,
     1' DEG. F)')
 1006 FORMAT(1X,3A6,6X,3A6)
 1007 FORMAT(3X,4A6,F6.1,8X,F6.1,9X,F6.1)
 1008 FORMAT(3X,4A6,F6.1,8H * WIDTH,F6.1,9H * HEIGHT,F6.1,' CENTIMETERS'
     1/21X,'LENGTH'F6.1,8H * WIDTH,F6.1,9H * HEIGHT,F6.1,'  INCHES')
 1009 FORMAT(6X,'PACKAGE AREA'7X,F7.1,' SQ. CENTIMETERS  '1H*,F8.1,
     1' SQ. INCHES'/6X,'PACKAGE VOLUME'5X,F7.1,' CU. CENTIMETERS  '1H*,
     2F8.1,' CU. INCHES')
 1010 FORMAT(3A6,9X,F6.1)
 1011 FORMAT(3A6,9X,F6.1,' KILOGRAMS  '1H*,F7.1,' POUNDS')
 1012 FORMAT(2(6X,F5.1,3X,F5.0))
 1013 FORMAT(6X,F5.1,' AT'F5.0,' DEG, 'F5.1,' AT'F5.0,' DEG  (WATTS AT D
     1EG. KELVIN)'/6X,F5.1,' AT'F5.0,' DEG, 'F5.1,' AT'F5.0,' DEG  (WATT
     2S AT DEG. FAHRENHEIT)')
C
      PI=3.1415926536
      REWIND 12
    1 READ(12,1001,END=1000) (DATA(I),I=1,12)
      IFLAG=0
      IF(DATA(2).EQ.6H     SP)            GO TO 100
      WRITE(6,1001) (DATA(I),I=1,12)
      GO TO 1
  100 CONTINUE
      WRITE(6,1003) (DATA(I),I=1,7), (DATA(I),I=11,12)
      DO 101 J=1,6
      READ(12,1001) (DATA(I),I=1,12)
      WRITE(6,1001) (DATA(I),I=1,12)
  101 CONTINUE
      IF(DATA(1).EQ.6H     FC.OR.DATA(1).EQ.6H    BAT)IFLAG=1
      DO 102 J=1,4
      READ(12,1004)  (DATA(I),I=1,8), TC, TH
      CALL CONVRT (TC,TH,TCK,THK)
      WRITE(6,1005) (DATA(I),I=1,8), TCK, THK, TC, TH
  102 CONTINUE
      READ(12,1006) (DATA(I),I=1,3),(DATA(I),I=4,6)
      IF(DATA(4).EQ.6HRECTAN)           IPACK=1
      IF(DATA(4).EQ.6HCYLIND)           IPACK=2
      IF(DATA(4).EQ.6HSPHERI)           IPACK=3
      WRITE(6,1006) (DATA(I),I=1,6)
      READ(12,1007) (DATA(I),I=1,4), XL, W, H
      XLC=XL*2.54
      WC=W*2.54
      HC=H*2.54
      WRITE(6,1008) (DATA(I),I=1,4), XLC, WC, HC, XL, W, H
      IF(IPACK-2) 103,104,105
  103 AC=2.*(HC*(XLC+WC)+WC*XLC)
      A=2.*(H*(XL+W)+W*XL)
      VC=XLC*WC*HC
      V=XL*W*H
      GO TO 110
  104 AC=2.*PI*(WC**2+WC*XLC)
```

```
      A=2.*PI*(W**2+W*XL)
      VC=PI*XLC*WC**2
      V=PI*XL*W**2
      GO TO 110
  105 AC=4.*PI*WC**2
      A=4.*PI*W**2
      VC=4./3.*PI*WC**3
      V=4./3.*PI*W**3
  110 CONTINUE
      WRITE(6,1009)  AC, A, VC, V
      READ(12,1001) (DATA(I),I=1,12)
      WRITE(6,1001) (DATA(I),I=1,12)
      DO 111 J=1,2
      READ(12,1010) (DATA(I),I=1,3), W
      WK=W*.45359237
      WRITE(6,1011) (DATA(I),I=1,3), WK, W
  111 CONTINUE
      DO 112 J=1,2
      READ(12,1001) (DATA(I),I=1,12)
      WRITE(6,1001) (DATA(I),I=1,12)
  112 CONTINUE
      IF(IFLAG.EQ.0) GO TO 114
      READ(12,1001)(DATA(I),I=1,12)
      WRITE(6,1001)(DATA(I),I=1,12)
      GO TO 113
  114 READ(12,1012) PC, TC, PH, TH
      IF(PC.LT. .1)                       GO TO 113
      CALL CONVRT (TC,TH,TCK,THK)
      WRITE(6,1013) PC, TCK, PH, THK, PC, TC, PH, TH
  113 READ(12,1001) (DATA(I),I=1,12)
      IF(DATA(1).EQ.6H END**)             GO TO 1
      WRITE(6,1001) (DATA(I),I=1,12)
      GO TO 113
 1000 CONTINUE
      RETURN
      END
```

```
"FOR,IS THEREQ,THEREQ
      SUBROUTINE THEREQ
      COMMON/BLANK/  IPAGE
      DIMENSION DATA(12) ,  EQUIP(3),  MANUF(3), REMARK(8)
C
  999 FORMAT(1H1,//////////////////////
     153X,'SPACE TUG THERMAL CONTROL'//
     246X,'EQUIPMENT THERMAL REQUIREMENTS CATALOGUE'//
     359X,'PREPARED FOR'//
     443X,'NATIONAL AERONAUTICS AND SPACE ADMINSTRATION'//
     551X,'MARSHALL SPACE FLIGHT CENTER'//
     653X,'UNDER CONTRACT NAS 8-29670'//64X,'BY'//
     751X,'MARTIN MARIETTA CORPORATION'//58X,'DENVER DIVISION')
 1900 FORMAT(1H1,33X,'GLOSSARY FOR EQUIPMENT THERMAL REQUIREMENTS CATALO
     1GUE'/////////10X,'YES  PERTAINS TO THE REQUIREMENTS OF UNIT TO BE
     1ON DURING THESE PERIODS OF FLIGHT.'//10X,'INT  PERTAINS TO THE REQ
     1UIREMENTS OF UNIT TO BE ON INTERMITTENTLY DURING THESE PERIODS OF
     1FLIGHT.'//10X,'THERMAL DESIGN GROUND ACTIVE  ACTIVE COOLING FOR GR
     1OUND OPERATION MEANS A REQUIREMENT FOR FORCED CONVECTION.')
  998 FORMAT(2A6)
 1001 FORMAT(I1)
 1002 FORMAT(7X,7A6)
 1004 FORMAT(2X,A4,I3,1X,3A6,2X,3A6)
 1005 FORMAT(1H1,40X,'EQUIPMENT THERMAL REQUIREMENTS CATALOGUE'30X,
     1'PAGE'I4,/)
 1003 FORMAT(41X,7A6,/)
 1010 FORMAT(1H-,6H******,A4,I3,' IS NOT A DEFINED EQUIPMENT ITEM')
 1011 FORMAT(41X,'EQUIPMENT ITEM  INERTIAL MEASUREMENT UNITS')
 1012 FORMAT(41X,'EQUIPMENT ITEM  STAR TRACKERS')
 1013 FORMAT(41X,'EQUIPMENT ITEM  STAR TRACKER ELECTRONICS')
 1014 FORMAT(41X,'EQUIPMENT ITEM  HORIZON SCANNERS')
 1015 FORMAT(41X,'EQUIPMENT ITEM  HORIZON SCANNER ELECTRONICS')
 1016 FORMAT(41X,'EQUIPMENT ITEM  LASER RADARS')
 1017 FORMAT(41X,'EQUIPMENT ITEM  LASER RADAR ELECTRONICS')
 1018 FORMAT(41X,'EQUIPMENT ITEM  TELEVISION')
 1019 FORMAT(41X,'EQUIPMENT ITEM  ACS ELECTRONICS')
 1020 FORMAT(41X,'EQUIPMENT ITEM  AUTOCOLLIMATORS')
 1021 FORMAT(41X,'EQUIPMENT ITEM  COMPUTERS')
 1022 FORMAT(41X,'EQUIPMENT ITEM  TAPE RECORDERS')
 1023 FORMAT(41X,'EQUIPMENT ITEM  DATA ACQUISITION UNITS')
 1024 FORMAT(41X,'EQUIPMENT ITEM  TELEMETRY FORMATORS')
 1025 FORMAT(41X,'EQUIPMENT ITEM  DATA BUS CONTROLLERS')
 1026 FORMAT(41X,'EQUIPMENT ITEM  TRANSPONDERS, PM')
 1027 FORMAT(41X,'EQUIPMENT ITEM  TRANSMITTERS, FM')
 1028 FORMAT(41X,'EQUIPMENT ITEM  POWER AMPLIFIERS')
 1029 FORMAT(41X,'EQUIPMENT ITEM  HYBRID JUNCTIONS')
 1030 FORMAT(41X,'EQUIPMENT ITEM  RF MULTIPLEXERS')
 1031 FORMAT(41X,'EQUIPMENT ITEM  FILTERS')
 1032 FORMAT(41X,'EQUIPMENT ITEM  DECODER')
 1033 FORMAT(41X,'EQUIPMENT ITEM  MODULATION PROCESSERS')
 1034 FORMAT(41X,'EQUIPMENT ITEM  OMNI ANTENNAS')
 1035 FORMAT(41X,'EQUIPMENT ITEM  PRESSURE TRANSDUCERS')
 1036 FORMAT(41X,'EQUIPMENT ITEM  TEMPERATURE TRANSDUCERS')
 1037 FORMAT(41X,'EQUIPMENT ITEM  POSITION INDICATORS')
 1038 FORMAT(41X,'EQUIPMENT ITEM  VOLTAGE MEASUREMENTS')
 1039 FORMAT(41X,'EQUIPMENT ITEM  CURRENT MEASUREMENTS')
 1040 FORMAT(41X,'EQUIPMENT ITEM  FLOW MEASUREMENTS')
 1041 FORMAT(41X,'EQUIPMENT ITEM  LIQUID LEVEL MEASUREMENTS')
 1042 FORMAT(41X,'EQUIPMENT ITEM  DISCRETE MEASUREMENTS')
 1043 FORMAT(41X,'EQUIPMENT ITEM  FUEL CELL POWER SYSTEMS')
 1044 FORMAT(41X,'EQUIPMENT ITEM  BATTERIES')
 1045 FORMAT(41X,'EQUIPMENT ITEM  POWER DISTRIBUTATION UNITS')
```

```
1046 FORMAT(41X,'EQUIPMENT ITEM  POWER CONVERSION SYSTEMS')
1047 FORMAT(41X,'EQUIPMENT ITEM  SUN SENSOR')
1048 FORMAT(41X,'EQUIPMENT ITEM  RATE GYROS')
1101 FORMAT(1H0,   127('-'),/3X,'REF.  DESCRIPTION AND   THERMAL  POWER
    1  MISSION PHASE THERMAL REQUIREMENTS AND TEMPERATURE LIMITS'12X,
    2  'REMARKS'/4X,'NO.  MANUFACTURE          DESIGN  WATTS           D
    3EGREES KELVIN / (FAHRENHEIT) - MIN / MAX'/
    427X,'GROUND/  MIN/    PRELAUNCH  SHUTTLE            MANEUVERS'13X,
    5     'REENTRY'/27X,'ORBITAL  MAX'17X,'CARRY    SHUTTLE    TUG
    6PAYLOAD    AND'/67X,'TUG      ORBITAL     TUG    LANDING',/
    7    1X,127('-'),/)
1102 FORMAT(52X,F5.0,4X,F5.0)
1103 FORMAT(32X,F6.1)
1104 FORMAT(5X,F6.1,13X,F6.1)
1105 FORMAT(31X,A6,A1,6X,A6,A1)
1106 FORMAT(40X,A3,9X,A3,10X,A3)
1107 FORMAT(36X,A3,12X,A3,10X,A3)
1108 FORMAT(A6)
1109 FORMAT(1X,A4,I2,1X,3A6,1X,A6,A1,2X,I3,'/',6(7X,A3),4X,4A6,/8X,3A6,
    1 1X,A6,A1,2X,I3,3X,6(3X,I3,'/'I3),2X,4A6,/44X,6('('I3,'/'I3,')'1X)
    2)
C
     REWIND 12
     IPAGE=1
     JEQUIP=4H
     WRITE(6,999)
     WRITE(6,1900)
   1 READ(12,998,END=1000) (DATA(I),I=1,2)
     IF(DATA(2).EQ.6H     SP)              GO TO 2
     GO TO 1
   2 DO 3 J=1,3
     READ(12,1001)IDUM
   3 CONTINUE
     READ(12,1002) (DATA(I),I=1,7)
     READ(12,1002) DUM
     READ(12,1004) IEQUIP, NO, (EQUIP(I),I=1,3), (MANUF(J),J=1,3)
     IF(IEQUIP.EQ.JEQUIP)                  GO TO 100
     JEQUIP=IEQUIP
     ILINE=60
     IPAGE=IPAGE+1
     WRITE(6,1005) IPAGE
     WRITE(6,1003) (DATA(I),I=1,7)
     IF(IEQUIP.EQ.4H IMU)                  GO TO 11
     IF(IEQUIP.EQ.4H  ST)                  GO TO 12
     IF(IEQUIP.EQ.4H STE)                  GO TO 13
     IF(IEQUIP.EQ.4H  HS)                  GO TO 14
     IF(IEQUIP.EQ.4H HSE)                  GO TO 15
     IF(IEQUIP.EQ.4H  LR)                  GO TO 16
     IF(IEQUIP.EQ.4H LRE)                  GO TO 17
     IF(IEQUIP.EQ.4H  TV)                  GO TO 18
     IF(IEQUIP.EQ.4HACSE)                  GO TO 19
     IF(IEQUIP.EQ.4HAUTO)                  GO TO 20
     IF(IEQUIP.EQ.4HCOMP)                  GO TO 21
     IF(IEQUIP.EQ.4H  TR)                  GO TO 22
     IF(IEQUIP.EQ.4H DAU)                  GO TO 23
     IF(IEQUIP.EQ.4H  IF)                  GO TO 24
     IF(IEQUIP.EQ.4H DBC)                  GO TO 25
     IF(IEQUIP.EQ.4H TPM)                  GO TO 26
     IF(IEQUIP.EQ.4H TFM)                  GO TO 27
     IF(IEQUIP.EQ.4H  PA)                  GO TO 28
     IF(IEQUIP.EQ.4H  HJ)                  GO TO 29
     IF(IEQUIP.EQ.4H RFM)                  GO TO 30
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      IF(IEQUIP.EQ.4H   F)                     GO TO 31
      IF(IEQUIP.EQ.4H DEC)                     GO TO 32
      IF(IEQUIP.EQ.4H  MP)                     GO TO 33
      IF(IEQUIP.EQ.4H  OA)                     GO TO 34
      IF(IEQUIP.EQ.4HPRES)                     GO TO 35
      IF(IEQUIP.EQ.4HTEMP)                     GO TO 36
      IF(IEQUIP.EQ.4H POS)                     GO TO 37
      IF(IEQUIP.EQ.4HVOLT)                     GO TO 38
      IF(IEQUIP.EQ.4HCURR)                     GO TO 39
      IF(IEQUIP.EQ.4HFLOW)                     GO TO 40
      IF(IEQUIP.EQ.4HLLEV)                     GO TO 41
      IF(IEQUIP.EQ.4HDISC)                     GO TO 42
      IF(IEQUIP.EQ.4H  FC)                     GO TO 43
      IF(IEQUIP.EQ.4H BAT)                     GO TO 44
      IF(IEQUIP.EQ.4H PDU)                     GO TO 45
      IF(IEQUIP.EQ.4H  PC)                     GO TO 46
      IF(IEQUIP.EQ.4H  SS)                     GO TO 47
      IF(IEQUIP.EQ.4H  RG)                     GO TO 48
      WRITE(6,1010)  IEQUIP, NO
      CALL EXIT
   11 WRITE(6,1011)
      GO TO 100
   12 WRITE(6,1012)
      GO TO 100
   13 WRITE(6,1013)
      GO TO 100
   14 WRITE(6,1014)
      GO TO 100
   15 WRITE(6,1015)
      GO TO 100
   16 WRITE(6,1016)
      GO TO 100
   17 WRITE(6,1017)
      GO TO 100
   18 WRITE(6,1018)
      GO TO 100
   19 WRITE(6,1019)
      GO TO 100
   20 WRITE(6,1020)
      GO TO 100
   21 WRITE(6,1021)
      GO TO 100
   22 WRITE(6,1022)
      GO TO 100
   23 WRITE(6,1023)
      GO TO 100
   24 WRITE(6,1024)
      GO TO 100
   25 WRITE(6,1025)
      GO TO 100
   26 WRITE(6,1026)
      GO TO 100
   27 WRITE(6,1027)
      GO TO 100
   28 WRITE(6,1028)
      GO TO 100
   29 WRITE(6,1029)
      GO TO 100
   30 WRITE(6,1030)
      GO TO 100
   31 WRITE(6,1031)
      GO TO 100
```

```
 32 WRITE(6,1032)
    GO TO 100
 33 WRITE(6,1033)
    GO TO 100
 34 WRITE(6,1034)
    GO TO 100
 35 WRITE(6,1035)
    GO TO 100
 36 WRITE(6,1036)
    GO TO 100
 37 WRITE(6,1037)
    GO TO 100
 38 WRITE(6,1038)
    GO TO 100
 39 WRITE(6,1039)
    GO TO 100
 40 WRITE(6,1040)
    GO TO 100
 41 WRITE(6,1041)
    GO TO 100
 42 WRITE(6,1042)
    GO TO 100
 43 WRITE(6,1043)
    GO TO 100
 44 WRITE(6,1044)
    GO TO 100
 45 WRITE(6,1045)
    GO TO 100
 46 WRITE(6,1046)
    GO TO 100
 47 WRITE(6,1047)
    GO TO 100
 48 WRITE(6,1048)
100 CONTINUE
    IF(ILINE.LT.56)                        GO TO 109
    WRITE(6,1101)
    ILINE=15
109 READ(12,1102)  DOCTC, DOCTH
    READ(12,1102)   SCTC,  SCTH
    DO  110  I=1,8
    READ(12,1001) IDUM
110 CONTINUE
    READ(12,1103)  SSP
    READ(12,1104)  CPC, CPH
    READ(12,1103)   OP
    READ(12,1105) ITDG,ITDG1, ITDO, ITDO1
    DO 111 I=1,2
    READ(12,1001)  IDUM
111 CONTINUE
    READ(12,1106)  IPRE, ICAR, IRFE
    READ(12,1107) IST, ITO, IPT
    DO 112 I=1,50
    READ(12,1108) IEND
    IF(IEND.EQ.6H END**)                   GO TO 120
112 CONTINUE
120 CONTINUE
    IF(IPRE.EQ.3HYES.AND.ICAR.EQ.3HOFF)          GO TO 113
    IF(IPRE.EQ.3HYES.AND.ICAR.EQ.3HYES)          GO TO 114
    IF(IREE.EQ.3HYES)                            GO TO 115
113 REMARK(1)=6HUN DUR
    REMARK(2)=6HING PR
    REMARK(3)=6HELAUNC
```

```
      REMARK(4)=6HH FOR
      REMARK(5)=6HCHECKU
      REMARK(6)=6HUT
      REMARK(7)=6H
      REMARK(8)=6H
      GO TO 116
  114 REMARK(1)=6HON PRI
      REMARK(2)=6HOR TO
      REMARK(3)=6HLAUNCH
      REMARK(4)=6H FOR
      REMARK(5)=6HCHECKU
      REMARK(6)=6HUT AND
      REMARK(7)=6H STAB
      REMARK(8)=6H
      GO TO 116
  115 REMARK(1)=6HON FOR
      REMARK(2)=6H MISSI
      REMARK(3)=6HON OR
      REMARK(4)=6H
      REMARK(5)=6HTHERMA
      REMARK(6)=6HL CONT
      REMARK(7)=6HROL PU
      REMARK(8)=6HRPOSES
  116 CONTINUE
      IQMIN= SSP+ CPC- OP
      IQMAX= SSP + CPH - OP
      DOCTCK=(5./9.)*(DOCTC+459.67)
      DOCTHK=(5./9.)*(DOCTH+459.67)
       SCTCK=(5./9.)*( SCTC+459.67)
       SCTHK=(5./9.)*( SCTH+459.67)
      IF(IPRE.EQ.3HYES)                         GO TO 126
      ICPREK=SCTCK
      IHPREK=SCTHK
      ICPREF=SCTC
      IHPREF=SCTH
  121 IF(ICAR.EQ.3HYES)                         GO TO 127
      ICCARK=SCTCK
      IHCARK=SCTHK
      ICCARF=SCTC
      IHCARF=SCTH
  122 IF(IST.EQ.3H ON)                          GO TO 128
      IF(IST.EQ.3HINT)                          GO TO 132
      ICSTK=SCTCK
      IHSTK=SCTHK
      ICSTF=SCTC
      IHSTF=SCTH
  123 IF(ITO.EQ.3H ON)                          GO TO 129
      IF(ITO.EQ.3HINT)                          GO TO 133
      ICTOK=SCTCK
      IHTOK=SCTHK
      ICTOF=SCTC
      IHTOF=SCTH
  124 IF(IPT.EQ.3H ON)                          GO TO 130
      IF(IPT.EQ.3HINT)                          GO TO 134
      ICPTK=SCTCK
      IHPTK=SCTHK
      ICPTF=SCTC
      IHPTF=SCTH
  125 IF(IREE.EQ.3HYES)                         GO TO 131
      ICREEK=SCTCK
      IHREEK=SCTHK
      ICREEF=SCTC
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      IHREEF=SCTH
      GO TO 140
  126 ICPREK=DOCTCK
      IHPREK=DOCTHK
      ICPREF=DOCTC
      IHPREF=DOCTH
      GO TO 121
  127 ICCARK=DOCTCK
      IHCARK=DOCTHK
      ICCARF=DOCTC
      IHCARF=DOCTH
      GO TO 122
  128 ICSTK=DOCTCK
      IHSTK=DOCTHK
      ICSTF=DOCTC
      IHSTF=DOCTH
      GO TO 123
  129 ICTOK=DOCTCK
      IHTOK=DOCTHK
      ICTOF=DOCTC
      IHTOF=DOCTH
      GO TO 124
  130 ICPTK=DOCTCK
      IHPTK=DOCTHK
      ICPTF=DOCTC
      IHPTF=DOCTH
      GO TO 125
  131 ICREEK=DOCTCK
      IHREEK=DOCTHK
      ICREEF=DOCTC
      IHREEF=DOCTH
      GO TO 140
  132 ICSTK=SCTCK
      IHSTK=DOCTHK
      ICSTF=SCTC
      IHSTF=DOCTH
      GO TO 123
  133 ICTOK=SCTCK
      IHTOK=DOCTH
      IHTOF=DOCTH
      GO TO 124
  134 ICPTK=SCTCK
      IHPTK=DOCTHK
      ICPTF=SCTC
      IHPTF=DOCTH
      GO TO 125
  140 CONTINUE
      WRITE(6,1109) IEQUIP,NO,(EQUIP(I),I=1,3), ITDG,ITDG1,IQMIN,  IPRE,
     1 ICAR,  IST,  ITO,  IPT,  IREF, (REMARK(I),I=1,4),
     2(MANUF(I),I=1,3), ITDO, ITDO1,IQMAX, ICPREK, IHPREK, ICCARK,
     3 IHCARK, ICSTK, IHSTK, ICTOK, IHTOK, ICPTK, IHPTK, ICREEK, IHREEK,
     4(REMARK(I),I=5,8), ICPREF, IHPREF, ICCARF, IHCARF, ICSTF, IHSTF,
     5 ICTOF, IHTOF, ICPTF, IHPTF, ICREEF, IHREEF
      ILINE=ILINE+3
      IF(ILINE.GT.56)     JEQUIP=4H
      GO TO 1
 1000 CONTINUE
      RETURN
      END
```

```
"FOR,IS CHAR,CHAR
      SUBROUTINE CHAR
      COMMON/BLANK/  IPAGE
      DIMENSION DATA(12) ,  EQUIP(3),  MANUF(3)
C
  999 FORMAT(1H1,///////////////////////
     153X,'SPACE TUG THERMAL CONTROL'//
     235X,'EQUIPMENT PHYSICAL CHARACTERISTICS AND CONSTRAINTS CATALOGUE'
     3//59X,'PREPARED FOR'//
     443X,'NATIONAL AERONAUTICS AND SPACE ADMINSTRATION'//
     551X,'MARSHALL SPACE FLIGHT CENTER'//
     653X,'UNDER CONTRACT NAS 8-29670'//64X,'BY'//
     751X,'MARTIN MARIETTA CORPORATION'//58X,'DENVER DIVISION')
  998 FORMAT(2A6)
 1001 FORMAT(I1)
 1002 FORMAT(7X,7A6)
 1004 FORMAT(2X,A4,I3,1X,3A6,2X,3A6)
 1005 FORMAT(1H1,34X,'EQUIPMENT PHYSICAL CHARACTERISTICS AND CONSTRAINTS
     1 CATALOGUE'18X,'PAGE'I4,/)
 1901 FORMAT(1H1,33X,'GLOSSARY FOR EQUIPMENT PHYSICAL CHARACTERISTICS AN
     1D CONSTRAINTS CATALOGUE'/////////10X,'PACKAGE SHAPE RECT  RECTANGU
     1LAR.'//10X,'PACKAGE SHAPE CYLI  CYLINDRICAL.'//10X,'PACKAGE SHAPE
     1SPHE  SPHERE.'//10X,'ALPHA  SOLAR ABSOPBTIVITY.'//10X,'EMISS  SURF
     1ACE EMISSIVITY.'//10X,'POWER DENSITY  THE TOTAL DISSIPATED POWER P
     1ER UNIT SURFACE AREA.'//)
 1902 FORMAT(10X,'TIME CONSTANT HOURS  THE TIME REQUIRED TO ACHIEVE 67 P
     1RECENT OF THE DELTA TEMPERATURE DEFINED BY THE DESIGN OPERATING'//
     110X,'TEMPERATURE LESS ROOM AMBIENT TEMPERATURE.'//10X,'ADIABATIC R
     1ISE RATE  THE TEMPERATURE RISE IN ONE HOUR IF ALL THE HEAT DISSIPA
     1TED IS CONTAINED WITHIN THE UNIT.'//10X,'THERMAL MASS  THE AMOUNT
     1OF ENERGY REQUIRED TO RAISE A UNIT ONE DEGREE IN TEMPERATURE.'//)
 1903 FORMAT(10X,'ALLOWABLE SINK TEMP.  THE EQUIVALENT VACUUM CHAMBER WA
     1LL TEMPERATURE WHICH WILL RESULT IN SPECEIFIED CASE TEMPERATURE.')
 1003 FORMAT(41X,7A6,/)
 1010 FORMAT(1H-,6H******,A4,I3,' IS NOT A DEFINED EQUIPMENT ITEM')
 1011 FORMAT(41X,'EQUIPMENT ITEM  INERTIAL MEASUREMENT UNITS')
 1012 FORMAT(41X,'EQUIPMENT ITEM  STAR TRACKERS')
 1013 FORMAT(41X,'EQUIPMENT ITEM  STAR TRACKER ELECTRONICS')
 1014 FORMAT(41X,'EQUIPMENT ITEM  HORIZON SCANNERS')
 1015 FORMAT(41X,'EQUIPMENT ITEM  HORIZON SCANNER ELECTRONICS')
 1016 FORMAT(41X,'EQUIPMENT ITEM  LASER RADARS')
 1017 FORMAT(41X,'EQUIPMENT ITEM  LASER RADAR ELECTRONICS')
 1018 FORMAT(41X,'EQUIPMENT ITEM  TELEVISION')
 1019 FORMAT(41X,'EQUIPMENT ITEM  ACS ELECTRONICS')
 1020 FORMAT(41X,'EQUIPMENT ITEM  AUTOCOLLIMATORS')
 1021 FORMAT(41X,'EQUIPMENT ITEM  COMPUTERS')
 1022 FORMAT(41X,'EQUIPMENT ITEM  TAPE RECORDERS')
 1023 FORMAT(41X,'EQUIPMENT ITEM  DATA ACQUISITION UNITS')
 1024 FORMAT(41X,'EQUIPMENT ITEM  TELEMETRY FORMATORS')
 1025 FORMAT(41X,'EQUIPMENT ITEM  DATA BUS CONTROLLERS')
 1026 FORMAT(41X,'EQUIPMENT ITEM  TRANSPONDERS, PM')
 1027 FORMAT(41X,'EQUIPMENT ITEM  TRANSMITTERS, FM')
 1028 FORMAT(41X,'EQUIPMENT ITEM  POWER AMPLIFIERS')
 1029 FORMAT(41X,'EQUIPMENT ITEM  HYBRID JUNCTIONS')
 1030 FORMAT(41X,'EQUIPMENT ITEM  RF MULTIPLEXERS')
 1031 FORMAT(41X,'EQUIPMENT ITEM  FILTERS')
 1032 FORMAT(41X,'EQUIPMENT ITEM  DECODER')
 1033 FORMAT(41X,'EQUIPMENT ITEM  MODULATION PROCESSERS')
 1034 FORMAT(41X,'EQUIPMENT ITEM  OMNI ANTENNAS')
 1035 FORMAT(41X,'EQUIPMENT ITEM  PRESSURE TRANSDUCERS')
 1036 FORMAT(41X,'EQUIPMENT ITEM  TEMPERATURE TRANSDUCERS')
 1037 FORMAT(41X,'EQUIPMENT ITEM  POSITION INDICATORS')
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1038 FORMAT(41X,'EQUIPMENT ITEM  VOLTAGE MEASUREMENTS')
1039 FORMAT(41X,'EQUIPMENT ITEM  CURRENT MEASUREMENTS')
1040 FORMAT(41X,'EQUIPMENT ITEM  FLOW MEASUREMENTS')
1041 FORMAT(41X,'EQUIPMENT ITEM  LIQUID LEVEL MEASUREMENTS')
1042 FORMAT(41X,'EQUIPMENT ITEM  DISCRETE MEASUREMENTS')
1043 FORMAT(41X,'EQUIPMENT ITEM  FUEL CELL POWER SYSTEMS')
1044 FORMAT(41X,'EQUIPMENT ITEM  BATTERIES')
1045 FORMAT(41X,'EQUIPMENT ITEM  POWER DISTRIBUTATION UNITS')
1046 FORMAT(41X,'EQUIPMENT ITEM  POWER CONVERSION SYSTEMS')
1047 FORMAT(41X,'EQUIPMENT ITEM  SUN SENSOR')
1048 FORMAT(41X,'EQUIPMENT ITEM  RATE GYROS')
1101 FORMAT(1H0,  127('-'),/3X,'REF.  DESCRIPTION          WEIGHT PACKAGE
    1SURFACE VOLUME  RAD.  POWER  POWER  TIME   ADIABATIC THERMAL ALLOW
    2ABLE SINK        OP'    /4X,'NO.  MANUFACTURER AND   KG      SHAPE
    3 AREA   CUBIC  ALPHA/ WATTS DENSITY CONST. RISE RATE  MASS   TEMP.
    4 DEG K/(F)       MODE'/12X,'REMARKS           (LBS)           SQUARE
    5 CM    EMISS    MIN/  Q/A     HOURS  DEG K/HR  W-HR/K  DESIGN     QUA
    6L '/44X,'CM         (FT)            MAX     W/ M2    MIN    DEG F/HR  BTU/F
    7 MIN   MAX   MIN   MAX'/43X,'(FT)'23X,'(W/FT2)   MAX    MIN  MAX'/1X,
    8127('-'),/)
1102 FORMAT(52X,F5.0,4X,F5.0)
1103 FORMAT(25X,A4)
1104 FORMAT(27X,F6.1,8X,F6.1,9X,F6.1)
1105 FORMAT(27X,F6.1)
1106 FORMAT(39X,F5.3,17X,F5.3)
1107 FORMAT(32X,F5.1,9X,4A6)
1108 FORMAT(2(6X,F5.1,3X,F5.0))
1109 FORMAT(1X,A4,I3,1X,3A6,F5.1,3X,A4,3X,F6.0,2X,F6.0,1X,F4.2,'/',3X,
    1I3,'/ 'I3,'/'I3,1X,F5.2,2X,I3,2X,I3,2X,F5.1,4(2X,I3),4X,A4,/
    29X,3A6,'('F4.1,')'9X,'('F4.1,')'2X,'('F4.2,')'1X,F4.2,4X,I3,1X,'('
    3I3,'/'I3,')'F5.2,2X,I3,2X,I3,2X,F5.1,4(1X,I4))
1110 FORMAT(6X,11A6)
1111 FORMAT(10X,11A6)
1112 FORMAT(36X,A3,12X,A3,10X,A3)
1113 FORMAT(1H )
1114 FORMAT(10X,6H******,' NOTE  CONDUCTIVE HEAT LOSSES MUST EXCEED '
    1 F5.0,' AND ' F5.0,' TO MAINTAIN THE MIN AND MAX OPERATING TEMP')
1115 FORMAT(10X,6H******,' NOTE  CONDUCTIVE HEAT LOSSES MUST EXCEED '
    1 F5.0,' AND ' F5.0,' TO MAINTAIN THE MIN AND MAX QUAL TEMP')
C
      REWIND 12
      IPAGE=1
      JEQUIP=4H
      PI=3.1415926536
      WRITE(6,999)
      WRITE(6,1901)
      WRITE(6,1902)
      WRITE(6,1903)
    1 READ(12,998,END=1000) (DATA(I),I=1,2)
      IF(DATA(2).EQ.6H    SP)             GO TO 2
      GO TO 1
    2 DO 3 J=1,3
      READ(12,1001)IDUM
    3 CONTINUE
      READ(12,1002) (DATA(I),I=1,7)
      READ(12,1002) DUM
      READ(12,1004) IEQUIP, NO, (EQUIP(I),I=1,3), (MANUF(J),J=1,3)
      IF(IEQUIP.EQ.JEQUIP)                GO TO 100
      JEQUIP=IEQUIP
      ILINE=60
      IPAGE=IPAGE+1
      WRITE(6,1005) IPAGE
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      WRITE(6,1003) (DATA(I),I=1,7)
      IF(IEQUIP.EQ.4H IMU)              GO TO 11
      IF(IEQUIP.EQ.4H  ST)              GO TO 12
      IF(IEQUIP.EQ.4H STE)              GO TO 13
      IF(IEQUIP.EQ.4H  HS)              GO TO 14
      IF(IEQUIP.EQ.4H HSE)              GO TO 15
      IF(IEQUIP.EQ.4H  LR)              GO TO 16
      IF(IEQUIP.EQ.4H LRE)              GO TO 17
      IF(IEQUIP.EQ.4H  TV)              GO TO 18
      IF(IEQUIP.EQ.4HACSE)              GO TO 19
      IF(IEQUIP.EQ.4HAUTO)              GO TO 20
      IF(IEQUIP.EQ.4HCOMP)              GO TO 21
      IF(IEQUIP.EQ.4H  TR)              GO TO 22
      IF(IEQUIP.EQ.4H DAU)              GO TO 23
      IF(IEQUIP.EQ.4H  TF)              GO TO 24
      IF(IEQUIP.EQ.4H DBC)              GO TO 25
      IF(IEQUIP.EQ.4H TPM)              GO TO 26
      IF(IEQUIP.EQ.4H TFM)              GO TO 27
      IF(IEQUIP.EQ.4H  PA)              GO TO 28
      IF(IEQUIP.EQ.4H  HJ)              GO TO 29
      IF(IEQUIP.EQ.4H RFM)              GO TO 30
      IF(IEQUIP.EQ.4H   F)              GO TO 31
      IF(IEQUIP.EQ.4H DEC)              GO TO 32
      IF(IEQUIP.EQ.4H  MP)              GO TO 33
      IF(IEQUIP.EQ.4H  OA)              GO TO 34
      IF(IEQUIP.EQ.4HPRES)              GO TO 35
      IF(IEQUIP.EQ.4HTEMP)              GO TO 36
      IF(IEQUIP.EQ.4H POS)              GO TO 37
      IF(IEQUIP.EQ.4HVOLT)              GO TO 38
      IF(IEQUIP.EQ.4HCURR)              GO TO 39
      IF(IEQUIP.EQ.4HFLOW)              GO TO 40
      IF(IEQUIP.EQ.4HLLEV)              GO TO 41
      IF(IEQUIP.EQ.4HDISC)              GO TO 42
      IF(IEQUIP.EQ.4H  FC)              GO TO 43
      IF(IEQUIP.EQ.4H BAT)              GO TO 44
      IF(IEQUIP.EQ.4H PDU)              GO TO 45
      IF(IEQUIP.EQ.4H  PC)              GO TO 46
      IF(IEQUIP.EQ.4H  SS)              GO TO 47
      IF(IEQUIP.EQ.4H  RG)              GO TO 48
      WRITE(6,1010)  IEQUIP, NO
      CALL EXIT
   11 WRITE(6,1011)
      GO TO 100
   12 WRITE(6,1012)
      GO TO 100
   13 WRITE(6,1013)
      GO TO 100
   14 WRITE(6,1014)
      GO TO 100
   15 WRITE(6,1015)
      GO TO 100
   16 WRITE(6,1016)
      GO TO 100
   17 WRITE(6,1017)
      GO TO 100
   18 WRITE(6,1018)
      GO TO 100
   19 WRITE(6,1019)
      GO TO 100
   20 WRITE(6,1020)
      GO TO 100
   21 WRITE(6,1021)
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      GO TO 100
   22 WRITE(6,1022)
      GO TO 100
   23 WRITE(6,1023)
      GO TO 100
   24 WRITE(6,1024)
      GO TO 100
   25 WRITE(6,1025)
      GO TO 100
   26 WRITE(6,1026)
      GO TO 100
   27 WRITE(6,1027)
      GO TO 100
   28 WRITE(6,1028)
      GO TO 100
   29 WRITE(6,1029)
      GO TO 100
   30 WRITE(6,1030)
      GO TO 100
   31 WRITE(6,1031)
      GO TO 100
   32 WRITE(6,1032)
      GO TO 100
   33 WRITE(6,1033)
      GO TO 100
   34 WRITE(6,1034)
      GO TO 100
   35 WRITE(6,1035)
      GO TO 100
   36 WRITE(6,1036)
      GO TO 100
   37 WRITE(6,1037)
      GO TO 100
   38 WRITE(6,1038)
      GO TO 100
   39 WRITE(6,1039)
      GO TO 100
   40 WRITE(6,1040)
      GO TO 100
   41 WRITE(6,1041)
      GO TO 100
   42 WRITE(6,1042)
      GO TO 100
   43 WRITE(6,1043)
      GO TO 100
   44 WRITE(6,1044)
      GO TO 100
   45 WRITE(6,1045)
      GO TO 100
   46 WRITE(6,1046)
      GO TO 100
   47 WRITE(6,1047)
      GO TO 100
   48 WRITE(6,1048)
  100 CONTINUE
      IF(ILINE.LT.56)                     GO TO 109
      WRITE(6,1101)
      ILINE=15
  109 READ(12,1102)  DOCTC, DOCTH
      DO  110  I=1,2
      READ(12,1001) IDUM
  110 CONTINUE
```

```
      READ(12,1102) QTTRC, QTTRH
      READ(12,1103) IPAC
      IF(IPAC.EQ.4HRECT)                    IIPAC=1
      IF(IPAC.EQ.4HCYLI)                    IIPAC=2
      IF(IPAC.EQ.4HSPHE)                    IIPAC=3
      READ(12,1104) XL, W, H
      XLC=XL*2.54
      WC=W*2.54
      HC=H*2.54
      IF(IIPAC-2) 111, 112, 113
  111 AC=2.*(HC*(XLC+WC)+WC*XLC)
      A=2.*(H*(XL+W)+W*XL)/144.
      VC=XLC*WC*HC
      V=XL*W*H/1728.
      GO TO 114
  112 AC=2.*PI*(WC**2+WC*XLC)
      A=2.*PI*(W**2+W*XL)/144.
      VC=PI*XLC*WC**2
      V=PI*XL*W**2/1728.
      GO TO 114
  113 AC=4.*PI*WC**2
      A=4.*PI*W**2/144.
      VC=4./3.*PI*WC**3
      V=4./3.*PI*W**3/1728.
  114 CONTINUE
      READ(12,1103) IMAT
      IF(IMAT.EQ.4HALUM)                     CPC=.208
      IF(IMAT.EQ.4HMAGN)                     CPC=.238
      IF(IMAT.EQ.4HSTAI)                     CPC=.11
      IF(IMAT.EQ.4HBERL)                     CPC=.38
      IF(IMAT.EQ.4HEPOX)                     CPC=.28
      READ(12,1105) CW
      READ(12,1105) TW
      TM=(CW*CPC+.2*(TW-CW))
      TMWK=TM*5./(9.*.293)
      CWK=CW*.45359237
      TWK=TW*.45359237
      READ(12,1106)  ALPHA, EMISS
      READ(12,1107)  SSP,(DATA(I),I=1,4)
      PC=0.
      PH=0.
      READ(12,1108) PC, TC, PH, TH
      READ(12,1107) OP, (DATA(I),I=1,4)
      QMIN=SSP+PC-OP
      QMAX=SSP+PH-OP
      IQMIN=QMIN
      IQMAX=QMAX
      DO 116 I=1,4
      READ(12,1001) IDUM
  116 CONTINUE
      IOM=4H
      READ(12,1112) IST, ITO, ITP
      IF(IST.EQ.3H ON.AND.ITO.EQ.3H ON.AND.ITP.EQ.3H ON)    IOM=4HCONT
      IF(IST.NE.3H ON.OR.ITO.NE.3H ON.OR.ITP.NE.3H ON)      IOM=4H INT
      CALL SINK(DOCTC,DOCTH,DSMI,DSMA,QMIN,QMAX,A,EMISS,QDCC,QDCH)
      CALL SINK(QTTRC,QTTRH,QSMI,QSMA,QMIN,QMAX,A,EMISS,QQCC,QQCH)
      CALL CONVRT (DSMI,DSMA,DSMIK,DSMAK)
      CALL CONVRT (QSMI,QSMA,QSMIK,QSMAK)
      IPDLM=QMIN/ AC*1.E+4
      IPDHM=QMAX/ AC*1.E+4
      IPDLF=QMIN/A
      IPDHF=QMAX/A
```

```
      ARRL=QMIN/TM
      ARRH=QMAX/TM
      IRRLK=ARRL*5./9.
      IRRHK=ARRH*5./9.
      IRRL=ARRL
      IRRH=ARRH
      IDSMI=DSMI
      IDSMA=DSMA
      IDSMIK=DSMIK
      IDSMAK=DSMAK
      IQSMI=QSMI
      IQSMA=QSMA
      IQSMIK=QSMIK
      IQSMAK=QSMAK
      CALL TIMCON (TM,A,QMIN,EMISS,DOCTH,TCL)
      CALL TIMCON (TM,A,QMAX,EMISS,DOCTH,TCH)
      WRITE(6,1109)IEQUIP,NO,(EQUIP(I),I=1,3), TWK, IPAC, AC, VC, ALPHA,
     1IQMIN, IPDLM, IPDHM, TCL,IRRLK, IRRHK, TMWK, IDSMIK, IDSMAK,
     2IQSMIK, IQSMAK, IOM, (MANUF(I),I=1,3), TW, A, V, EMISS, IQMAX,
     3IPDLF, IPDHF, TCH,IRRL, IRRH, TM, IDSMI, IDSMA, IQSMI, IQSMA
      ILINE=ILINE+2
  117 READ(12,1110) (DATA(I),I=1,11)
      IF(DATA(1).EQ.6H******.OR.DATA(1).EQ.6H      )           GO TO 118
      WRITE(6,1111) (DATA(I),I=1,11)
      ILINE=ILINE+1
      GO TO 117
  118 CONTINUE
      IF(QDCC.GT. 0. .OR. QDCH.GT. 0.)  GO TO 131
  130 IF(QQCC.GT. 0. .OR. QQCH.GT. 0.)  GO TO 132
      GO TO 133
  131 WRITE(6,1114)  QDCC, QDCH
      ILINE=ILINE+1
      GO TO 130
  132 WRITE(6,1115)  QQCC, QQCH
      ILINE=ILINE+1
  133 CONTINUE
      WRITE(6,1113)
      ILINE=ILINE+1
      DO 119 K=1,50
      READ(12,998) (DATA(I),I=1,2)
      IF(DATA(1).EQ.6H END**)          GO TO 120
  119 CONTINUE
  120 IF(ILINE.GT.51)     JEQUIP=4H
      GO TO 1
 1000 CONTINUE
      RETURN
      END
```

```
"FUR,IS CONVRT,CONVRT
      SUBROUTINE CONVRT (T1,T2,T1K,T2K)
      T1K=(5./9.)*(T1+459.67)
      T2K=(5./9.)*(T2+459.67)
      RETURN
      END
```

```
"FOR,IS SINK,SINK
      SUBROUTINE SINK(T1,T2,TS1,TS2,Q1,Q2,A,EMISS,QCC,QCH)
      QCC=0.
      QCH=0.
      SIGMA=.1714E-8
      IF((T1+460.)**4.LT. Q2/(.293*SIGMA*A*EMISS))    GO TO 1
      TS1=(((T1+460.)**4)- Q2/(.293*SIGMA*A*EMISS))**.25
      GO TO 2
    1 TS1=0.
      QCC=Q2-.293*SIGMA*A*EMISS*(T1+460.)**4
    2 TS1=TS1-460.
      IF((T2+460.)**4.LT. Q1/(.293*SIGMA*A*EMISS))    GO TO 3
      TS2=(((T2+460.)**4)- Q1/(.293*SIGMA*A*EMISS))**.25
      GO TO 4
    3 TS2=0.
      QCH=Q1-.293*SIGMA*A*EMISS*(T2+460.)**4
    4 TS2=TS2-460.
      RETURN
      END
```

```
@FOR,IS TIMCON,TIMCON
      SUBROUTINE TIMCON (TM,A,QW,E,TSINK,TIME)
      TINT=70.
      A1=0.67
      SIG=1.714E-09
      Q=QW/.293
      TS=TSINK+460.
      TO=TINT+460.
      TS4=TS**4
      TF4=(Q+SIG*E*A*TS4)/(SIG*E*A)
      TF=TF4**0.25
      TFIN=TF-460.
      TF3=TF4/TF
      T=TO+(TF-TO)*A1
      A2=4.*TF3*SIG*E*A/TM
      A3=((T+TF)*(TO-TF))/((TO+TF)*(T-TF))
      A4=ALOG(A3)
      A4A=T/TF
      A4B=TO/TF
      A5=2.*(ATAN(A4A)-ATAN(A4B))
      TIME=(A4+A5)/A2
      RETURN
      END
```

```
"XQT
"END
RAW        FINAL       THEREQ      CHAR
"FIN
```