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FINAL REPORT
SHUTTLE CRYOGENICS
SUPPLY SYSTEM
OPTIMIZATION STUDY

VOLUME V B-4

PROGRAMMERS MANUAL FOR
SPACE SHUTTLE ORBIT INJECTION ANALYSIS
(SOPSA)

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Prepared for Manned Spacecraft Center
by
Manned Space Programs, Space Systems Division

LOCKHEED MISSILES & SPACE COMPANY, INC.
A SUBSIDIARY OF LOCKHEED AIRCRAFT CORPORATION

FINAL REPORT
SHUTTLE CRYOGENIC SUPPLY SYSTEM
OPTIMIZATION STUDY

VOLUME VB-4

PROGRAMMERS MANUAL FOR SPACE SHUTTLE
ORBIT INJECTION SYSTEM ANALYSIS (SOPSA)

FOREWORD

This Final Report provides the results obtained in the Shuttle Cryogenics Supply System Optimization Study, NAS 9-11330, performed by Lockheed Missiles & Space Company (LMSC) under contract to the National Aeronautics and Space Administration, Manned Spacecraft Center, Houston, Texas. The study was under the technical direction of Mr. T. L. Davies, Cryogenics Section of the Power Generation Branch, Propulsion and Power Division. Technical effort producing these results was performed in the period from October 1970 to June 1973.

The Final Report is published in eleven volumes*:

Volume I	Executive Summary
Volumes II, III, and IV	Technical Report
Volumes VA-1 and VA-2	Math Model - Users Manual
Volumes VB-1, VB-2, VB-3, and VB-4	Math Model - Programmers Manual
Volume VI	Appendixes

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*The Table of Contents for all volumes appears in Volume I only. Section 12 in Volume III contains the List of References for volumes I through IV.

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INTRODUCTION

SOPSA (Space Shuttle Orbit Injection Propulsion System Analysis) is a computer program developed by Lockheed Missiles & Space Company, Inc., as part of the Shuttle Cryogenic Supply System Optimization Study, Contract NAS9-11330, for the NASA, Manned Spacecraft Center. This manual contains a detailed description of the program, its operational characteristics, and computer system requirements.

SOPSA DEVELOPMENT AND UTILIZATION

The SOPSA program was developed by IMSC primarily as an analytical tool to aid in the preliminary design of propellant feed systems for the Space Shuttle Orbiter main engines. The primary purpose of the SOPSA program is to evaluate propellant tank ullage pressure requirements imposed by the need to accelerate propellants rapidly during the engine start sequence. These requirements can influence the system design for a given engine as well as the suitability of a given system for use with different engines. During the vehicle design phase, the SOPSA program is used to establish feed system weight variations as a function of nominal line diameter and component and line configurations. The weight data are used in conjunction with pertinent cost data to establish optimum feed system designs.

The SOPSA program will generate parametric feed system pressure histories and weight data for a range of nominal feedline sizes. This is accomplished by evaluating tank ullage pressure requirements during the startup phase using the constraints of engine inlet pressure (or NPSP) requirements and instantaneous values of feedline flow resistance. Program flexibility has been incorporated to allow for engine start on the ground or at altitude, computations for oxidizer, fuel or both oxidizer and fuel feedlines,

and a multiple restart capability requiring restart data input only for quantities whose values have changed from the previous case.

The SOPSA program utilizes a simple, in-line computational sequence to solve for the propellant tank ullage pressure requirements. Input data describe the number of main propellant feedline sizes to be considered, and the number of engine feedlines attached to each main feedline (i.e., the number of branch lines feeding each engine). The number and type of components in each line are described, with up to 23 line components currently being available. These components include straight and curved line sections, valves, bellows, venturis and PVC's. (The program computes component weights and flow resistance coefficients and display total values for each line as part of the output data.) Engine flowrate, NPSP and thrust profiles during the startup transient are also input. In addition propellant tank geometry and propellant and vehicle weights are required, along with input data control flags and miscellaneous boundary conditions. The program will compute the various pressure drop components needed to evaluate tank pressure requirements during engine start. These calculations are performed for each candidate main feedline size (engine feedline sizes assumed fixed) as a function of time throughout the start transient. Feedline weights are computed based on the maximum value of engine inlet pressure, the maximum value of tank bottom pressure, or an input design pressure, which ever is greatest.

The output data display consists of reformatted input data, feedline flow resistance coefficients, time-varying values of the pressure drop components to hydrostatic head, flow acceleration, and line friction and configuration losses. Computed values of nominal and minimum required values of tank ullage pressure are displayed, as well as tank bottom and engine inlet pressures. Total feedline system weights are also output for each candidate main feedline size.

In summary, the present SOPSA capabilities are as follows:

- Performs pressure drop calculations for up to four engines per main feedline.
- Handles up to 12 candidate main feedline sizes per engine.
- Computes component weight and flow resistance for up to 100 components in each feedline.
- Input options available to describe 23 types of components, 7 material types, and 6 insulation types.
- Operates on the UNIVAC 1108 computer utilizing the EXEC 8 operating system.
- Approximate computer run time is 6 seconds per case.

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Section 1

SOPSA PROPELLANT FEED SYSTEM ANALYSIS PROGRAM

A major consideration in the design of propellant tanks and feed systems for the Space Shuttle Orbiter vehicle is the requirement that propellants be accelerated rapidly during the engine start sequence. Propellant tank structural design is influenced by the maximum ullage pressure levels required to provide sufficient flow acceleration, as well as hydrostatic pressure levels incurred during boost. Flow acceleration requirements, in turn, are dictated by pressure levels required to provide specified propellant flowrates at the engine during startup, while simultaneously satisfying minimum NPSP and inlet pressure requirements. Propellant feed system weight and flow resistance are influenced by component size and design pressure levels. Thus optimization of feed system design requires values of tank ullage pressure as a function of feedline diameter as well as feed system weight. The SOPSA program is designed to compute required pressure values and feed system weights for a range of main feedline diameters.

The SOPSA program consists of a main program (STAR), in which the basic pressure drop calculations are performed, and 16 subprograms which provide thermodynamic property data and perform auxiliary computations. The main program also controls the input of data and the output of computed results.

The UNIVAC 1108-Procedure Definition Processor (PDP) is used to define two blocks of FORTRAN code which are introduced into the main program (and selected subprograms) during compilation by use of the source control statement INCLUDE. The first PDP element is named DIMN and contains COMMON statements for labeled COMMON block DIMEN, as well as REAL and EQUIVALENCE statement definitions.

The second PDP element is named UC/NST and contains only the COMMON block labeled UC/NST.

The variables defined in these COMMON blocks are described in Section 1.1.3 below.

1.1 PROGRAM STAR

1.1.1 Program Description

STAR is the SØPSA main program; all data input and output is controlled by STAR and the solution of the time-varying pressure drop components is accomplished in STAR.

Required values of propellant tank ullage pressures during engine start are determined by the pressures required to accelerate the propellant at the rate necessary to supply required flowrates at the engine. A proper accounting of the system pressure drops yields the following relation for ullage pressure requirement at any time t during the start transient:

$$P_u(t) = P_{\min} - \Delta P_{\text{HEAD}}(t) + \Delta P_F(t) + \Delta P_{\text{ACC}}(t) + P_{\text{TOL}} \quad (1)$$

where

$$P_{\min} = \text{Maximum value of } \left\{ \begin{array}{l} P_{\text{NPSP}} + P_{\text{VAP}} \\ \text{or} \\ P_{\text{ENG}} \end{array} \right\}$$

P_{NPSP} = Engine NPSP requirement

P_{VAP} = Propellant vapor pressure at engine inlet

P_{ENG} = Minimum engine inlet pressure

ΔP_{HEAD} = Hydrostatic pressure at engine inlet due to vehicle acceleration

ΔP_F = Pressure drop due to friction in main feedline and engine feedlines

ΔP_{ACC} = Pressure drop required to accelerate propellant to meet the specified flowrate variation during startup

P_{TOL} = Component pressure control tolerance

The pressure control tolerance is generally interpreted to be a combined tolerance on ullage pressure controls and engine inlet requirements.

Equation (1) is solved for an assumed feedline configuration employing a single main feedline for each propellant with up to four branching engine feedlines. Feed systems employing dual main feedlines can be analyzed by restarts or separate runs. Currently, the program is restricted to consider liquid oxygen as the oxidizer and liquid hydrogen as the fuel. An input data flag (SYSNUM) is used to specify whether computations are to be performed for the oxidizer system, fuel system or both feed systems. A ground start flag (NGST) is used to distinguish between engine start on the ground ($g/g_0 = 1.0$) or at altitude ($g/g_0 = \text{Total Thrust/Vehicle Mass}$) for purposes of hydrostatic head computations.

Inputs to the program are required to:

- Describe the alphanumeric output heading for each case
- Flag data groups to be input
- Describe the propellant tank and feed system configuration
- Describe initial propellant loadings and nominal flow conditions
- Describe transient flowrate, pressure and engine inlet requirements

Input requirements are described in detail in the Space Shuttle Orbit Injection Propulsion System Analysis (SOPSA), User's Manual, IMSC-A991396.

Printed output data include a listing of several input data quantities as follows:

Total number of feedline sizes, NSIZE

Total number of engines on vehicle, NØP1

~~Number of engines for each feed system, NØP~~

Nominal oxidizer flowrate, WDØTNØ, lb/sec

Nominal fuel flowrate, WDØTINH, lb/sec

Vehicle loaded weight, VWGTN, lb

Nominal thrust for each engine, $FN\phi$, lb
 Oxygen engine inlet temperature, $TENIN\phi$, R
 Hydrogen engine inlet temperature, $TENINH$, R
 Component pressure tolerance, $PENT\phi L$, Psi
 Oxidizer feedline head height, $\phi XHTLN$, ft
 Fuel feedline head height, $HYHTLN$, ft
 Initial oxidizer loading, $L\phi AD\phi l$, lb
 Initial fuel loading, $L\phi ADHl$, lb
 Oxygen feedline design pressure, $PDL\phi$, psia
 Hydrogen feedline design pressure, $PDLH$, psia
 Tank geometry data, $EQLRl$, ft
 Oxidizer feedline diameters, ϕPD , inches
 Hydrogen feedline diameters, HPD , inches
 Main oxygen feedline lengths, $T\phi TML\phi$, ft
 Main hydrogen feedline lengths, $T\phi TMLH$, ft

In addition, computer values of oxidizer and fuel head heights in the propellant tanks ($HEADI\phi$ and $HEADIH$), initial ullage volumes ($ULVLI\phi$ and $ULVLIH$), external surface areas of the propellant tanks ($ASKIN$), surface area of the common bulkhead ($AD\phi ME$) total tank surface area ($AT\phi T$), and feedline flow-resistance coefficients (ϕKPD and $HKPD$) are printed.

Input values of component descriptors are listed in the following order:

	Comp. Seq. No.	Component Type Flag	Material Flag	Insulation Flag	Spec. No. 1	Spec. No. 2
Oxidizer Main Line	I	IDML ϕ (I)	IMML ϕ (I)	IIML ϕ (I)	SPIML ϕ (I)	SP2ML ϕ (I)
Oxidizer Engine Line	I	IDEL ϕ (NL,I)	IMELO(NL,I)	IIELO(NL,I)	SPIELO(NL,I)	SP2ELO(NL,I)
Fuel Main Line	I	IDMLH(I)	IMMLH(I)	IIMLH(I)	SPIMLH(I)	SP2MLH(I)
Fuel Engine Number NL	I	IDELH(NL,I)	IMELH(NL,I)	IIEH(NL,I)	SPIELH(NL,I)	SP2ELH(NL,I)

In addition to the basic fixed input data, values of time-varying input quantities are output. These include the following variables:

Time during engine start, $TIMEA$, sec
 Oxidizer suction pressure requirement, $NPSP\phi$, psi
 Fuel suction pressure requirement, $NPSPH$, psi
 Fraction of steady-state engine thrust, $FIFRAC$
 Engine inlet oxidizer pressure requirement $PENMN\phi$, psia
 Engine inlet fuel pressure requirement, $PENMNH$, psia
 Partial pressure of pressurant gas in oxidizer tank, $PPDG\phi T$, psia
 Partial pressure of pressurant gas in fuel tank, $PPDGHT$, psia
 Inlet temperature of pressurant gas in oxidizer tank, $TDG\phi T$, R
 Inlet temperature of pressurant gas in fuel tank, $TDGHT$, R

Values of several quantities obtained at intermediate stages of the pressure drop computations are also output as a function of time.

These quantities include:

Oxidizer flowrate derivatives, $WDD\phi T\phi$, lb/sec^2
 Fuel flowrate derivatives, $WDD\phi TH$, lb/sec^2
 Total vehicle weight, $VWGTNU$, lb
 Thrust-to-weight ratio, $FT\phi W$
 Oxidizer hydrostatic pressure heat at engine inlet due to vehicle acceleration, $DLPHD\phi$, psi
 Incremental oxidizer consumption, $PCWGT\phi$, lb
 Incremental fuel consumption, $PCWGT\phi H$, lb
 Cumulative total propellant consumption, $PR\phi WGT$, lb
 Minimum oxidizer engine inlet pressure required, $PENG\phi$, psia
 Minimum fuel engine inlet pressure required, $PENGH$, psia

Additional intermediate output includes pressure drop components as follows:

Pressure drop required to accelerate oxidizer to meet specified flowrates, $DLPAC\phi$, psi

Pressure drop required to accelerate fuel to meet specified flowrates, $DLFACH$, psi

Oxidizer pressure drop due to line friction and configuration losses, $DLPLN\emptyset$, psi

Fuel pressure drop due to line friction and configuration losses, $DLPLNH$, psi

Nominal ullage pressure requirements in oxidizer and fuel tanks, respectively (without accounting for minimum engine inlet requirements), $PULL\emptyset$ and $PULLH$, psia

Oxidizer and fuel vapor pressures at the liquid surfaces, $PULVAP\emptyset$ and $PULVAPH$, psia

Minimum oxidizer and fuel ullage pressures required for main feedline No. 1, $PULLR\emptyset$ (NELP) and $PULLRH$ (NELP), psia

Tank bottom pressures for feedline No. 1, $PTKBT\emptyset$ (NELP), and $PTKBTH$ (NELP), psia

Line head pressure components, $PHDLN\emptyset$ and $PHDLNH$, psia

Tank ullage volumes, $ULVL\emptyset 2$ and $ULVLH 2$, ft^3

Tank head heights, $HEAD\emptyset 2$ and $HEADH 2$, ft

Ullage vapor weights, $WTULG\emptyset$ and $WTULGH$, lb

The final computations are printed in the following order.

Minimum required ullage pressure in oxidizer tank, $PULLR\emptyset$, psia

Minimum required ullage pressure in fuel tank, $PULLRH$, psia

Recomputed tank bottom pressures using minimum required ullage pressures, $PTKBT\emptyset$ and $PTKBTH$, psia

Recomputed engine inlet pressures using minimum required ullage pressures, $PENNU\emptyset$ and $PENNUH$, psia

Individual engine feedline weights, $WEL\emptyset$ and $WELH$, lb

Total weights of all engine feedlines, $WEL\emptyset T$ and $WELHT$, lb

Main feedline weights, $WML\emptyset$ and $WMLH$, lb

Engine and main feedline insulation weights, $WELI\emptyset T$, $WELIHT$, $WMLI\emptyset$, $WMLIH$, lb

Total feed system weights, $WL\emptyset TT$ and $WLHTT$, lb

1.1.2 External Subprograms

<u>Name</u>	<u>Type*</u>	<u>Reference**</u>	<u>Name</u>	<u>Type</u>	<u>Reference</u>
MOVER	S		ZFIND	S	
INIVOL	S		FINDR	F	
ULLHED	S		PTDENS	F	
FLORES	S		WICTRL	S	
PVAPOR	S		EXIT	S	Transfer control to system

1.1.3 COMMON Description

The COMMON block labeled DIMEN is INCLUDED in the main program STAR and sub-routines INIVOL and ULLHED. This block contains the following variables:

<u>Name</u>	<u>Type***</u>	<u>Dimension</u>	<u>Description</u>
EQLR	R	9	Array containing tank geometry data
V1	R		Volumes of sections of liquid oxygen tank
V2	R		
V3	R		
V4	R		
V5	R		Volumes of sections of liquid hydrogen tank
V6	R		
V7	R		

*P - Program, S - Subroutine, F - Function
 **Page number where subprogram is described
 ***I - Integer, R - Real, L - Logical

<u>Name</u>	<u>Type</u>	<u>Dimension</u>	<u>Description</u>
VTØ2	R		Total volume LO ₂ tank
VTH2	R		Total volume LH ₂ tank
VTØT	R		Total volume both tanks
UVLØ2	R		Ullage volume LO ₂ tank
UVLH2	R		Ullage volume LH ₂ tank
HDØ2	R		Liquid height in LO ₂ tank
HDH2	R		Liquid height in LH ₂ tank
A1	R		Surface area of sections of LO ₂ tank
A2	R		
A3	R		
A4	R		
A6	R		Surface area of sections of LH ₂ tank
A7	R		
ATØT	R		Total surface area of both tanks
ASKIN	R		External surface area of both tanks
ADØME	R		Area of common bulkhead

The ~~COMMON~~ block labeled UCØNST is INCLUDED in the main program STAR and subroutines ULLHED, GØMTRY and SPHSEG. This block contains the following variables:

<u>Name</u>	<u>Type</u>	<u>Dimension</u>	<u>Description</u>
IIN	I		Hardware logical input unit number
IØT	I		Hardware logical output unit number
PI	R		3.1415927
PI2Ø3	R		2.0943951

Seven additional labeled ~~COMMON~~ blocks contain the significant variables used in the main program. Storage allocated for these variables is described in Tables l-1 through l-7.

Table 1-1
LAYOUT OF COMMON BLOCK AAA

Address ⁽¹⁾	Name	Dimension ⁽²⁾	Description
0	FIFRAC	21	Fraction of nominal thrust
25	TIMEA	21	Time values of events in transient
52	WDTFRO	21	Fraction of oxidizer flowrate
77	WDTFRH	21	Fraction of fuel flowrate
124	NPSPO	21	Net positive suction pressure for oxidizer
151	NPSPH	21	Net positive suction pressure for fuel
176	PPDGOT	36	Partial pressure of oxidizer pressurant gas
242	PPDGHT	36	Partial pressure of fuel pressurant gas
306	TLIQSO		Temperature of oxidizer liquid surface in tank
307	TLIQSH		Temperature of fuel liquid surface in tank
310	TSSVAP0		Temperature of oxidizer liquid surface in tank
311	TSSVAPH		Temperature of fuel liquid surface in tank
312	TDGOT	35	Temperature of oxidizer pressurant gas
355	TDGHT	35	Temperature of fuel pressurant gas
420	LOAD01		Loaded weight of oxidizer
421	LOADH1		Loaded weight of fuel
422	LOAD02		Loaded volume of oxidizer
423	LOADH2		Loaded volume of fuel

Table 1-2
LAYOUT OF COMMON BLOCK BBB

Address	Name	Dimension	Description
0	NSIZE		Total number of feedlines per tank
1	SYSNUM		Propellant selection flag
2	NOP		Number of engines fed by a main feedline
3	NOPL		Number of engines on vehicle
4	IGOON		Restart flag
5	NPTS		Number of time points in start transient
6	MPTS		NPTS-1

Note: (1) Address in octal notation
(2) Decimal dimension

Table 1-3
LAYOUT OF COMMON BLOCK CCC

Address	Name	Dimension	Description
0	GC		Acceleration of gravity, 32.172 fps ²
1	RHOOX		Oxidizer density
2	RHOHY		Fuel density
3	VWGTN		Total vehicle weight at ignition

Table 1-4
LAYOUT OF COMMON BLOCK DDD

Address	Name	Dimension	Description
0	WDOFNO		Nominal oxidizer flowrate per engine
1	WDOFNH		Nominal fuel flowrate per engine
2	FNOM		Nominal thrust per engine
3	OPIPEL	16	Oxidizer feedline lengths
2	HPIPEL	16	Fuel feedline lengths
43	OPD	16	Oxidizer feedline diameters
63	HPD	16	Fuel feedline diameters
103	OKPD	16	Oxidizer feedline flow resistance coefficients
123	HKPD	16	Fuel feedline flow resistance coefficients
143	ST	7	Alphanumeric title
152	OXHTLN		Oxidizer lead height in feedline
153	HYHTLN		Fuel lead height in feedline
154	PENMNO	30	Minimum engine inlet oxidizer pressures
212	PENMNH	30	Minimum engine inlet fuel pressures
250	PENTOL		Component pressure tolerance
251	TENINO		Temperature of oxidizer at engine inlet
252	TENINH		Temperature of fuel at engine inlet

Table 1-5
LAYOUT OF COMMON BLOCK EEE

Address	Name	Dimension	Description
0	OPDUM		Oxidizer line length used in acceleration calcs.
1	ODDUM		Square of oxidizer line diameter
2	HPDUM		Fuel line length used in acceleration calcs.
3	HDDUM		Square of fuel line diameter
4	VWGTCH		Variable used in vehicle weight calculations
5	ODLDUM		Fourth power of oxidizer line diameter
6	OCAYP		Variable used in pressure drop calculations
7	ODTINC		Not used
10	HDLDUM		Fourth power of fuel line diameter
11	HCAYP		Variable used in pressure drop calculations
12	HDTINC		Not used
13	TVAPO		Equivalent oxidizer engine inlet temperature
14	TVAPH		Equivalent fuel engine inlet temperature
15	PVAPO		Oxidizer vapor pressure
16	PVPENO		Oxidizer vapor pressure at engine inlet
17	PVAPH		Fuel vapor pressure
20	PVPENH		Fuel vapor pressure at engine inlet
21	PNCWGT		Equivalent cumulative propellant consumption

Table 1-6
LAYOUT OF COMMON BLOCK FFF

Address	Name	Dimension	Description
0	WDDOTO	20	Oxidizer flowrate derivative
24	WDDOTH	20	Fuel flowrate derivative
50	ZLPACO	20	Not used
74	ZLPACH	20	Not used
120	VWGTNU	20	Vehicle weight
144	FTOW	20	Thrust-to-weight ratio
170	DIFWGT	20	Propellant flowrate increment
214	DLPHDO	20	Oxidizer pressure head in tank
240	DLPHDH	20	Fuel pressure head in tank
264	ZLPLNO	20	Not used
310	ZLPLNH	20	Not used
334	PENGO	20	Minimum oxidizer engine inlet pressure
360	PENGH	20	Minimum fuel engine inlet pressure
404	PCWGTO	20	Incremental oxidizer consumption
430	PCWGTH	20	Incremental fuel consumption
454	PUVAPO		Oxidizer vapor pressure at liquid surface
455	PSVAPO		(Same as PUVAPO)
456	PUVAPH		Fuel vapor pressure at liquid surface
457	PSVAPH		(Same as PUVAPH)
460	PPVAPO		Not used
461	PPVAPH		Not used
462	ULVLIO		Initial ullage volume in oxidizer tank
463	ULVLIH		Initial ullage volume in fuel tank
464	HEADIO		Oxidizer head height in the tank
465	HEADIH		Fuel head height in the tank

Table 1-7
LAYOUT OF COMMON BLOCK GGG

Address	Name	Dimension	Description
0	WTULGO	35	Oxidizer tank ullage vapor weight
43	WTULGH	35	Fuel tank ullage vapor weight
106	ULVO2		Not used
107	ULVH2		Not used
110	HEADO2	35	Oxidizer tank head height
153	HEADH2	35	Fuel tank head height
216	ULVLO2	35	Oxidizer tank ullage volume
261	ULVLH2	35	Fuel tank ullage volume

1.1.4 Significant Variables

In addition to the variables defined in Tables 1-1 through 1-7, the following quantities are significant in the operation of program STAR:

<u>Name</u>	<u>Type</u>	<u>Dimension</u>	<u>Description</u>
IP	I	16	Input data flag
WELØT	R	16	Total oxidizer engine feedline weight
WELHT	R	16	Total fuel engine feedline weight
UMLØ	R	16	Main oxidizer feedline weight
WMLH	R	16	Main fuel feedline weight
WLØTT	R	16	Total oxidizer feed system weight
WLHTT	R	16	Total fuel feed system weight

1.1.5 Tape Usage

No tapes are used by this program.

1.1.6 Flow Chart and Listing Reference

STAR Flow Chart	Fig. 1-1
STAR Program Listing	Page B-2
Variable Table	Page C-3
Statement Number Table	Page C-10
Transfer Table	Page C-15

1.1.7 Subprogram Descriptions

Each subprogram of STAR will be described using the following format:

Description

Description will briefly describe the subprogram.

Calling Sequence

Calling Sequence will contain the following elements:

<u>Name</u>	<u>Type</u>	<u>I/O</u>	<u>Dimension</u>	<u>Description</u>
-------------	-------------	------------	------------------	--------------------

Name is the name of the variable in the calling sequence.

Type indicates the type of the variable; I - integer, R - real, or L - logical.

I/O indicates if the variable is input (I) to the routine through the calling sequence, output (O) from this routine through the calling sequence, or I/O if both.

Significant Variables

Significant Variables will contain the following elements:

<u>Name</u>	<u>Type</u>	<u>Dimension</u>	<u>Description</u>
-------------	-------------	------------------	--------------------

The elements of Significant Variables will be as described under Calling Sequence.

Subprograms Referenced in this Subprogram

<u>Name</u>	<u>Type</u>	<u>Reference</u>
-------------	-------------	------------------

The elements of Subprograms Referencing this Subprogram will be the same as described under Subprograms Referenced in this Subprogram.

Flow Chart and Listing Reference

Flow Chart references the figure number of the applicable flow chart. Appendix A illustrates and explains the flow chart symbols.

Listing references include the page numbers of the SOPSAs listings and subroutine dictionary listings where the subroutine listing, variable table, statement number table, and transfer table may be found.

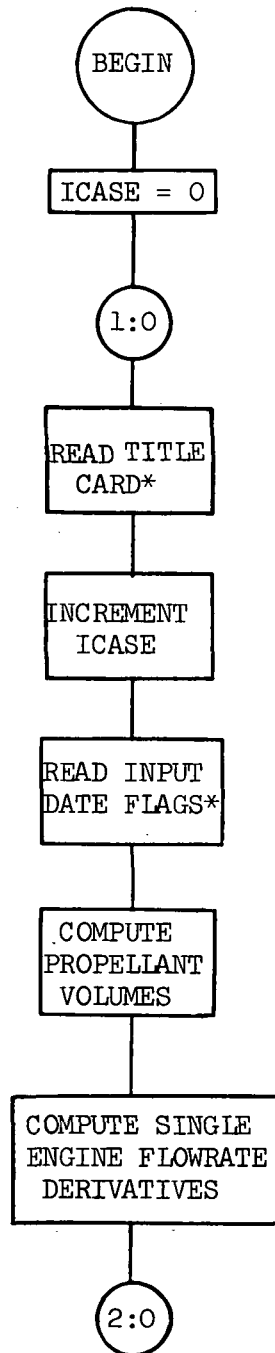


Fig. 1-1 STAR Flow Chart

*NOTE: TITLE CARD AND INPUT DATA FLAG CARD ARE REQUIRED FOR EACH CASE. THE REMAINING DATA MUST BE SUPPLIED FOR THE FIRST CASE; SUBSEQUENT CASES (RESTARTS) REQUIRE ONLY THAT REVISED DATA GROUPS BE INPUT (SEE SOPSA USER'S MANUAL, PAGE).

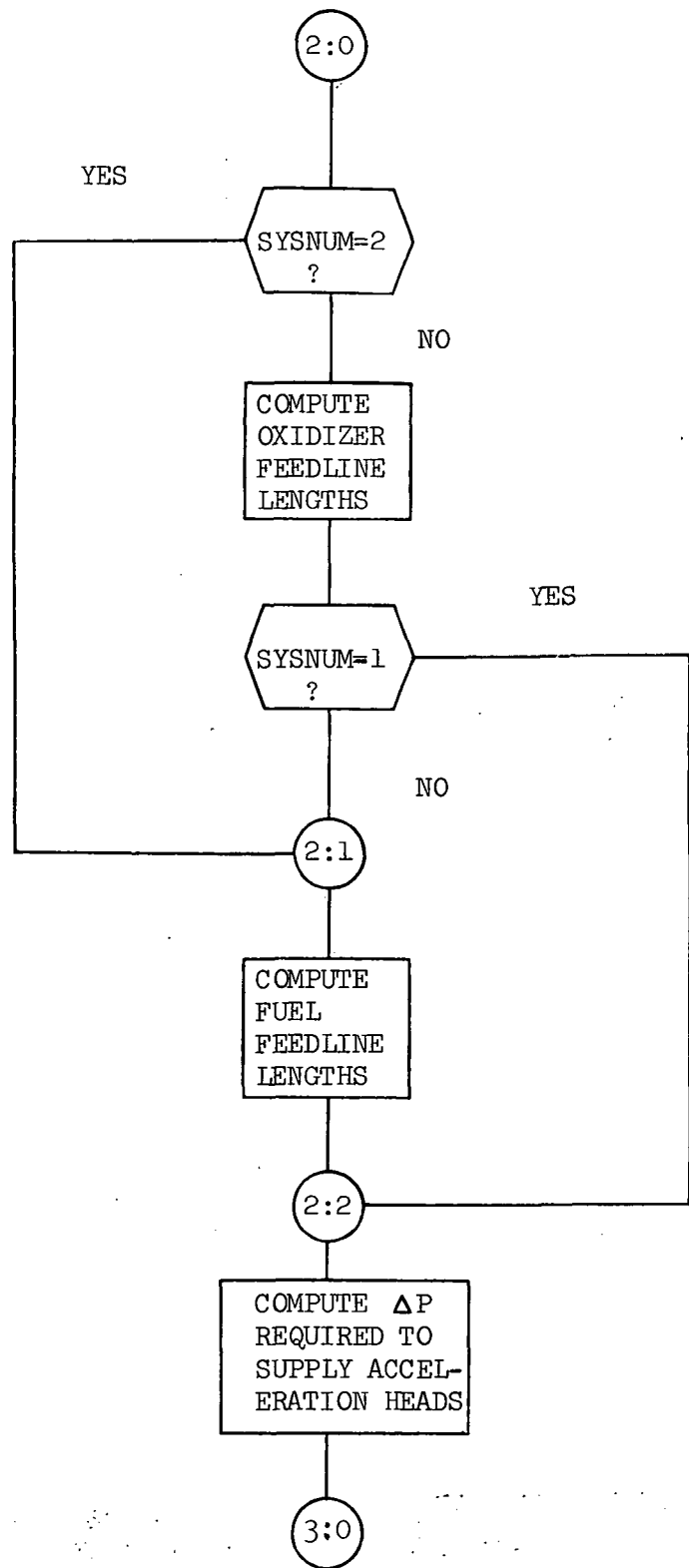


Fig. 1-1 STAR Flow Chart (Cont'd)

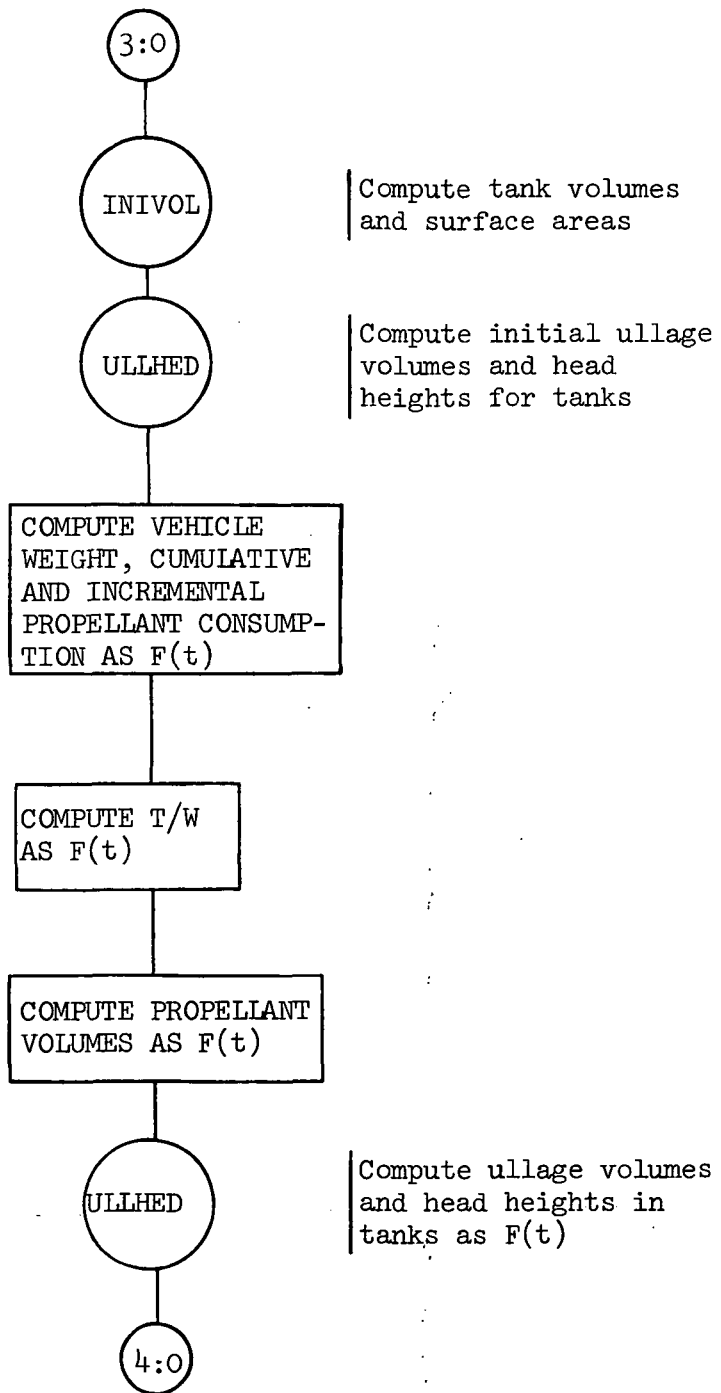


Fig. 1-1 STAR Flow Chart (Cont'd)

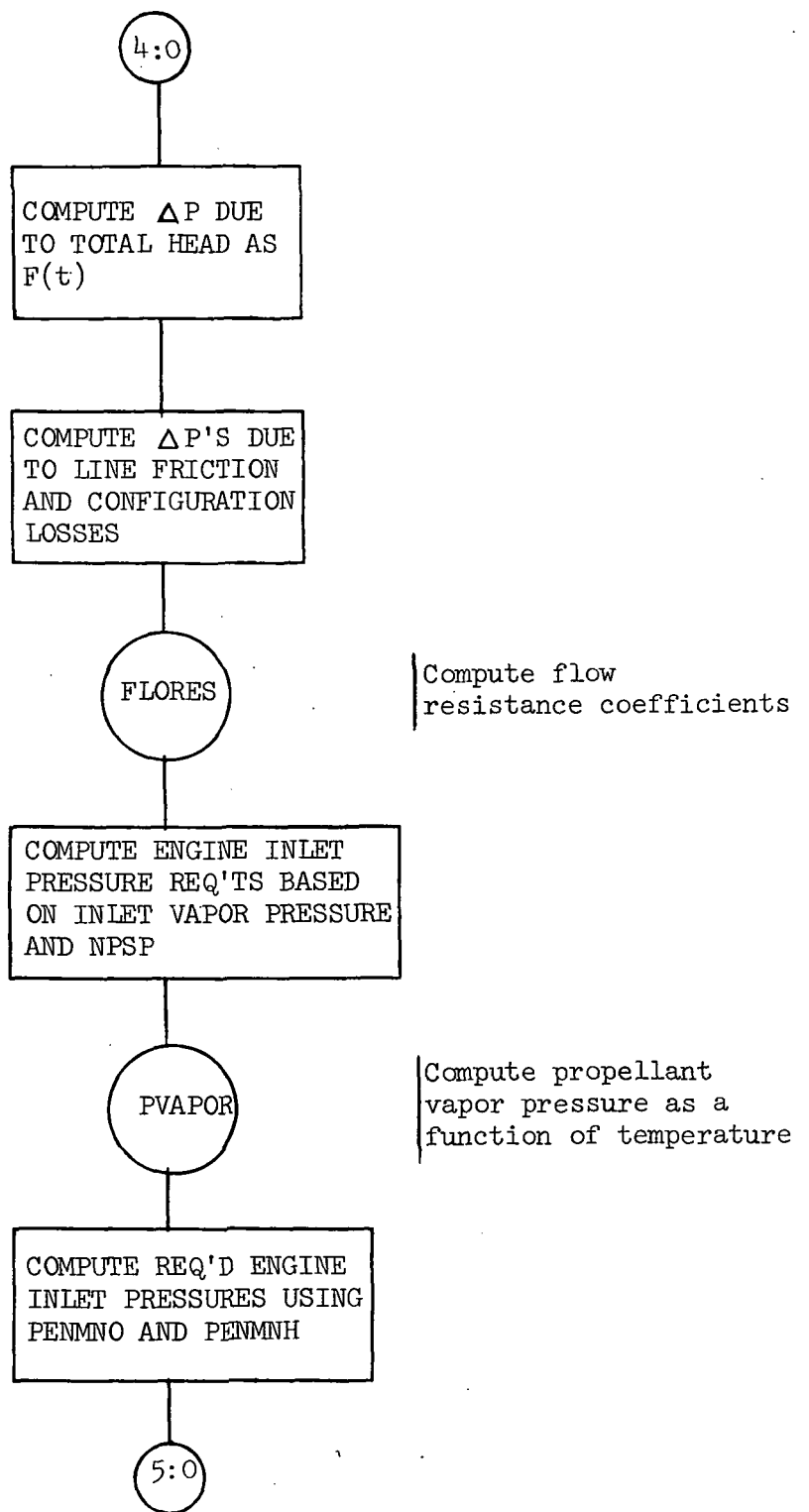


Fig. 1-1 STAR Flow Chart (Cont'd)

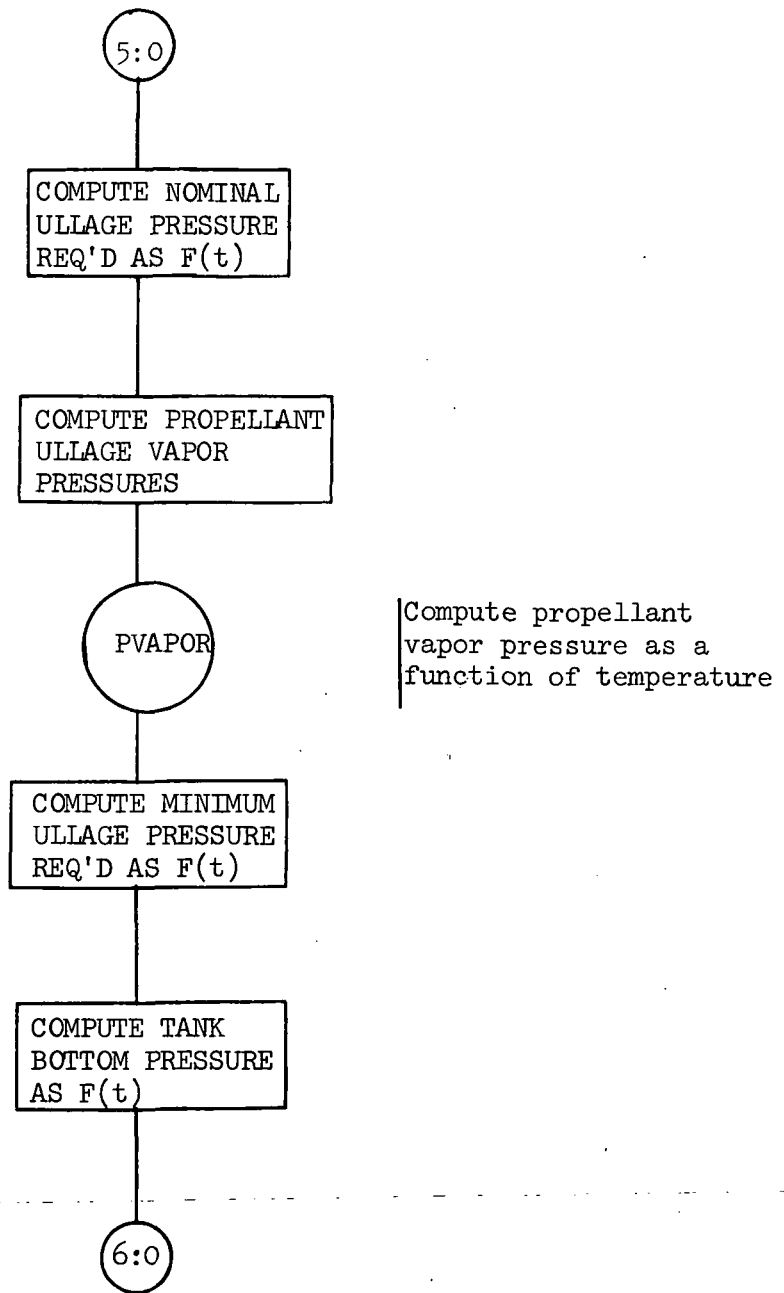


Fig. 1-1 STAR Flow Chart (Cont'd)

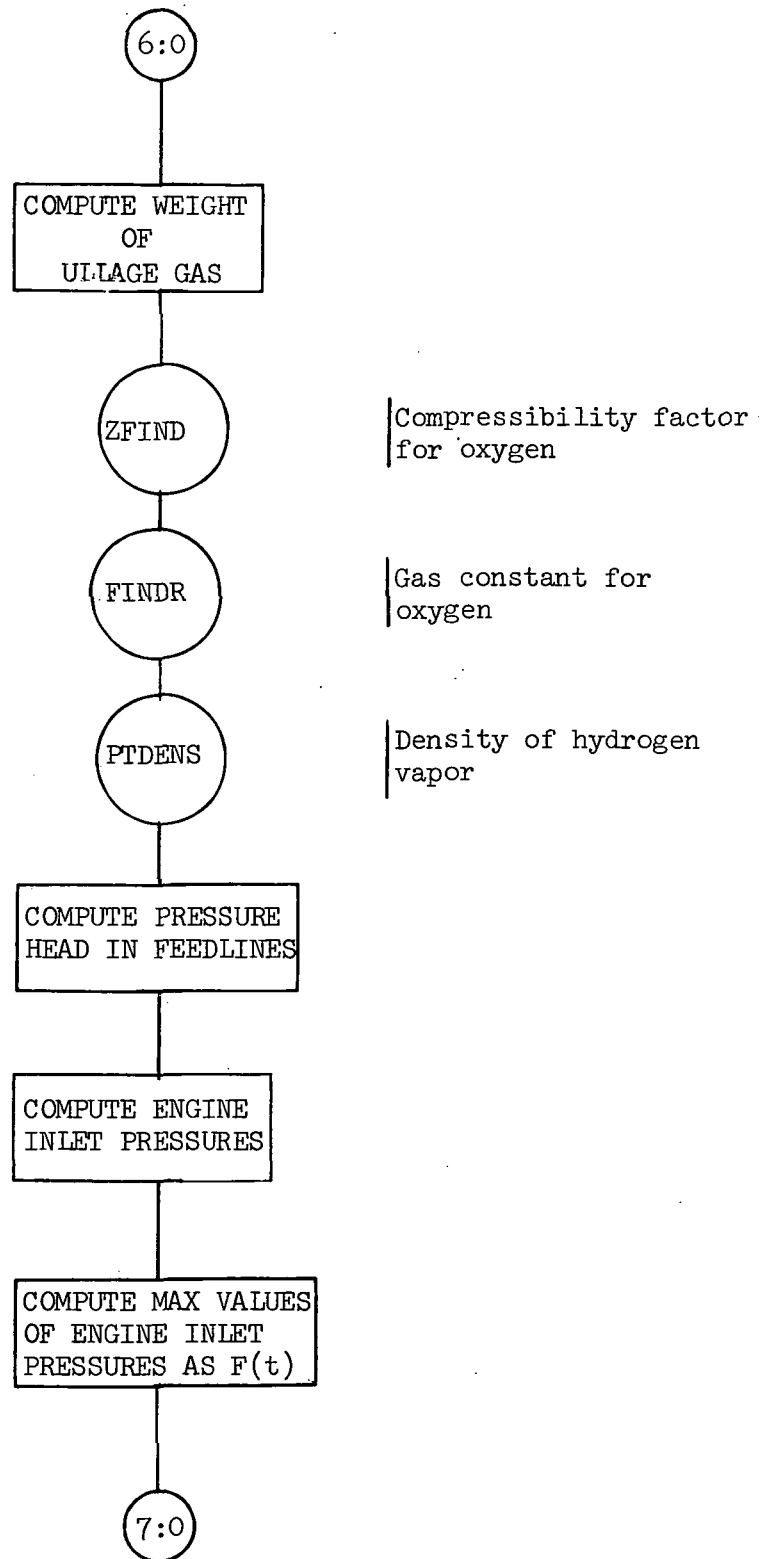


Fig. 1-1 STAR Flow Chart (Cont'd)

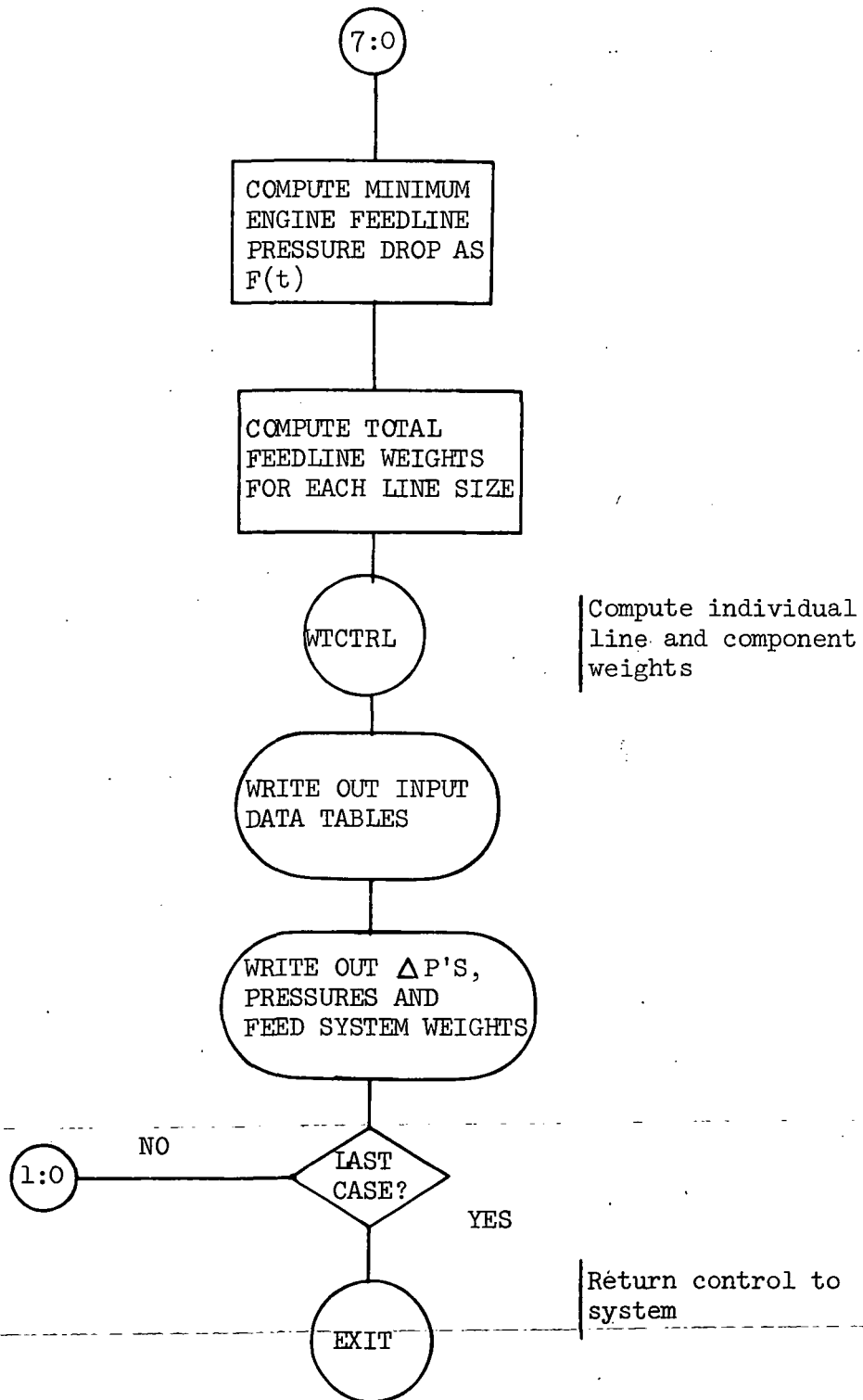


Fig. 1-1 STAR Flow Chart (Cont'd)

1.1.7.1 Subroutine INIVOLDescription

Subroutine INIVOL computes the volume and surface areas of individual sections of the propellant tanks using the dimensions supplied in input data group 2. The individual volumes and areas are summed for each tank and the total external surface area is computed.

Calling Sequence

```
CALL INIVOL
```

Significant Variables

<u>Name</u>	<u>Type</u>	<u>Dimension</u>	<u>Description</u>
VT02	R		Volume oxygen tank
VTH2	R		Volume hydrogen tank
VTOT	R		Total tank volume
ASKIN	R		External surface area
ADOME	R		Area of common bulkhead

Subprograms Referenced in this Subprogram

<u>Name</u>	<u>Type</u>	<u>Reference</u>
GOMETRY	F	38

Subprograms Referencing this Subprogram

<u>Name</u>	<u>Type</u>	<u>Reference</u>
STAR	P	6

Flow Chart and Listing Reference

INIVOL Flow Chart	None
INIVOL Program Listing	Page B-27
Variable Table	Page C-16
Statement Number Table	None
Transfer Table	Page C-17

1.1.7.2 Subroutine ULLHED

Description

This subroutine uses the given values of propellant volumes and tank dimensions to compute ullage volumes and liquid head heights in the tanks.

Calling Sequence

CALL ULLHED (L ϕ AD ϕ 2, L ϕ ADH2)

<u>Name</u>	<u>Type</u>	<u>I/O</u>	<u>Dimension</u>	<u>Description</u>
L ϕ AD ϕ 2	R	I		Oxidizer volume
L ϕ ADH2	R	I		Fuel volume

Significant Variables

<u>Name</u>	<u>Type</u>	<u>Dimension</u>	<u>Description</u>
UVL ϕ 2	R		Oxidizer ullage volume
UVLH2	R		Full ullage volume
HD ϕ 2	R		Oxidizer head height
HDH2	R		Fuel head height

Subprograms Referenced in this Subprogram

<u>Name</u>	<u>Type</u>	<u>Reference</u>
SPHSEG	S	41

Subprogram Referencing this Subprogram

<u>Name</u>	<u>Type</u>	<u>Reference</u>
STAR	P	1-2

Flow Chart and Listing Reference

ULLHED Flow Chart	None
ULLHED Program Listing	Page B- 8
Variable Table	Page C-16
Statement Number Table	Page C-20
Transfer Table	Page C-21

1.1.7.3 Subroutine FLORESDescription

This subroutine uses empirical correlations for pressure drop in turbulent flow (Reynold's No. greater than 10^6) to compute flow resistance coefficients due to configuration losses for the configurations defined in Table 1-1 of the SOPSA Program User's Manual.

Calling Sequence

CALL FLORES (ID, D, S1, S2, RES)

<u>Name</u>	<u>Type</u>	<u>I/O</u>	<u>Dimension</u>	<u>Description</u>
ID	I	I		Component ID number
D	R	I		Diameter
S1	R	I		Component specification No. 1
S2	R	I		Component specification No. 2
RES	R	O		Flow resistance factor

Significant Variables

None

Subprograms Referenced in this Subprogram

None

Subprograms Referencing this Subprogram

<u>Name</u>	<u>Type</u>	<u>Reference</u>
STAR	P	6

Flow Chart and Listing Reference

FLORES Flow Chart	None
FLORES Program Listing	Page B-29
Variable Table	Page C-22
Statement Number Table	Page C-23
Transfer Table	Page C-24

1.1.7.4 Subroutine PVAPORDescription

Subroutine PVAPOR computes the saturation vapor pressure of a liquid given the value of liquid temperature.

Calling Sequence

CALL PVAPOR (T, I, P)

<u>Name</u>	<u>Type</u>	<u>I/O</u>	<u>Dimension</u>	<u>Description</u>
T	R	I		Liquid temperature
I	I	I		Fluid type flag, I = 1 for oxygen I = 2 for hydrogen
P	R	O		Vapor pressure

Significant Variables

None

Subprograms Referenced in this Subprogram

None

Subprograms Referencing this Subprogram

<u>Name</u>	<u>Type</u>	<u>Reference</u>
STAR	P	6
ZFIND	S	31

Flow Chart and Listing Reference

PVAPOR Flow Chart	None
PVAPOR Program Listing	Page B-32
Variable Table	Page C-25
Statement Number Table	Page C-26
Transfer Table	Page C-27

1.1.7.5 Subroutine ZFINDDescription

Subroutine ZFIND computes the compressibility of a gas given its temperature and pressure.

Calling Sequence

CALL ZFIND (T, P, N, V)

<u>Name</u>	<u>Type</u>	<u>I/O</u>	<u>Dimension</u>	<u>Description</u>
T	R	I		Temperature
P	R	I		Pressure
N	I	I		Gas type flag, N = 1 for oxygen, N = 2 for hydrogen.
V	R	O		Compressibility factor

Significant Variables

None

Subprogram Referenced in this Subprogram

<u>Name</u>	<u>Type</u>	<u>Reference</u>
PVAPOR	S	29
PTDENS	F	33

Subprograms Referencing this Subprogram

<u>Name</u>	<u>Type</u>	<u>Reference</u>
STAR	P	6

Flow Chart and Listing Reference

ZFIND Flow Chart	None
ZFIND Program Listing	Page B-33
Variable Table	Page C-28
Statement Number Table	Page C-29
Transfer Table	Page C-30

1.1.7.6 Function FINDRDescription

Function FINDR supplies the gas constant corresponding to an input gas type flag.

Calling Sequence

$$R = \text{FINDR}(N)$$

<u>Name</u>	<u>Type</u>	<u>I/O</u>	<u>Dimension</u>	<u>Description</u>
N	I	I		Gas type flag, N = 1 for oxygen, N = 2 for hydrogen

Significant Variables

None

Subprograms Referenced in this Subprogram

None

Subprograms Referencing this Subprogram

<u>Name</u>	<u>Type</u>	<u>Reference</u>
STAR	P	6

Flow Chart and Listing Reference

FINDR Flow Chart	None
FINDR Program Listing	Page B-35
Variable Table	Page C-31
Statement Number Table	None
Transfer Table	Page C-32

1.1.7.7 Function PTDENSDescription

Function PTDENS returns the density of hydrogen vapor corresponding to input values of vapor pressure and temperature.

Calling Sequence

$$RH\emptyset = \text{PTDENS} (\text{PRES}, \text{TEMP})$$

<u>Name</u>	<u>Type</u>	<u>I/O</u>	<u>Dimension</u>	<u>Description</u>
PRES	R	I		Gas pressure
TEMP	R	I		Gas temperature

Significant Variables

None

Subprograms Referenced in this Subprogram

None

Subprograms Referencing this Subprogram

<u>Name</u>	<u>Type</u>	<u>Reference</u>
STAR	P	6
ZFIND	S	31

Flow Chart and Listing Reference

PTDENS Flow Chart	None
PTDENS Program Listing	Page B- 36
Variable Table	Page C- 33
Statement Number Table	Page C- 34
Transfer Table	Page C- 35

1.1.7.8 Subroutine WTCTRLDescription

Subroutine WTCTRL uses empirical correlations for weight as a function of nominal size to obtain the weight of components described in Table 1-1 of the SOPSA Program User's Manual.

Calling Sequence

Call WTCTRL (P, I, IM, II, D, S1, S2, S3, IV, IF, WT, WI)

<u>Name</u>	<u>Type</u>	<u>I/O</u>	<u>Dimension</u>	<u>Description</u>
P	R	I		Internal fluid presssre
I	I	I		Component type flag
IM	I	I		Material flag
II	I	I		Insulation flag
D	R	I		Nominal line diameter
S1	R	I		Component specification No. 1
S2	R	I		Component specification No. 2
S3	R	I		Component specification No. 3
IV	I	I		Valve weight flag
IF	I	I		Fluid type flag
WT	R	0		Component weight
WI	R	0		Insulation weight

Significant Variables

None

Subprograms Referenced in this Subprogram

<u>Name</u>	<u>Type</u>	<u>Reference</u>
CBWT	F	37
GFTW	F	36

Subprogram Referencing this Subprogram

<u>Name</u>	<u>Type</u>	<u>Reference</u>
STAR	P	6

Flow Chart and Listing Reference

WTCTRL Flow Chart	None
WTCTRL Program Listing	Page B-40
Variable Table	Page C-36
Statement Number Table	Page C-37
Transfer Table	Page C-38

1.1.7.9 Function CFTW

Description

Function CFTW computes the weight of valves and disconnects described in Table 1-1 of the SOPS Program User's Manual.

Calling Sequence

WT = CFTW (D, P, IDV)

<u>Name</u>	<u>Type</u>	<u>I/O</u>	<u>Dimension</u>	<u>Description</u>
D	R	I		Nominal diameter
P	R	I		Internal pressure
IDV	I	I		Valve type flag

Significant Variables

None

Subprograms Referenced in this Subprogram

None

Subprograms Referencing this Subprogram

<u>Name</u>	<u>Type</u>	<u>Reference</u>
WTCTRL	S	34

Flow Chart and Listing Reference

CFTW Flow Chart	None
CFTW Program Listing	Page B-42
Variable Table	Page C-39
Statement Number Table	Page C-40
Transfer Table	Page C-41

1.1.7.10 Function CBWTDescription

Function CBWT computes the weight of the various types of bellows and pressure-volume compensators described in Table 1-1 of the SOPSA Program User's Manual.

Calling Sequence

WT = CBWT (D, P, IB)

<u>Name</u>	<u>Type</u>	<u>I/O</u>	<u>Dimension</u>	<u>Description</u>
D	R	I		Nominal diameter
P	R	I		Internal pressure
IB	I	I		Bellows type flag

Significant Variables

None

Subprograms Referenced in this Subprogram

None

Subprograms Referencing this Subprogram

<u>Name</u>	<u>Type</u>	<u>Reference</u>
WTCTRL	S	34

Flow Chart and Listing Reference

CBWT Flow Chart	None
CBWT Program Listing	Page B-43
Variable Table	Page C-42
Statement Number Table	Page C-43
Transfer Table	Page C-44

1.1.7.11 Function GOMTRY

Description

Function GOMTRY computes the volume and/or area of a variety of geometrical surface of revolution. This function consists of a variety of subfunctions each of which is accessed by an ENTRY whose name describes the geometrical figure desired.

Calling Sequence

The calling sequence for functions of each type of surface is as follows:

Volume of Circular Cone

$$V = \text{CONE} (R, H)$$

<u>Name</u>	<u>Type</u>	<u>Description</u>
R	R	Radius of base of cone
H	R	Height of cone

Volume of Right-Circular Cylinder

$$V = \text{CYLNDR} (R,H)$$

<u>Name</u>	<u>Type</u>	<u>Description</u>
R	R	Radius of cylinder
H	R	Height of cylinder

Volume Contained Between Cylinder and Spheroid

$$V = \text{CYLSPH} (RR\phi T,R)$$

<u>Name</u>	<u>Type</u>	<u>Description</u>
RR ϕ T	R	Height of cylinder (spheroid)
R	R	Radius of cylinder

Volume of Frustum of Right-Circular Cone

$$V = \text{FRCONE} (R, H, R2)$$

<u>Name</u>	<u>Type</u>	<u>Description</u>
R	R	Radius at top of cone
H	R	Height of cone
R2	R	Radius of base of cone

Volume of Hemisphere or Half-Spheroid

$$V = \text{HSPHER} (RR\phi T, R)$$

<u>Name</u>	<u>Type</u>	<u>Description</u>
RRØT	R	Height along axis of rotation
R	R	Radius

Volume of Sphere or Spheroid

$$V = \text{SPHERE} (\text{RRØT}, R)$$

<u>Name</u>	<u>Type</u>	<u>Description</u>
RRØT	R	Height along axis of rotation
R	R	Radius

Area of Cylinder

$$A = \text{ARACYL} (R, H)$$

Arguments defined as in CYLNDR.

Area of Conical Frustum

$$A = \text{AFEAFR} (R, H, R2)$$

Arguments defined as in FRCØNE.

Area of Hemi-Spheroid or Hemisphere

$$A = \text{ARSPHR} (\text{RRØT}, R)$$

Arguments defined as in HSPHER.

Significant Variables

None

Subprograms Referenced in this Subprogram

None

Subprograms Referencing this Subprogram

<u>Name</u>	<u>Type</u>	<u>Reference</u>
INIVOL	S	26

Flow Chart and Listing Reference

GOMTRY Flow Chart	None
GOMTRY Program Listing	Page B-44
Variable Table	Page C-45
Statement Number Table	Page C-46
Transfer Table	Page C-47

1.1.7.12 Subroutine SPHSEGDescription

Subroutine SPHSEG computes the height of a given volume of liquid (head height) in an ellipsoid of revolution (including a hemisphere) or in the volume between a cylinder and a spheroid. One of two entries are used depending on the geometry involved.

Calling Sequence

The calling sequence for computing head heights contained in each type of volume is as follows:

Ellipsoidal Volume

$$H = \text{ELIPSG} (PV\phi L, \text{RAD}, \text{RPD}, H)$$

<u>Name</u>	<u>Type</u>	<u>Description</u>
PV ϕ L	R	Ullage vapor volume
RAD	R	Height of ellipse along axis of rotation
RPD	R	Radius
H	R	Liquid head height

Volume Between Cylinder and Spheroid

$$H = \text{CYMSPH} (PV\phi L, \text{RAD}, \text{RPD}, H)$$

<u>Name</u>	<u>Type</u>	<u>Description</u>
PV ϕ L	R	Ullage vapor volume
RAD	R	Height along axis of rotation
RPD	R	Radius of cylinder
H	R	Liquid head height

Significant Variables

None

Subprograms Referencing this Subprogram

<u>Name</u>	<u>Type</u>	<u>Reference</u>
ULLHED	S	27

Flow Chart and Listing Reference

SPHSEG Flow Chart	None
SPHSEG Program Listing	Page B-46
Variable Table	Page C-48
Statement Number Table	Page C-49
Transfer Table	Page C-50

Section 2

PROGRAM OPERATION

Input deck setup and input data requirements for the SOPSA program are described in detail in the SOPSA Program User's Manual. This program has been developed using the EXEC 8 operating system on the UNIVAC 1108 operating system. The SOPSA program can be compiled and executed on comparable systems containing the FORTRAN V utility and standard UNIVAC routines described in Section 4 below.

2.1 NORMAL PROGRAM EXECUTION

During normal operation, the program will read input data, perform the required operations, and print the final results. No intermediate output is provided, so that in the event of an input data error, the user must diagnose the malfunction from the final printed output.

2.2 ABNORMAL PROGRAM EXECUTION

In the event that the program does not produce a final data printout, the user must diagnose the error by rechecking input data types and formats. Diagnostic printouts are provided in two subroutines, ULLHED and SPHSEG. The ULLHED diagnostic is of the form

'ULLAGE VOLUME IS NEGATIVE'

and indicates that input tank geometry data is not compatible with the specified propellant loading.

The SPHSEG diagnostic is of the form

'ERROR INPUT TO SPHSEG'

and indicates that input tank geometry data are not correct.

Section 3

LIBRARY ROUTINES

The SOPSA program uses both Lockheed system routines and FORTRAN utility routines, in addition to the UNIVAC 1108, EXEC 8, system routines.

3.1 LOCKHEED SYSTEM ROUTINES

The Lockheed system contains a standard library of FORTRAN V mathematical function routines, of which the following are used by SOPSA:

SQRT	Square root
EXP	Exponential
CPS	Cosine
ASIN	Arcsine
ACOS	Arccosine
ATAN	Arctangent
ALOG	Natural logarithm (log x)

3.2 FORTRAN UTILITY ROUTINES

3.2.1 Subroutine MOVER

The subroutine MOVER is available to permit rapid transfer of data words from one area to another. The 1108 block transfer is used; thus, the use of MOVER will be considerably faster than a corresponding transfer of data by a DO-loop. It is used as follows:

```
CALL MOVER (FROM, INCF, TO, INCT, NWDS)
```

where

FROM is the array from which data are moved.

INCF is the increment to be used in selecting data from the FROM array.

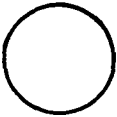



TO is the array to which data are moved.

INCT is the increment to be used in placing data into the TO array.

NWDS is the number of words to transfer.

NOTE: MOVER checks to see if the argument NWDS is negative. If it is, the run is "errored off."

APPENDIX A
FLOW CHART SYMBOLS

<u>SYMBOL</u>	<u>DEFINITION</u>
	Subprogram Reference
	Processing Function
	Step Connector
	Program Modification or Decision Function

APPENDIX B
SOPSA PROGRAM LISTINGS

This Appendix contains a symbolic listing of the FORTRAN V code for the SOPSA main program and subprograms.

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```

1. C      * * * * *
2. C      * * * * *
3. C      * * ENGINE START TRANSIENT ANALYSIS PROGRAM * *
4. C      * * * * *
5. C      * * THE PROGRAM I.D. CODE IS - FD1306 * *
6. C      * * * * *
7. C      * PROGRAMMED BY R.F. HAUSMAN; DEPT 62-13; BLDG 104, 3-0235
8. C      * REVISED BY R.M. VERNON; DEPT, 62-03; BLDG 562, 24385
9. C      * * * * *
10. C     * * * * *
11. C     * * * * *
12. C     * * * * *
13.      INCLUDE DIMN.LIST
14.      INCLUDE UCONST.LIST
15. DIMENSION JIFWGT(20),FTOW(20),CLPHD0(20),DLPHDH(20),VWGTNU(20)
16. DIMENSION DFAGT0(20),DFWGT0(20),PCWGT0(20),PCWGT0(20)
17. DIMENSION EGCR1(9)
18. DIMENSION FIFRAC(21),TIMEA(21),WDTFRG(21),WDTFRH(21)
19. DIMENSION HEAD02(35),HEAD02(35)
20. DIMENSION HPO(16),HPIPEL(16),HKPD(16),CPU(16),OP(PEL(16),OKPD(16)
21. DIMENSION PI(1),GC(1),RHOGX(1),RHOHY(1),VWGTN(1),FNOM(1)
22. DIMENSION PENGG(20),PENGGH(20),NPSPO(21),NPSPH(21)
23. DIMENSION PENMNO(30),PENMNH(30)
24. DIMENSION PDGOT(35),PDGHT(35)
25. DIMENSION TENINO(1),TENINH(1)
26. DIMENSION TLQSO(1),TLQSH(1),PPDGT(30),PPDHT(30)
27. DIMENSION VLQOZ(35),VLQMH(35),LLVLOZ(35),ULLVMH(35)
28. DIMENSION WDOTNO(1),WDOTNH(1),CXHTLN(1),HYMTLN(1),ST(7)
29. DIMENSION WDDOTO(20),WDDOTH(20)
30. DIMENSION WTULG0(35),WTULGH(35)
31. DIMENSION ZLPACO(20),ZLPACH(20),ZLPLNO(20),ZLPLNH(20),PROWGT(20)
32. DIMENSION ZLPACO(16,20),ZLPACH(16,20)
33. DIMENSION ZLPLNO(16,20),ZLPLNH(16,20)
34. DIMENSION PENNJO(16,35),PENMNO(16,35),PENMJO(16,35),PENMNH(16,35)
35. DIMENSION PULLO(16,20),PULLH(16,20)
36. DIMENSION PTKBTO(16,35),PTKBTN(16,35),PMDLNO(35),PMDLNH(35)
37. DIMENSION PULMNO(35),PULLRO(16,35),PULMNH(35),PULLRH(16,35)
38. DIMENSION SPJMLO(100),SPJEL0(4,100),SPJMLH(100),SPJELH(4,100)
39. DIMENSION WMLI0(16),WELI0(16,4),WELICT(16),WLIOT(16),WLOTT(16)
40. DIMENSION WMLIH(16),WELIH(16,4),WELIHT(16),WLIHT(16),WLHTT(16)
41. DIMENSION IP(15)
42. DIMENSION IMDELO(4),IMMLO(100),IMMLO(100),SPIMLO(100),SP2MLO(100)
43. DIMENSION IDELO(4,100),IMEL0(4,100),IIELO(4,100),SPIELO(4,100)
44. DIMENSION SP2EL0(4,100),IMMLH(100),IMMLO(100)
45. DIMENSION IMDELH(4),IMMLH(100),IIMLH(100),SPIMLH(100),SP2MLH(100)
46. DIMENSION IDELH(4,100),IMELH(4,100),IIEH(4,100),SPIELH(4,100)
47. DIMENSION SP2ELH(4,100),IDEL(4),IDELH(4),IDEL(4,100),IDEL(4,100)
48. DIMENSION SUMMO(20),SUMMH(20),PTBTMO(16),PTBTMH(16),PMAXO(16)
49. DIMENSION PMAXH(16),SUMNO(20),SUMNH(20),PDESO(16),PDESH(16)

```

Fig. B-1 STAR Program Listing

```

50. DIMENSION D2(2),H2(2),WELH(16,4),WELHT(10),WMLH(16),WLHT(16) STAR0050
51. DIMENSION WELO(16,4),WELCT(16),WML0(16),WLOT(16) STAR0051
52. DIMENSION AD0(16),ADH(16) STAR0052
53. DIMENSION ABC(5504) STAR0053
54. EQUIVALENCE (ABC,WELO),(ABC(65),WEL0T),(ABC(81),WML0),(ABC(97),WLOSTAR0054
55. 1T),(ABC(113),WELH),(ABC(177),WELHT),(ABC(193),WMLH),(ABC(209),WLHTSTAR0055
56. 2),(ABC(225),DLPAC0),(ABC(545),DLPACH),(ABC(865),DLPLN0),(ABC(1185)STAR0056
57. 3,DLPLNH),(ABC(1505),PENNU0),(ABC(2065),PENNUH),(ABC(2625),PULLC), STAR0057
58. 4(ABC(2945),PULLH),(ABC(3265),PTKBT0),(ABC(3825),PTKBTH),(ABC(4385)STAR0058
59. 5,PULLRU),(ABC(4945),PULLRH) STAR0059
60. C STAR0060
61. INTEGER SYSNM STAR0061
62. REAL NPSPO,NPSPH STAR0062
63. REAL LOAD01,LOADH1,LOAD02,LOADH2 STAR0063
64. C STAR0064
65. COMMON/AAA/FIFRAC,TIMEA,WDTFR0,WDTFRH,NPSPO,NPSPH STAR0065
66. COMMON/AAA/PPDGT,PPDGH,TLQSC,TLQSH,TSVAP0,TSVAPH STAR0066
67. COMMON/AAA/TOG0T,TOGHT STAR0067
68. COMMON/AAA/LOAD01,LOADH1,LOAD02,LOADH2 STAR0068
69. COMMON/BBB/NSIZE,SYSNM,NOP,NOP1,IGCON,NPTS,MPTS STAR0069
70. COMMON/CCC/GC,RHCOX,RHONY,VWGTN STAR0070
71. COMMON/DDD/WOOTNO,WOOTNH,FROM,CPIPEL,HPIPEL,OPD,HPD,OKPD,HKPD,ST, STAR0071
72. 10XHTLN,HYHTLN,PELINO,PENMH,PENTCL,TEIN0,TEINH STAR0072
73. COMMON/EEE/OPDJM,ODDUM,HPDUM,HDUM,VWGTCH,ODLDM,OCAYP,ODTINC, STAR0073
74. 1HOLDUM,HCAYP,HJTINC,TVAP0,TVAPH,PVAPC,PVPEY0,PVAPH,PVPENH,PNCWGT STAR0074
75. COMMON/FFF/WDD0T0,WDD0TH,ZLPACC,ZLPACH,VWGTNU,FTOW,DIFWGT,DLPHDO, STAR0075
76. 1DLPHDH,ZLPLN0,ZLPLNH,PENGO,PENGH,PCWGTG,PCWGTH STAR0076
77. COMMON/FFF/PUVAP0,PSVAP0,PUVAPH,PSVAPH,PPVAP0,PPVAPH STAR0077
78. COMMON/FFF/ULVL0,ULVLH,HEAD0C,HEAD0H STAR0078
79. COMMON/GGG/XTULG0,XTULGH,ULV02,ULVH2,HEAD02,HEADH2 STAR0079
80. COMMON/GGG/ULV_02,ULVLH2 STAR0080
81. C STAR0081
82. DATA FEET,GC/12,,32,172/ STAR0082
83. DATA O2/'OXYGEN', ' 1/2/'HYDROG', 'EN 1/ STAR0083
84. DATA RHOOX,RH04Y/70,9,4,396/ STAR0084
85. DATA IIN,IOD,PI,PI203/5,6,3,1415927,2,0943951/ STAR0085
86. C STAR0086
87. CALL MOVER(0,0,ABC,1,5504) STAR0087
88. ICASE=0 STAR0088
89. C STAR0089
90. C READ IN THE INPUT DATA DECK STAR0090
91. C STAR0091
92. C ** INPUT DATA DEFINITIONS ** STAR0092
93. C STAR0093
94. C STAR0094
95. C ST - ANALYSIS TITLE CARD - SPECIFIES ENGINE CONSIDERED STAR0095
96. C THIS CARD MUST BE SUPPLIED FOR EACH CASE STAR0096
97. C STAR0097
98. C 10 READ (5,15)(ST(I),I=1,7) STAR0098
99. C 15 FORMAT(7A6) STAR0099
100. C ICASE=ICASE+1 STAR0100
101. C STAR0101
102. C DO 20 K=1,16 STAR0102
103. C IP(K)=0 STAR0103
104. C 20 CONTINUE STAR0104
105. C STAR0105
106. C STAR0106
107. C INPUT DATA FLAG STAR0107

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Fig. B-1 STAR Program Listing (Cont'd)

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108, C      THIS CARD MUST BE SUPPLIED FOR EACH CASE                      STAR0108
109, C
110, C      READ (5,25)(IP(K),K#1,16)                                     STAR0110
111, C      25 FORMAT(16I1)                                              STAR0111
112, C      IF (IP(1),LT,1) GO TO 35                                     STAR0112
113, C      ..... STAR0113
114, C      ..... STAR0114
115, C      NML = NUMBER OF MAIN FEEDLINE SIZES TO BE CONSIDERED (UP TO 12) STAR0115
116, C      NEL = NUMBER OF ENGINE FEEDLINE ATTACHE TO EACH MAIN LINE (UP STAR0116
117, C      SYSNUM = IF 1, PROGRAM COMPUTES FOR OXID. FEEDLINES ONLY,     STAR0117
118, C               = IF 2, PROGRAM COMPUTES FOR FUEL FEEDLINES ONLY,   STAR0118
119, C               = IF 3, PROGRAM COMPUTES FOR BOTH FEEDLINES,       STAR0119
120, C      NSIZE = TOTAL NUMBER OF FEEDLINES PER TANK = NEL*NML        STAR0120
121, C
122, C      NOP, = NUMBER OF ENGINES FED BY A MAIN FEEDLINE             STAR0122
123, C
124, C      NOP1 = NUMBER OF ENGINES ON VEHICLE                          STAR0124
125, C
126, C      NPTS = NUMBER OF TIME POINTS BEING CONSIDERED IN ANALYSIS(UP TO STAR0126
127, C
128, C      NGST = GROUND START FLAG (NGST=2 FOR GROUND START)           STAR0128
129, C      TOTMLO = TOTAL LENGTH OF MAIN OXYGEN FEEDLINE FT            STAR0129
130, C      TOTMLH = TOTAL LENGTH OF MAIN HYDROGEN FEEDLINE FT         STAR0130
131, C      READ (5,30)NEL,NML,SYSNUM,NOP,NOP1,NPTS,NGST                STAR0131
132, C      30 FORMAT(12I6)                                              STAR0132
133, C      READ (5,100)TOTMLO,TOTMLH                                    STAR0133
134, C      ..... STAR0134
135, C      NSIZE=NEL*NML                                               STAR0135
136, C      NELP=NEL*1                                                 STAR0136
137, C      ..... STAR0137
138, C      ..... STAR0138
139, C      35 IF (IP(2),LT,1) GO TO 40                                  STAR0139
140, C      ..... STAR0140
141, C
142, C      EGLR1 = LENGTHS AND RADII OF TANK SECTIONS ( 9 VALUES)     STAR0142
143, C
144, C      READ (5,100)EGLR1                                             STAR0144
145, C      ..... STAR0145
146, C      40 IF (IP(3),LT,1) GO TO 65                                  STAR0146
147, C      ..... STAR0147
148, C
149, C      MIDMLO = TOTAL NUMBER OF COMPONENTS IN MAIN OXYGEN FEEDLINE (UP TO STAR0149
150, C      MIDELO(NL)= TOTAL NUMBER OF COMPONENTS IN ENGINE OXYGEN     STAR0150
151, C      FEEDLINE NUMBER NL (UP TO 100)                               STAR0151
152, C      IDMLO = COMPONENT TYPE FLAG FOR MAIN OXYGEN LINE            STAR0152
153, C      IMMLO = COMPONENT MATERIAL FLAG FOR MAIN OXYGEN LINE        STAR0153
154, C      IIMLO = COMPONENT INSULATION FLAG FOR MAIN OXYGEN LINE      STAR0154
155, C      IMLO = SUBSCRIPT DENOTING COMPONENT POSITION IN MAIN         STAR0155
156, C      OXYGEN FEEDLINE (IMLO = 1 AT TANK BOTTOM)                   STAR0156
157, C      IELO(NL)=SUBSCRIPT DENOTING COMPONENT POSITION IN ENGINE     STAR0157
158, C      OXYGEN FEEDLINE (IELO(NL) = MIDELO(NL) AT INLET TO ENGINE STAR0158
159, C
160, C      SP1MLO(1),SP2MLO(1),SP3MLO(1) = COMPONENT SPECIFICATIONS (SEE MANU STAR0160
161, C
162, C      OPD(K),K#1,NEL = DIAMETERS OF OXYGEN ENGINE FEEDLINES (INCHES) STAR0162
163, C      OPD(K),K#NEL*1,NSIZE = CANDIDATE DIAPETEMS OF MAIN OXYGEN FEEDLINE STAR0163
164, C
165, C      READ (5,30)MIDMLO,MIDELO(NL),NL#1,NEL)                       STAR0165

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Fig. B-1 STAR Program Listing (Cont'd)

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166.      DO 50 I=1,MIDM_O                               STARJ166
167.      READ (5,45)IDM_O(I),IMMLO(I),IIMLO(I),SP1MLO(I),SP2MLO(I),SP3MLO(I) STARJ167
168.      1)                                             STARJ168
169.      IF (IDMLO(I),LE,25) GO TO 50                   STARJ169
170.      ITEMP=IDMLO(I)/10                               STARJ170
171.      IDO(I)=IDM_O(I)-ITEMP                           STARJ171
172.      IDMLO(I)=ITEMP                                  STARJ172
173.      45 FORMAT(3I6,3E12,8)                          STARJ173
174.      50 CONTINUE                                     STARJ174
175.      DO 60 NL=1,NEL                                  STARJ175
176.      MID=MIDELO(NL)                                  STARJ176
177.      DO 55 I=1,MID                                    STARJ177
178.      READ (5,45)IDELO(NL,I),IMELO(NL,I),IEELO(NL,I),SP1ELO(NL,I),SP2ELO(NL,I),SP3ELO(NL,I) STARJ178
179.      1(NL,I),SP3ELO(NL,I)                            STARJ179
180.      IF (IDELO(NL,I),LE,25) GO TO 55                STARJ180
181.      ITEMP=IDELO(NL,I)/10                            STARJ181
182.      IDOE(NL,I)=IDELO(NL,I)-ITEMP                   STARJ182
183.      IDELO(NL,I)=ITEMP                               STARJ183
184.      55 CONTINUE                                     STARJ184
185.      60 CONTINUE                                     STARJ185
186.      READ (5,100)(OPD(K),K=1,NSIZE)                 STARJ186
187.      C                                                                 STARJ187
188.      C ..... STARJ188
189.      65 IF ((IP(4),LT,1) GO TO A5                    STARJ189
190.      C ..... STARJ190
191.      C REPEAT FOR HYDROGEN FEED SYSTEM                STARJ191
192.      C ..... STARJ192
193.      C HPD(K) = DIAMETER FOR THE KTH FUEL FEED LINE      (INCHES) STARJ193
194.      READ (5,30)MIDMLH,(MIDELH(NL),NL=1,NEL)        STARJ194
195.      DO 70 I=1,MIDMLH                                 STARJ195
196.      READ (5,45)IDMLH(I),IMMLH(I),IIMLH(I),SP1MLH(I),SP2MLH(I),SP3MLH(I) STARJ196
197.      1)                                             STARJ197
198.      IF (IDMLH(I),LE,25) GO TO 70                   STARJ198
199.      ITEMP=IDMLH(I)/10                               STARJ199
200.      IDH(I)=IDMLH(I)-ITEMP                           STARJ200
201.      IDMLH(I)=ITEMP                                  STARJ201
202.      70 CONTINUE                                     STARJ202
203.      DO 80 NL=1,NEL                                  STARJ203
204.      MID=MIDELH(NL)                                  STARJ204
205.      DO 75 I=1,MID                                    STARJ205
206.      READ (5,45)IDELH(NL,I),IMELH(NL,I),IEELH(NL,I),SP1ELH(NL,I),SP2ELH(NL,I),SP3ELH(NL,I) STARJ206
207.      1(NL,I),SP3ELH(NL,I)                            STARJ207
208.      IF (IDELH(NL,I),LE,25) GO TO 75                STARJ208
209.      ITEMP=IDELH(NL,I)                               STARJ209
210.      IDHE(NL,I)=IDELH(NL,I)-ITEMP                   STARJ210
211.      IDELH(NL,I)=ITEMP                               STARJ211
212.      75 CONTINUE                                     STARJ212
213.      80 CONTINUE                                     STARJ213
214.      READ (5,100)(HPD(K),K=1,NSIZE)                 STARJ214
215.      C ..... STARJ215
216.      85 IF ((IP(5),LT,1) GO TO 90                    STARJ216
217.      C ..... STARJ217
218.      C ..... STARJ218
219.      C OXHTLN = FEEDLINE HEAD HEIGHT ABOVE ENGINE INLET, OXID, (FT) STARJ219
220.      C HYHTLN = FEEDLINE HEAD HEIGHT ABOVE ENGINE INLET, FUEL, (FT) STARJ220
221.      C PDLO = OXYGEN FEEDLINE DESIGN PRESSURE (OPTIONAL) (PSI) STARJ221
222.      C PDLH = HYDROGEN FEEDLINE DESIGN PRESSURE (OPTIONAL) (PSI) STARJ222
223.      C ..... STARJ223

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Fig. B-1 STAR Program Listing (Cont'd)

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224, C      NOTE: A FACTOR OF SAFETY OF 2.5 IS APPLIED BY THE          STAR0224
225, C      PROGRAM TO THE ABOVE PRESSURES IN THE COMPUTATION        STAR0225
226, C      OF LINE WALL THICKNESSES, IF (PDLO,PJLH),LE,D, PROGRAM  STAR0226
227, C      USES MAXIMUM TANK BOTTOM PRESSURE OR ENGINE INLET PRESSURE, STAR0227
228, C
229, C      READ (5,100)OX4TLN,HYHTLN,PDLO,PDLH                        STAR0229
230, C
231, C      .....                                                    STAR0230
232, C      90 IF (IP(6),LT,1) GO TO 95                                STAR0232
233, C      .....                                                    STAR0233
234, C
235, C      LOADO1 = LOADED WEIGHT OF OXIDIZER                          LBS          STAR0235
236, C      LOADH1 = LOADED WEIGHT OF FUEL                            LBS          STAR0236
237, C
238, C      VWGTN = TOTAL VEHICLE WEIGHT AT IGNITION                    LBS          STAR0238
239, C      READ (5,100)LOADO1,LOADH1,VWGTN                          STAR0239
240, C
241, C      .....                                                    STAR0241
242, C      95 IF (IP(7),LT,1) GO TO 105                              STAR0242
243, C      .....                                                    STAR0243
244, C
245, C      WDOTNO = OXIDIZER NOMINAL FLOW RATE FOR SINGLE ENGINE      (LBS/SEC)   STAR0245
246, C      WDOTNH = FUEL NOMINAL FLOW RATE FOR SINGLE ENGINE        (LBS/SEC)   STAR0246
247, C      FNOM = NOMINAL THRUST FOR SINGLE ENGINE                  (LBS)       STAR0247
248, C
249, C      READ (5,100)WDOTNO,WDOTNH,FNOM                            STAR0249
250, C      100 FORMAT('6E12,8)                                       STAR0250
251, C
252, C      .....                                                    STAR0252
253, C      105 IF (IP(8),LT,1) GO TO 110                              STAR0253
254, C      .....                                                    STAR0254
255, C
256, C      TENINO = TEMP. OF OXID. FLUID AT ENGINE INLET              (DEG,R)     STAR0256
257, C      TENINH = TEMP. OF FUEL FLUID AT ENGINE INLET              (DEG,R)     STAR0257
258, C      TLIQSO = TEMP. OF OXID. FLUID SURFACE IN TANK            DEG, R      STAR0258
259, C      TLIQSH = TEMP. OF FUEL FLUID SURFACE IN TANK            DEG,R       STAR0259
260, C      PENTOL = ENGINE INLET FLUID PRESSURE TOLERANCE          (PSI)       STAR0260
261, C
262, C      READ (5,100)TENINO,TENINH,TLIQSO,TLIQSH,PENTOL            STAR0262
263, C
264, C      .....                                                    STAR0264
265, C      110 IF (IP(9),LT,1) GO TO 115                              STAR0265
266, C      .....                                                    STAR0266
267, C
268, C      TIMEA = TIME VALUES OF EVENTS IN TRANSIENT                STAR0268
269, C
270, C      READ (5,100)(TIMEA(I),I=1,NPTS)                            STAR0270
271, C      .....                                                    STAR0271
272, C      115 IF (IP(10),LT,1) GO TO 125                            STAR0272
273, C      .....                                                    STAR0273
274, C
275, C      WDTFRO = FRACTION OF OXIDIZER FLOW RATE AT TIMEA(I)        STAR0275
276, C      WDTFRH = FRACTION OF FUEL FLOW RATE AT TIMEA(I)          STAR0276
277, C
278, C      READ (5,100)(WDTFRO(I),I=1,NPTS)                          STAR0278
279, C      IF (SYSNUM,E3,1) GO TO 120                                STAR0279
280, C      READ (5,100)(WDTFRH(I),I=1,NPTS)                        STAR0280
281, C      120 CONTINUE                                              STAR0281

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Fig. B-1 STAR Program Listing (Cont'd)

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282, C .....STAR0292
283, C 125 IF (IP(11),LT,1) GO TO 130 .....STAR0293
284, C .....STAR0284
285, C .....STAR0295
286, C FIFRAC = FRACTION OF NOMINAL THRUST AT TIMEA .....STAR0286
287, C .....STAR0287
288, C READ (5,100)(FIFRAC(I),I=1,NPTS) .....STAR0298
289, C .....STAR0299
290, C 130 IF (IP(12),LT,1) GO TO 140 .....STAR0290
291, C .....STAR0291
292, C .....STAR0292
293, C NPSPO = NET POSITIVE SUCTION PRESSURE FOR OXIDIZER PSI .....STAR0293
294, C NPSPM = NET POSITIVE SUCTION PRESSURE FOR FUEL PSI .....STAR0294
295, C .....STAR0295
296, C READ (5,100)(NPSPO(N),N=1,NPTS) .....STAR0296
297, C IF (SYSNUM,EQ,1) GO TO 135 .....STAR0297
298, C READ (5,100)(NPSPH(N),N=1,NPTS) .....STAR0298
299, C 135 CONTINUE .....STAR0299
300, C .....STAR0300
301, C 140 IF (IP(13),LT,1) GO TO 150 .....STAR0301
302, C .....STAR0302
303, C .....STAR0303
304, C PENMNO = MINIMUM ENGINE INLET OXID.PRESSURE VALUE AT TIMEA .....STAR0304
305, C PENMNH = MINIMUM ENGINE INLET FUEL PRESSURE VALUE AT TIMEA .....STAR0305
306, C .....STAR0306
307, C READ (5,100)(PENMNO(N),N=1,NPTS) .....STAR0307
308, C IF (SYSNUM,EQ,1) GO TO 145 .....STAR0308
309, C READ (5,100)(PENMNH(N),N=1,NPTS) .....STAR0309
310, C 145 CONTINUE .....STAR0310
311, C .....STAR0311
312, C 150 IF (IP(14),LT,1) GO TO 160 .....STAR0312
313, C .....STAR0313
314, C .....STAR0314
315, C PPDGOT = PART.PRESS. OF PRESSURANT GAS IN OXID. TANK PSI .....STAR0315
316, C PPDGHT = PART.PRESS. OF PRESSURANT GAS IN FUEL TANK PSI .....STAR0316
317, C .....STAR0317
318, C READ (5,100)(PPDGOT(N),N=1,NPTS) .....STAR0318
319, C IF (SYSNUM,EQ,1) GO TO 155 .....STAR0319
320, C READ (5,100)(PPDGHT(N),N=1,NPTS) .....STAR0320
321, C 155 CONTINUE .....STAR0321
322, C .....STAR0322
323, C 160 IF (IP(15),LT,1) GO TO 170 .....STAR0323
324, C .....STAR0324
325, C .....STAR0325
326, C TOGOT = TEMP. OF PRESSURANT GAS; IF NCNE-SET EQUAL TO TLIQSO + 5, .....STAR0326
327, C TOGHT = TEMP. OF PRESSURANT GAS; IF NCNE-SET EQUAL TO TLIQSH + 5, .....STAR0327
328, C .....STAR0328
329, C READ (5,100)(TOGOT(N),N=1,NPTS) .....STAR0329
330, C IF (SYSNUM,EQ,1) GO TO 165 .....STAR0330
331, C READ (5,100)(TOGHT(N),N=1,NPTS) .....STAR0331
332, C 165 CONTINUE .....STAR0332
333, C .....STAR0333
334, C 170 IF (IP(16),LT,1) GO TO 175 .....STAR0334
335, C .....STAR0335
336, C .....STAR0336
337, C IGOON = INDEX FOR ADDITIONAL CASES, IF IGOON = 1 THERE ARE MORE, .....STAR0337
338, C IF IGOON = 0, NO MORE, .....STAR0338
339, C .....STAR0339

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Fig. B-1 STAR Program Listing (Cont'd)

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340.      HEAD (5,30)IG03N                                STAR0340
341.      175 CONTINUE                                    STAR0341
342.      C ..... STAR0342
343.      C ..... STAR0343
344.      LOAD02 = LOAD01/RH00X                            STAR0344
345.      LOADH2 = LOADH1/RH0HY                            STAR0345
346.      C ..... STAR0346
347.      C CALCULATE SLOPE OF FLOW RATE CURVE INCREMENTS STAR0347
348.      C ..... STAR0348
349.      MPTS = NPTS * 1                                  STAR0349
350.      DO 180 J=1,MPTS                                  STAR0350
351.      WDDOTO(J)=(WDTFR(J+1)-WDTFR(J))*WDCNTNO/(TIMEA(J+1)-TIMEA(J)) STAR0351
352.      WDDOTH(J)=(WDTFRH(J+1)-WDTFRH(J))*WDCNTNH/(TIMEA(J+1)-TIMEA(J)) STAR0352
353.      180 CONTINUE                                    STAR0353
354.      C ..... STAR0354
355.      C COMPUTE TOTAL LENGTHS OF FEEDLINES (ASSUME COMPONENT L/D = 1.0) STAR0355
356.      C ..... STAR0356
357.      IF (SYSNUM,EQ,2) GO TO 210                      STAR0357
358.      C ..... STAR0358
359.      C OXYGEN FEEDLINE LENGTHS                       STAR0359
360.      C ..... STAR0360
361.      DO 200 NL=1,NSIZE                                STAR0361
362.      SUM=0.                                           STAR0362
363.      IF(NL,LE,NEL) MID=MIDEL0(NL)                   STAR0363
364.      IF(NL,GT,NEL) MID=MIDMLO(1)                    STAR0364
365.      DO 195 I=1,MID                                    STAR0365
366.      IF(NL,LE,NEL) ID=IDEL0(NL,I)                   STAR0366
367.      IF(NL,GT,NEL) ID=IDMLO(I)                      STAR0367
368.      IF (ID,GT,1) GO TO 185                          STAR0368
369.      SUM=SUM+0.7854*OPD(NL)*0.083333               STAR0369
370.      GO TO 195                                       STAR0370
371.      185 IF (ID,EQ,9) GO TO 195                      STAR0371
372.      IF (ID,GT,10) GO TO 190                        STAR0372
373.      IF(NL,LE,NEL) SPEC=SP1EL0(NL,I)                STAR0373
374.      IF(NL,GT,NEL) SPEC=SP1MLO(1)                  STAR0374
375.      SUM=SUM+SPEC                                     STAR0375
376.      GO TO 195                                       STAR0376
377.      190 SUM=SUM+OPD(NL)*0.083333                   STAR0377
378.      195 CONTINUE                                    STAR0378
379.      OPIPEL(NL)=SUM                                   STAR0379
380.      200 CONTINUE                                    STAR0380
381.      C COMPUTE LENGTH RATIOS FOR STRAIGHT SECTIONS  STAR0381
382.      DO 205 NL=1,NSIZE                                STAR0382
383.      ADD(NL)=OPIPEL(NL)/TOTMLO                       STAR0383
384.      205 CONTINUE                                    STAR0384
385.      IF (SYSNUM,EQ,1) GO TO 240                     STAR0385
386.      C ..... STAR0386
387.      C HYDROGEN FEEDLINE LENGTHS                    STAR0387
388.      C ..... STAR0388
389.      210 DO 230 NL=1,NSIZE                            STAR0389
390.      SUM=0.                                           STAR0390
391.      IF(NL,LE,NEL) MID=MIDELH(NL)                   STAR0391
392.      IF(NL,GT,NEL) MID=MIDMLH(1)                    STAR0392
393.      DO 225 I=1,MID                                    STAR0393
394.      IF(NL,LE,NEL) ID=IDELH(NL,I)                   STAR0394
395.      IF(NL,GT,NEL) ID=IDMLH(I)                      STAR0395
396.      IF (ID,GT,1) GO TO 215                          STAR0396
397.      SUM=SUM+0.7854*HPD(NL)*0.083333               STAR0397

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Fig. B-1 STAR Program Listing (Cont'd)


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398,      GO TO 225                                     STARJ398
399,      215 IF (ID.EQ,9) GO TO 225                   STARJ399
400,      IF (ID.GT,10) GO TO 220                     STARJ400
401,      IF(NL,LE,NEL) SPEC=SP1ELM(NL,;)            STARJ401
402,      IF(NL,GT,NEL) SPEC=SP1MLM(I)               STARJ402
403,      SUM=SUM+SPEC                                 STARJ403
404,      GO TO 225                                     STARJ404
405,      220 SUM=SUM+HPJ(NL)*0.083333                STARJ405
406,      225 CONTINUE                                 STARJ406
407,      HPIPEL(NL)=SUM                               STARJ407
408,      230 CONTINUE                                 STARJ408
409,      C COMPUTE LENGTH RATIOS FOR STRAIGHT SECTIONS STARJ409
410,      DO 235 NL=NEP,NSIZE                           STARJ410
411,      ADH(NL)=HPIPEL(NL)/TOTMLM                   STARJ411
412,      235 CONTINUE                                 STARJ412
413,      C                                             STARJ413
414,      C CALCULATE PRESSURE DIFFERENCE TO SUPPLY ACCELERATION HEADS STARJ414
415,      C                                             STARJ415
416,      240 DO 295 I=1,NSIZE                           STARJ416
417,      GO TO (245,270,245),SYSNUM                   STARJ417
418,      245 OPDUM = OPPEL(I)                          STARJ418
419,      ODDUM = OPJ(I)**2                             STARJ419
420,      IF (I,GT,NEL) GO TO 255                       STARJ420
421,      C                                             STARJ421
422,      C COMPUTE ACCELERATION HEAD IN SINGLE ENGINE OX FEED SECTION STARJ422
423,      C                                             STARJ423
424,      DO 250 J=1,MPTS                               STARJ424
425,      DLPACO(I,J)=(4.0*WDDOTO(J)*OPDUM*1.0)/(GC*P1*ODDUM) STARJ425
426,      250 CONTINUE                                 STARJ426
427,      GO TO 265                                     STARJ427
428,      C                                             STARJ428
429,      C COMPUTE ACCELERATION HEAD IN MAIN OX FEED SECTION STARJ429
430,      C                                             STARJ430
431,      255 OPDUM=TOTMLO                               STARJ431
432,      DO 260 J=1,MPTS                               STARJ432
433,      DLPACO(I,J)=(4.0*WDDOTO(J)*OPDUM*NOP)/(GC*P1*ODDUM) STARJ433
434,      260 CONTINUE                                 STARJ434
435,      265 CONTINUE                                 STARJ435
436,      IF (SYSNUM.EQ,1) GO TO 295                   STARJ436
437,      270 HPDUM = HPIPEL(I)                         STARJ437
438,      HDDUM = HPJ(I)**2                             STARJ438
439,      IF (I,GT,NEL) GO TO 280                       STARJ439
440,      C                                             STARJ440
441,      C COMPUTE ACCELERATION HEAD IN SINGLE ENGINE FUEL FEED SECTION STARJ441
442,      C                                             STARJ442
443,      C                                             STARJ443
444,      DO 275 J=1,MPTS                               STARJ444
445,      DLPACH(I,J)=(4.0*WDDOTH(J)*HPDUM*1.0)/(GC*P1*HDDUM) STARJ445
446,      275 CONTINUE                                 STARJ446
447,      GO TO 290                                     STARJ447
448,      C                                             STARJ448
449,      C COMPUTE ACCELERATION HEAD IN MAIN FUEL FEED SECTION STARJ449
450,      C                                             STARJ450
451,      280 HPDUM=TOTM_H                               STARJ451
452,      DO 285 J=1,MPTS                               STARJ452
453,      DLPACH(I,J)=(4.0*WDDOTH(J)*HPDUM*NOP)/(GC*P1*HDDUM) STARJ453
454,      285 CONTINUE                                 STARJ454
455,      290 CONTINUE                                 STARJ454
455,      295 CONTINUE                                 STARJ455

```

Fig. B-1 STAR Program Listing (Cont'd)

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456. C COMPUTE THE INITIAL ULLAGE VOLUMES AND HEAD HEIGHTS FOR TANKS STARJ456
457. C STARJ457
458. C STARJ458
459. DO 300 I=1,9 STARJ459
460. 300 EQLR(I)=EQLR1(I)/FEET STARJ460
461. CALL INIVOL STARJ461
462. C STARJ462
463. CALL ULLMEJ(LOADO2,LOADH2) STARJ463
464. ULVLO = UVLO2 STARJ464
465. ULVLH = UVLH2 STARJ465
466. HEADIO = HD02 STARJ466
467. HEADIH = HDH2 STARJ467
468. C STARJ468
469. C COMPUTE VEHICLE WEIGHT CHANGE FOR NOP1 ENGINE OPERATION STARJ469
470. C STARJ470
471. VWGTC = VWGTN STARJ471
472. PNCWGT = 0.0 STARJ472
473. VL02 = 0.0 STARJ473
474. VLM2 = 0.0 STARJ474
475. DO 310 J=1,MPTS STARJ475
476. DFNGTO(J)=((WDTFR0(J+1)+ WDTFR0(J))/2.0)*WJOTNO STARJ476
477. DFNGTH(J)=((WDTFRH(J+1)+ WDTFRH(J))/2.0)*WJOTNH STARJ477
478. DIFWGT(J)=DFNGTO(J)+DFNGTH(J) STARJ478
479. DELTIM = (TIMEA(J+1)-TIMEA(J)) STARJ479
480. VWGTC = VWGTC + (DIFWGT(J)*NOP1*DELTIM) STARJ480
481. VWGTNU(J) =VWGTC STARJ481
482. PCWGT(J) = DFNGTO(J)*NOP1*DELTIM STARJ482
483. PCWGT(J) = DFNGTH(J)*NOP1*DELTIM STARJ483
484. PNCWGT = PNCWGT + (DIFWGT(J)*NOP1*DELTIM) STARJ484
485. PROWGT(J) = PNCWGT STARJ485
486. C STARJ486
487. C CALCULATE THRUST TO WGT RATIO AS F(T) STARJ487
488. C STARJ488
489. FTOW(J) = (FIFRAC(J)*FNOM*NOP1)/VWGTNU(J) STARJ489
490. IF (FTOW(J),GT.1.) GO TO 305 STARJ490
491. IF(NGST,GT.1) FTOW(J)=1. STARJ491
492. C STARJ492
493. C CALCULATE HEAD HEIGHT IN PROPELLANT TANKS FOR OXID. AND FUEL STARJ493
494. C STARJ494
495. 305 VL02 = VL02+((DFNGTO(J)*NOP1*(TIMEA(J+1)-TIMEA(J)))/RH00X) STARJ495
496. VL002(J)=VL02 STARJ496
497. VRM02 = LOAD02 = VL02 STARJ497
498. VLM2 = VLM2+((DFNGTH(J)*NOP1*(TIMEA(J+1)-TIMEA(J)))/RH0HY) STARJ498
499. VLGH2(J)=VLM2 STARJ499
500. VRMH2 = LOADH2 = VLM2 STARJ500
501. CALL ULLMEJ(VRMO2,VRMH2) STARJ501
502. ULVLO2(J)= UVLO2 STARJ502
503. ULVLH2(J)= UVLH2 STARJ503
504. HEAD02(J)= HD02 STARJ504
505. HEADH2(J)= HDH2 STARJ505
506. C STARJ506
507. C CALCULATE PRESSURE DIFFERENCE DUE TO TOTAL HEAD AS F(T) STARJ507
508. C STARJ508
509. DLPHD0(J)=(FTOW(J) * RH00X * (HD02+OXHTLN))/144.0 STARJ509
510. DLPHDH(J)=(FTOW(J) * RH0HY * (HDH2+HYHTLN))/144.0 STARJ510
511. 310 CONTINUE STARJ511
512. C STARJ512
513. C CALCULATE LINE PRESSURE DROP STARJ513

```

Fig. B-1 STAR Program Listing (Cont'd)

```

514. C
515. DO 385 I=1,NSIZE
516. GO TO (315,350,315),SYSNUM
517. 315 ODLDUM = OPD(I)**4
518. OCAYP=0,
519. D=OPD(I)
520. CONGP = 3.62806
521. IF (I,GT,NEL) GO TO 330
522. C
523. C COMPUTE LINE PRESSURE DROP IN SINGLE ENGINE OX FEED SECTION
524. C
525. MID=MIDELO(I)
526. DO 320 NID=1,MID
527. ID=IDELO( I,NID)
528. SP1=SPIELO( I,NID)
529. SP2=SPZELO( I,NID)
530. CALL FLORES(ID,D,SP1,SP2,RES)
531. OCAYP=OCAYP+RES
532. 320 CONTINUE
533. OCAYP=0.144*OPIDEL(I)/D*OCAYP
534. OKPD(I)=OCAYP
535. DO 325 J=1,MPTS
536. DLPLNO(I,J)=(CONGP*OCAYP*(DFWGT0(J)**2)*1.0)/(RHOOX*ODLDUM)
537. 325 CONTINUE
538. GO TO 345
539. C
540. C COMPUTE LINE PRESSURE DROP IN MAIN OX FEED LINE SECTION
541. C
542. 330 DO 335 NID=1,MIDMLO
543. ID=IDMLO(NID)
544. SP1=SP1MLO(NID)
545. SP2=SP2MLO(NID)
546. CALL FLORES(ID,D,SP1,SP2,RES)
547. OCAYP=OCAYP+RES
548. 335 CONTINUE
549. OCAYP=0.144*TOTMLO/D*OCAYP
550. OKPD(I)=OCAYP
551. DO 340 J=1,MPTS
552. DLPLNO(I,J)=(CONGP*OCAYP*((NOP*DFWGT0(J)**2))/(RHOOX*ODLDUM))
553. 340 CONTINUE
554. 345 CONTINUE
555. IF (SYSNUM,EQ,1) GO TO 385
556. 350 MDLDUM = HPD(I)**4
557. MCAYP=0,
558. D=HPD(I)
559. CONGP = 3.62806
560. IF (I,GT,NEL) GO TO 365
561. C
562. C COMPUTE LINE PRESSURE DROP IN SINGLE ENGINE FUEL FEED SECTION
563. C
564. MID=MIDELH(I)
565. DO 355 NID=1,MID
566. ID=IDELH( I,NID)
567. SP1=SPIELH( I,NID)
568. SP2=SPZELH( I,NID)
569. CALL FLORES(ID,D,SP1,SP2,RES)
570. MCAYP=MCAYP+RES
571. 355 CONTINUE
STAR0514
STAR0515
STAR0516
STAR0517
STAR0518
STAR0519
STAR0520
STAR0521
STAR0522
STAR0523
STAR0524
STAR0525
STAR0526
STAR0527
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STAR0560
STAR0561
STAR0562
STAR0563
STAR0564
STAR0565
STAR0566
STAR0567
STAR0568
STAR0569
STAR0570
STAR0571

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Fig. B-1 STAR Program Listing (Cont'd)

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572.      HCAYP=0,144*HPIPEL(I)/D*HCAYP
573.      HKPD(I)=HCAYP
574.      DO 360 J=1,MPTS
575.      DLPLNH(I,J)=(CONGP*HCAYP*(DFWGTW(J)**2)*I,J)/(RHOHY*HDLDUM)
576. 360 CONTINUE
577.      GO TO 380
578.
579. C      COMPUTE LINE PRESSURE DROP IN MAIN FUEL FEED LINE SECTION
580. C
581. 365 DO 370 NID=1,MIDMLH
582.      ID=IDMLH(NID)
583.      SP1=SP1MLH(NID)
584.      SP2=SP2MLH(NID)
585.      CALL FLORES(ID,D,SP1,SP2,RES)
586.      HCAYP=HCAYP+RES
587. 370 CONTINUE
588.      HCAYP=0,144*TOTMLH/D*HCAYP
589.      HKPD(I)=HCAYP
590.      DO 375 J=1,MPTS
591.      DLPLNH(I,J)=(CONGP*HCAYP*(NOP*DFWGTW(J)**2))/(RHOHY*HDLDUM)
592. 375 CONTINUE
593. 380 CONTINUE
594. 385 CONTINUE
595.
596. C      CALCULATE ULLAGE PRESSURE REQUIRED
597. C
598.      TVAPO = TEVINO
599.      CALL PVAPOR(TVAPO,1,PVAPO)
600.      PVPENO = PVAPO
601.      TVAPH = TEVINH
602.      CALL PVAPOR(TVAPH,2,PVAPH)
603.      PVPENH = PVAPH
604.      DO 400 J=1,MPTS
605.      GO TO (390,395,390),SYSNUM
606. 390 PENG0(J)=PVPENO + NPSPO(J)
607.      IF(PENG0(J),LT,PENMNO(J)) PENG0(J)=PENMNO(J)
608.      IF (SYSNUM,EQ,1) GO TO 400
609. 395 PENGH(J)=PVPENH + NPSPH(J)
610.      IF(PENGH(J),LT,PENMNH(J)) PENGH(J)=PENMNH(J)
611. 400 CONTINUE
612.      DO 425 I=NELP,NSIZE
613.      DO 420 J=1,MPTS
614.      SUM0=0.
615.      SUMH=0.
616.      SUMMO(J)=0.
617.      SUMMH(J)=0.
618.      DO 405 N=1,NEL
619.      SUM0=DLPLNO(N,J)+DLPACO(N,J)
620.      SUMH=DLPLNH(N,J)+DLPACH(N,J)
621.      IF(SUM0,GT,SUMMO(J)) SUMMO(J)=SUM0
622.      IF(SUMH,GT,SUMMH(J)) SUMMH(J)=SUMH
623. 405 CONTINUE
624.      GO TO (410,415,410),SYSNUM
625. 410 PULL0(I,J)=PENG0(J)+DLPLNO(I,J)+DLPACO(I,J)
626.      -DLPHO(J)+SUMMO(J)+PENTOL
627.      IF (SYSNUM,EQ,1) GO TO 420
628. 415 PULLH(I,J)=PENGH(J)+DLPLNH(I,J)+DLPACH(I,J)
629.      -DLPHH(J)+SUMMH(J)+PENTOL

```

Fig. B-1 STAR Program Listing (Cont'd)

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630,      420 CONTINUE                                STAR0630
631,      425 CONTINUE                                STAR0631
632,      C                                          STAR0632
633,      C      CALCULATE MINIMUM ULLAGE PRESSURE REQUIRED STAR0633
634,      C                                          STAR0634
635,      TSVAP0 = TL1350                            STAR0635
636,      CALL PVAPOR(TSVAP0,1,PSVAP0)                STAR0636
637,      PUVAP0 = PSVAP0                             STAR0637
638,      TSVAPH = TL1354                             STAR0638
639,      CALL PVAPOR(TSVAPH,2,PSVAPH)                STAR0639
640,      PUVAPH = PSVAPH                             STAR0640
641,      C                                          STAR0641
642,      DO 445 I=NELP,NSIZE                          STAR0642
643,      DO 440 J=1,MPTS                              STAR0643
644,      GO TO (430,435,430),SYSNUM                  STAR0644
645,      430 PULMNO(J) = PUVAP0 + PPDGCT(J)          STAR0645
646,      IF(PULL0(I,J).GT,PULMNO(J)) PULLRO(I,J) = PULL0(I,J) STAR0646
647,      IF(PULL0(I,J).LE,PULMNO(J)) PULLRO(I,J)=PULMNO(J) STAR0647
648,      IF (SYSNUM,EQ,1) GO TO 440                  STAR0648
649,      435 PULMNH(J) = PUVAPH + PPDGHT(J)          STAR0649
650,      IF(PULLH(I,J).GT,PULMNH(J)) PULLRH(I,J) = PULLH(I,J) STAR0650
651,      IF(PULLH(I,J).LE,PULMNH(J)) PULLRH(I,J)=PULMNH(J) STAR0651
652,      440 CONTINUE                                STAR0652
653,      445 CONTINUE                                STAR0653
654,      C                                          STAR0654
655,      C      CALCULATE PRESSURE AT TANK BOTTOM (OXID, AND FUEL) STAR0655
656,      C                                          STAR0656
657,      DO 465 I=NELP,NSIZE                          STAR0657
658,      PTBTMO(I)=0,                                STAR0658
659,      PTBTMH(I)=0,                                STAR0659
660,      DO 460 J=1,MPTS                              STAR0660
661,      GO TO (450,455,450),SYSNUM                  STAR0661
662,      450 PTKBTO(I,J) = PULLRO(I,J) + ((RHOOX * FTOW(J) + HEAD02(J))/144.0) STAR0662
663,      IF (SYSNUM,EQ,1) GO TO 460                  STAR0663
664,      455 PTKBTH(I,J) = PULLRH(I,J) + ((RHOHY * FTOW(J) + HEADH2(J))/144.0) STAR0664
665,      IF(PTKBTO(I,J).GT,PTBTMO(I)) PTBTMO(I)=PTKBTO(I,J) STAR0665
666,      IF(PTKBTH(I,J).GT,PTBTMH(I)) PTBTMH(I)=PTKBTH(I,J) STAR0666
667,      460 CONTINUE                                STAR0667
668,      465 CONTINUE                                STAR0668
669,      C                                          STAR0669
670,      C      CALCULATE WEIGHT OF ULLAGE GAS        STAR0670
671,      C                                          STAR0671
672,      DO 485 J=1,MPTS                              STAR0672
673,      GO TO (470,475,470),SYSNUM                  STAR0673
674,      470 TMPULO=((TL1350 + TDCGT(J))/2.0)        STAR0674
675,      I=NELP                                       STAR0675
676,      CALL ZFIND(TMPULO,PULLRO(I,J),1,2)          STAR0676
677,      HOX = FINDER(1)                               STAR0677
678,      RHOLQG=144.0*PJLLRO(I,J)/(Z*ROX*TMPULO)    STAR0678
679,      WTULGQ(J)=RHOLQG*ULVLQ2(J)                  STAR0679
680,      IF (SYSNUM,EQ,1) GO TO 480                  STAR0680
681,      475 TMPULH=((TL1354 + TDCHT(J))/2.0)        STAR0681
682,      RHOLHG = PTDENS(PULLRH(I,J),TMPULH)        STAR0682
683,      WTULGH(J)=RHOLHG*ULVLH2(J)                  STAR0683
684,      480 CONTINUE                                STAR0684
685,      485 CONTINUE                                STAR0685
686,      C                                          STAR0686
687,      C      CALCULATE LINE HEAD PRESSURE        STAR0687

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Fig. B-1 STAR Program Listing (Cont'd)

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688. C
689. DO 500 J=1,MPTS STAR0688
690. GO TO (490,495,490),SYSNUM STAR0689
691. 490 PHDLNO(J)=((RHDOX*FTOW(J)+OXHTLN)/144,0) STAR0690
692. IF (SYSNUM,EQ,1) GO TO 500 STAR0691
693. 495 PHDLNH(J)=((RHONY*FTOW(J)+HYHTLN)/144,0) STAR0692
694. 500 CONTINUE STAR0693
695. C STAR0694
696. C RECOMPUTE PRESSURE AT THE ENGINE STAR0695
697. C STAR0696
698. DO 520 I=NELP,NSIZE STAR0697
699. DO 515 J=1,MPTS STAR0698
700. GO TO (505,510,505),SYSNUM STAR0699
701. 505 PENNUO(I,J)=PT<BTO(I,J)+PHDLNO(J)-DLPACO(I,J) STAR0700
702. =D_PLNO(I,J)-SUMMO(J) STAR0701
703. 1 IF (SYSNUM,EQ,1) GO TO 515. STAR0702
704. 510 PENNUH(I,J)=PT<BTH(I,J)+PHDLNH(J)-DLPACH(I,J) STAR0703
705. 1 =DLPLNH(I,J)-SUMMH(J) STAR0704
706. 515 CONTINUE STAR0705
707. 520 CONTINUE STAR0706
708. C STAR0707
709. C COMPUTE MAXIMUM VALUE OF ENGINE INLET PRESSURE AS A FUNCTION OF T STAR0708
710. C STAR0709
711. DO 570 I=NELP,NSIZE STAR0710
712. PMAXO(I)=0. STAR0711
713. PMAXH(I)=0. STAR0712
714. DO 530 J=1,MPTS STAR0713
715. C STAR0714
716. C COMPUTE MINIMUM ENGINE LINE PRESSURE DROP AT THIS TIME STAR0715
717. C STAR0716
718. SUMNO(J)=1.E+10 STAR0717
719. SUMNH(J)=1.E+10 STAR0718
720. DO 525 N=1,NEL STAR0719
721. SUMO=DLPLNO(N,J)+DLPACO(N,J) STAR0720
722. SUMH=DLPLNH(N,J)+DLPACH(N,J) STAR0721
723. IF (SUMO,LT,SUMNO(J)) SUMNO(J)=SUMO STAR0722
724. IF (SUMH,LT,SUMNH(J)) SUMNH(J)=SUMH STAR0723
725. 525 CONTINUE STAR0724
726. PENMUO(I,J)=PENNUO(I,J)+SUMMO(J)-SUMNO(J) STAR0725
727. PENMUH(I,J)=PENNUH(I,J)+SUMMH(J)-SUMNH(J) STAR0726
728. IF (PENMUO(I,J).GT,PMAXO(I)) PMAXO(I)=PENMUO(I,J) STAR0727
729. IF (PENMUH(I,J).GT,PMAXH(I)) PMAXH(I)=PENMUH(I,J) STAR0728
730. 530 CONTINUE STAR0729
731. C STAR0730
732. C COMPUTE TOTAL FEEDLINE WEIGHTS FOR EACH LINE SIZE STAR0731
733. C STAR0732
734. IF (SYSNUM,EQ,2) GO TO 550 STAR0733
735. PDES0(I)=AMAX1(PMAXO(I),PTBTMO(I),PDLO) STAR0734
736. PUES=PDES0(I) STAR0735
737. SUM=0. STAR0736
738. SUMI=0. STAR0737
739. DIA=OPD(I) STAR0738
740. DO 535 MID=1,MIDMLO STAR0739
741. IDV=0 STAR0740
742. ID=IDMLO(MID) STAR0741
743. IM=IMMLO(MID) STAR0742
744. II=IIMLO(MID) STAR0743
745. SP1=SP1MLO(MID) STAR0744

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Fig. B-1 STAR Program Listing (Cont'd)

```

746.      IF(ID,EG,2) SP1=SP1*AD0(I) ----- STAR0746
747.      SP2=SP2MLO(MID) ----- STAR0747
748.      SP3=SP3MLO(MID) ----- STAR0748
749.      IF(ID,EG,13,OR,ID,EG,14) IDV=ID0(MID) ----- STAR0749
750.      CALL WTCTRL(PDES, ID, IM, II, DIA, SP1, SP2, SP3, IDV, 1, WGT, W1) ----- STAR0750
751.      SUM=SUM+WGT ----- STAR0751
752.      SUMI=SUMI+W1 ----- STAR0752
753.      535 CONTINUE ----- STAR0753
754.      WML0(I)=SUM ----- STAR0754
755.      WMLIO(I)=SUMI ----- STAR0755
756.      SUMT=0 ----- STAR0756
757.      SUMIT=0 ----- STAR0757
758.      DO 545 NL=1,NEL ----- STAR0758
759.      SUM=0 ----- STAR0759
760.      SUMI=0 ----- STAR0760
761.      MID=MIDEL0(NL) ----- STAR0761
762.      DIA=OPD(NL) ----- STAR0762
763.      DO 540 J=1,MID ----- STAR0763
764.      ID=IDEL0(NL,J) ----- STAR0764
765.      IM=IMELO(NL,J) ----- STAR0765
766.      II=IIELO(NL,J) ----- STAR0766
767.      IDV=0 ----- STAR0767
768.      SP1=SP1ELO(NL,J) ----- STAR0768
769.      SP2=SP2ELO(NL,J) ----- STAR0769
770.      SP3=SP3ELO(NL,J) ----- STAR0770
771.      IF(ID,EG,13,OR,ID,EG,14) IDV=ID0E(NL,J) ----- STAR0771
772.      CALL WTCTRL(PDES, ID, IM, II, DIA, SP1, SP2, SP3, IDV, 1, WGT, W1) ----- STAR0772
773.      SUM=SUM+WGT ----- STAR0773
774.      SUMI=SUMI+W1 ----- STAR0774
775.      540 CONTINUE ----- STAR0775
776.      WEL0(I,NL)=SUM ----- STAR0776
777.      WELIO(I,NL)=SUMI ----- STAR0777
778.      SUMT=SUMT+SUM ----- STAR0778
779.      SUMIT=SUMIT+SUMI ----- STAR0779
780.      545 CONTINUE ----- STAR0780
781.      WELOT(I)=SUMT ----- STAR0781
782.      WELIOT(I)=SUMIT ----- STAR0782
783.      WLOT(I)=WML0(I)+WELOT(I) ----- STAR0783
784.      WLIOT(I)=WMLIO(I)+WELIOT(I) ----- STAR0784
785.      WLOTT(I)=WLOT(I)+WLIOT(I) ----- STAR0785
786.      550 IF (SYSNUM,EG,1) GO TO 570 ----- STAR0786
787.      PDESH(I)=AMAX1(PMAXH(I),PTBTMH(I),PDLH) ----- STAR0787
788.      PDES=PDESH(I) ----- STAR0788
789.      SUM=0 ----- STAR0789
790.      SUMI=0 ----- STAR0790
791.      DIA=HPD(I) ----- STAR0791
792.      DO 555 MID=1,MIDMLH ----- STAR0792
793.      IDV=0 ----- STAR0793
794.      ID=IDMLH(MID) ----- STAR0794
795.      IM=IMMLH(MID) ----- STAR0795
796.      II=IJMLH(MID) ----- STAR0796
797.      SP1=SP1MLH(MID) ----- STAR0797
798.      IF(ID,EG,2) SP1=SP1*ADH(I) ----- STAR0798
799.      SP2=SP2MLH(MID) ----- STAR0799
800.      SP3=SP3MLH(MID) ----- STAR0800
801.      IF(ID,EG,13,OR,ID,EG,14) IDV=IDH(MID) ----- STAR0801
802.      CALL WTCTRL(PDES, ID, IM, II, DIA, SP1, SP2, SP3, IDV, 2, WGT, W1) ----- STAR0802
803.      SUM=SUM+WGT ----- STAR0803

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Fig. B-1 STAR Program Listing (Cont'd)

```

004.      SUMI=SUMI+WI      STAR0804
005.  555 CONTINUE      STAR0805
006.      WMLH(1)=SUM      STAR0806
007.      WMLH(1)=SUMI      STAR0807
008.      SUMT=C      STAR0808
009.      SUMIT=0      STAR0809
010.      DO 565 NL=1,NEL      STAR0810
011.      SUM=0      STAR0811
012.      SUMI=0      STAR0812
013.      MID=MIDELH(NL)      STAR0813
014.      DIA=WDJ(NL)      STAR0814
015.      DO 560 J=1,MID      STAR0815
016.      ID=IDELH(NL,J)      STAR0816
017.      IM=IMELH(NL,J)      STAR0817
018.      II=IITELH(NL,J)      STAR0818
019.      IDV=0      STAR0819
020.      SP1=SP1ELH(NL,J)      STAR0820
021.      SP2=SP2ELH(NL,J)      STAR0821
022.      SP3=SP3ELH(NL,J)      STAR0822
023.      IF(ID.EQ.13.OR.ID.EQ.14) IDV=ICHE(NL,J)      STAR0823
024.      CALL XCTRL(PDES, ID, IM, II, DIA, SP1, SP2, SP3, IDV, 2, WGT, WI)      STAR0824
025.      SUM=SUM+WGT      STAR0825
026.      SUMI=SUMI+WI      STAR0826
027.  560 CONTINUE      STAR0827
028.      WELH(1,NL)=SUM      STAR0828
029.      WELH(1,NL)=SUMI      STAR0829
030.      SUMT=SUMT+SUM      STAR0830
031.      SUMIT=SUMIT+SUMI      STAR0831
032.  565 CONTINUE      STAR0832
033.      WELHT(1)=SUMT      STAR0833
034.      WELHT(1)=SUMIT      STAR0834
035.      WLHT(1)=WMLH(1)+WELHT(1)      STAR0835
036.      WLHT(1)=WMLH(1)+WELHT(1)      STAR0836
037.      WLHTT(1)=WLHT(1)+WLHT(1)      STAR0837
038.  570 CONTINUE      STAR0838
039.  C      STAR0839
040.  C      WRITE OUT THE GIMMICK      STAR0840
041.  C      STAR0841
042.  C      STAR0842
043.      IPASS = IPASS + 1      STAR0843
044.      IF (IPASS,GT,1) GO TO 590      STAR0844
045.  C      STAR0845
046.      WHITE (6,575)      STAR0846
047.  575 FORMAT(1H1,////////)      STAR0847
048.      WRITE (6,580)      STAR0848
049.  580 FORMAT(//T123,'+',/T33,'SSSSS',T42,'SSSSSS',T51,'SSSSS',T5A,'SSS',STAR0849
050.  1T63,'SS S',T111,'EEEEEE',T121,'+',/T33,'S',T38,'S',T42,'S',T50,STAR0850
051.  2'S',T59,'S',T63,'S S S',T96,'+++++X+E',T116,'E '+/T33,STAR0851
052.  3'SSSSS',T42,'SSSS',T50,'S',T54,'SS',T59,'S',T63,'S S S',T96,'+',STAR0852
053.  4T111,'E',T116,'E+',/T33,'S S',T42,'S',T50,'S S',T59,'S',T63,STAR0853
054.  5'S S S',T96,'+',T107,'',XDE E '+/T33,'SSSSS',T42,'SSSSSSSTAR0854
055.  6',T51,'SSSSS',T58,'SSS',T63,'S SS',T96,'+',T107,'+',T111,'EEEEESTAR0855
056.  7E',T123,'+',/T96,'+',T107,'+',T123,'+',/T96,'+',T107,'+',/T7,'SSSSSTAR0856
057.  8SS',T16,'SSSSS',T26,'S',T33,'SSSSS',T42,'SSSSS',T55,'SSSSS',T63, STAR0857
058.  9'SSSSS',T74,'S',T81,'SS S',T96,'+',T107,'+',/T7,'S',T18,'S', STAR0858
059.  AT25,'S S',T33,'S S',T44,'S',T57,'S',T63,'S S',T73,'S S',T81,STAR0859
060.  B'S S S',T96,'+',T107,'+',T123,'+',/T7,'SSSSSS',T18,'S',T24,'SSSSSTAR0860
061.  CS',T33,'SSSSS',T44,'S',T49,'XXX',T57,'S',T63,'SSSSS',T72,'SSSSS',STAR0861

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Fig. B-1 STAR Program Listing (Cont'd)


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862. DT81,'S S S',T96,'+',T107,'@',T111,'EEEEEE',T121,'+',/T12,'S', STAR0842
863. ET18,'S',T23,'S',T29,'S',T33,'S S',T44,'S',T57,'S',T63,'S S',T71,STAR0843
864. E'S S',T81, STAR0844
865. F'S S S',T96,'+++++.....+*E',T116,'E',T119,'+',/T7,'SSSSSS', STAR0845
866. GT18,'S',T22,'S',T33,'S',T33,'S S',T44,'S',T57,'S',T63,'S S', STAR0846
867. HT70,'S',T78,'S',T81,'S SS',T96,'+',T107,'@',T111,'E E') STAR0847
868. WRITE (6,595) STAR0848
869. 585 FORMAT(T96,'+',T107,'@X@E E @',/T96,'+',T107,'@',T111,'EEEEEE' STAR0849
870. 1',T121,'+',/T96,'+',T107,'@',T123,'+',/T96,'+',T107,'+',/T47,'+' STAR0870
871. 2+++++*PVC+++++.....+*PVC+++++,'T107,'C',/T47,'+', STAR0871
872. JT107,'@',/T47,'X',T107,'X',/T47,'+',/T107,'+',/T24,'@ . . . . STAR0872
873. 4@ . . . . Z . . . . . . . . . . . . . . . . STAR0873
874. 5@ Z . . . . .',/T21,'@',T37,'@',T47,'X',T137,'X',T112,'+',T117, STAR0874
875. 6'+',/T18,'+',T38,'+',T47,'+',T107,'@',T114,'+',T117,'+',/T15,'+', STAR0875
876. 7T39,'+',T47,'+',T107,'@',T116,'+',/T12,'+',T40,'+',T47,'+',T107, STAR0876
877. 8'+',T118,'+',/T9,'+',T41,'+',T47,'+',T107,'@',T120,'+',/T6,'+', STAR0877
878. 9T42,'+++++',T107,'@',T118,'+',T121,'+',/T9,'+',T41,'+',T120, STAR0878
879. A'+',/T12,'+',T40,'+',T118,'+',/T15,'+',T39,'+',T116,'+',/T18,'+', STAR0879
880. BT38,'+',T114,'+',/T21,'+',T37,'+',T112,'+',T117,'+',/T24,'@ . . STAR0880
881. C . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . STAR0881
882. D . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . STAR0882
883. ESTART TRANSIENT ANALYSIS PROGRAM',///T30,'A PARAMETRIC PROPULSION SYSTEMS STAR0883
884. F',/T100,'PROGRAMMER - R.F.HAUSMAN',/T100,'DEPT. 62-13, BLDG. 104')STAR0884
885. 590 CONTINUE STAR0885
886. C STAR0886
887. C WRITE OUT THE INPUT DATA TABLE STAR0887
888. C STAR0888
889. WRITE (6,785) STAR0889
890. WRITE (6,790)(ST(I),I=1,7) STAR0890
891. WRITE (6,595) STAR0891
892. 595 FORMAT(IH0,T20,'INPUT DATA FOR START TRANSIENT PROBLEM CONSIDERED STAR0892
893. 1IN THIS ANALYSIS,'//) STAR0893
894. WRITE (6,600)NSIZE STAR0894
895. 600 FORMAT(T5,'THE NUMBER OF LINE SIZES TO BE CONSIDERED IS ',15) STAR0895
896. GO TO (605,615,625),SYSNUM STAR0896
897. 605 WRITE (6,610) STAR0897
898. 610 FORMAT(T5,'THE PROBLEM CONSIDERS THE OXIDIZER FEED SYSTEM') STAR0898
899. GO TO 635 STAR0899
900. 615 WRITE (6,620) STAR0900
901. 620 FORMAT(T5,'THE PROBLEM CONSIDERS THE FUEL FEED SYSTEM') STAR0901
902. GO TO 635 STAR0902
903. 625 WRITE (6,630) STAR0903
904. 630 FORMAT(T5,'THE PROBLEM CONSIDERS BOTH OXIDIZER AND FUEL FEED SYSTEM' STAR0904
905. 1MS') STAR0905
906. 635 CONTINUE STAR0906
907. WRITE (6,640)NOP1,NOP,WDOTNO,WCOTNH,VGDN,FNUM STAR0907
908. 640 FORMAT(T5,'THE NUMBER OF ENGINES FOR THE VEHICLE IS ',15, STAR0908
909. 1/T5,'THE NUMBER OF ENGINES FOR EACH FEED SYSTEM IS ',15, STAR0909
910. 2 /T5,'THE NOMINAL OXIDIZER FLOW RATE IS',F8,2,' LBS/SEC',/T5,'T' STAR0910
911. 3HE NOMINAL FUEL FLOW RATE IS',F8,2,' LBS/SEC',/T5,'THE VEHICLE LOASTAR0911
912. 4DED WEIGHT IS',F12,2,' LBS',/T5,'THE NOMINAL THRUST FOR EACH ENGIN' STAR0912
913. 5E IS',F10,2,' LBS') STAR0913
914. WRITE (6,645)TENINO,TENINH,PENTOL,HEADIO,OXHTLN,HEADIH,HYHTLN,ULVL' STAR0914
915. 110,ULVLIN,LOADOI,LOADHI,ASKIN,ADOME,ATCT STAR0915
916. 645 FORMAT(T5,'THE BULK OXID. ENGINE INLET TEMPERATURE IS',F8,2,' DEG, STAR0916
917. 1R',/T5,'THE BULK FUEL ENGINE INLET TEMPERATURE IS',F8,2,' DEG,R', STAR0917
918. 3 /T5,'THE STAR0918
919. 4COMPONENT PRESSURE TOLERANCE IS',F6,2,' PSI',/T5,'THE OXID. HEAD HSTAR0919

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Fig. B-1 STAR Program Listing (Cont'd)

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920. SEIGHT IN THE TANK IS',F8,3,' FT',/T5,'THE OXID. HEAD HEIGHT IN THESTAR0920
921. 6FEED LINE IS',F8,3,' FT',/T5,'THE FUEL HEAD HEIGHT IN THE TANK IS'STAR0921
922. 7',F8,3,' FT',/T5,'THE FUEL HEAD HEIGHT IN THE FEED LINE IS',F8,3, STAR0922
923. 8'FT',/T5,'THE INITIAL ULLAGE VOLUME IN THE OXICIZER TANK IS',F10,0STAR0923
924. 9,'CU,FT',/T5,'THE INITIAL ULLAGE VOLUME IN THE FUEL TANK IS',F10,0STAR0924
925. A,' CU,FT',/T5,'THE INITIAL OXICIZER LOADING IS',F12,0,' LBS',/T5,'STAR0925
926. BTHE INITIAL FUEL LOADING IS',F12,0,' LBS',/T5,'THE EXTERNAL SURFACSTAR0926
927. CE AREA OF THE DROP TANK IS',F12,1,' SQ, FT',/T5,'THE EXTERNAL SURSTAR0927
928. DFACE AREA OF THE LOX/LH2 BULKHEAD IS',F8,1,' SQ, FT',/T5,'THE TOTSTAR0928
929. EAL SURFACE AREA IS THEREFORE',F12,1,' SQ, FT,') STAR0929
930. WRITE (6,650)PDL0,PDLH STAR0930
931. 650 FORMAT(T5,'THE OXYGEN FEEDLINE DESIGN PRESSURE IS',G13,8,' PSI',/ STAR0931
932. 1T5,'THE HYDROGEN FEEDLINE DESIGN PRESSURE IS',G13,8,' PSI') STAR0932
933. WRITE (6,655) STAR0933
934. WRITE (6,655) STAR0934
935. WRITE (6,655) STAR0935
936. 655 FORMAT(T5,'THE TANK GEOMETRY INPUT VALUES ARE AS FOLLOWS - ',/ ) STAR0936
937. WRITE (6,660)(EQLR1(N),N=1,9) STAR0937
938. 660 FORMAT(T5,'L1=',F8,3,T17,'L2=',F8,3,T29,'L3=',F8,3,T41,'L4=',F8,3,STAR0938
939. 1T53,'R1=',F8,3,T65,'R2=',F8,3,T77,'R3=',F8,3,T89,'R4=',F8,3,T101, STAR0939
940. 2'R5=',F8,3) STAR0940
941. WRITE (6,665) STAR0941
942. 665 FORMAT(1H0) STAR0942
943. WRITE (6,670) STAR0943
944. 670 FORMAT(T36,'TABLE OF FEED LINE DATA',/T20,'OXIDIZER LINES',T60,'FUSTAR0944
945. 1EL LINES',/T10,'DIAMETER',T22,'LENGTH',T32,'K-FACTOR',T50,'DIAMETSTAR0945
946. 2ER',T62,'LENGTH',T72,'K-FACTOR',/T11,'INCHES',T21,'FEET',T51,'INCHSTAR0946
947. 3ES',T63,'FEET',/) STAR0947
948. DO 685 K=1,NSIZE STAR0948
949. IF (K,GT,NEL) GO TO 675 STAR0949
950. WRITE (6,680)OPD(K),OPIPEL(K),CKPD(K),HPD(K),HPPEL(K),HKPD(K) STAR0950
951. GO TO 685 STAR0951
952. 675 WRITE (6,680)OPD(K),TOTML0,OKPD(K),HPD(K),TOTMLH,MKPD(K) STAR0952
953. 680 FORMAT(T11,F6,2,T21,F7,2,T33,F7,4,T51,F6,2,T61,F7,2,T73,F7,4) STAR0953
954. 685 CONTINUE STAR0954
955. WRITE (6,685) STAR0955
956. IF (SYSDUM,EQ,2) GO TO 730 STAR0956
957. WRITE (6,695) STAR0957
958. 695 FORMAT(T15,'COMPONENT DESCRIPTORS FOR MAIN OXYGEN FEEDLINE',/) STAR0958
959. WRITE (6,700) STAR0959
960. 700 FORMAT(T5,'COMPONENT TYPE MATL INSUL SPEC1 SPEC2 STAR0960
961. 1 SPEC3') STAR0961
962. DO 705 I=1,MIDML0 STAR0962
963. 705 WRITE (6,710)I,ICML0(I),IMML0(I),IIML0(I),SP1ML0(I),SP2ML0(I),SP3MSTAR0963
964. 1LO(I) STAR0964
965. 710 FORMAT(T7,I3,T17,I3,T23,I2,T30,I2,T36,G9,4,T47,G9,4,T58,G9,4) STAR0965
966. DO 725 NL=1,NE STAR0966
967. MID=MIDLO(NL) STAR0967
968. WRITE (6,715)NL STAR0968
969. 715 FORMAT(1H0,T14,'COMPONENT DESCRIPTORS FOR ENGINE OXYGEN FEEDLINE NSTAR0969
970. 1UMBER ',I1,/) STAR0970
971. WRITE (6,700) STAR0971
972. DO 720 I=1,MID STAR0972
973. 720 WRITE (6,710)I,IDELO(NL,I),IMELO(NL,I),IIELO(NL,I),SP1ELO(NL,I),SPSTAR0973
974. 1ZELO(NL,I),SP3ELO(NL,I) STAR0974
975. 725 CONTINUE STAR0975
976. 730 IF (SYSDUM,EQ,1) GO TO 760 STAR0976
977. WRITE (6,735) STAR0977

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Fig. B-1 STAR Program Listing (Cont'd)

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978.      735 FORMAT(15,'COMPONENT DESCRIPTORS FOR MAIN HYDROGEN FEEDLINE',/) STAR0978
979.      WRITE (6,700) STAR0979
980.      DO 740 I=1,MIDMLH STAR0980
981.      740 WRITE (6:710)I,ICMLH(I),IMLH(I),IIMLH(I),SP1MLH(I),SP2MLH(I),SP3MLH(I) STAR0981
982.      ILM(I) STAR0982
983.      DO 755 NL=1,NEL STAR0983
984.      MID=MIDELH(NL) STAR0984
985.      WRITE (6,745)NL STAR0985
986.      745 FORMAT(14C,T14,'COMPONENT DESCRIPTORS FOR ENGINE HYDROGEN FEEDLINE STAR0986
987.      1 NUMBER ',I1,/) STAR0987
988.      WRITE (6,700) STAR0988
989.      DO 750 I=1,MID STAR0989
990.      750 WRITE (6:710)I,DELH(NL,I),IMELH(NL,I),IIEELH(NL,I),SP1ELH(NL,I),SP2ELH(NL,I) STAR0990
991.      I2ELH(NL,I),SP3ELH(NL,I) STAR0991
992.      755 CONTINUE STAR0992
993.      760 CONTINUE STAR0993
994.      WRITE (6,785) STAR0994
995.      WRITE (6,765) STAR0995
996.      765 FORMAT(14C,T20,'THE TIME DEPENDENT PERFORMANCE CHARACTERISTIC INPUT STAR0996
997.      1T VALUES ARE AS FOLLOWS - ,') STAR0997
998.      WRITE (6,770) STAR0998
999.      770 FORMAT(14C,T5,'TIME',T15,'NPSPC',T25,'NPSPH',T35,'WDTFR0',T45,'WDT STAR0999
1000.      1FRH',T55,'FIFRAC',T65,'PENMNO',T75,'PENMNH',T85,'PPDGOT',T95,'PPDG STAR1000
1001.      2HT',T105,'TOGOT',T115,'TOGHT') STAR1001
1002.      DO 780 N=1,NPTS STAR1002
1003.      WRITE (6,775)TIMEA(N),NPSPO(N),NPSPH(N),WDTFR0(N),WDTFRH(N),FIFRAC STAR1003
1004.      1(N),PENMNO(N),PENMNH(N),PPDGOT(N),PPDGHT(N),TOGOT(N),TOGHT(N) STAR1004
1005.      775 FORMAT(T3,F6,2,T14,F6,2,T24,F6,2,T35,F6,3,T45,F6,3,T55,F6,3,T65, STAR1005
1006.      1F6,2,T75,F6,2,T85,F6,2,T95,F6,2,T105,F6,2,T115,F6,2) STAR1006
1007.      780 CONTINUE STAR1007
1008.      C STAR1008
1009.      C WRITE OUT THE SINGLY SUBSCRIPTED VARIABLES TABLE STAR1009
1010.      C STAR1010
1011.      WRITE (6,785) STAR1011
1012.      785 FORMAT(14I) STAR1012
1013.      WRITE (6,790)(ST(I),I=1:7) STAR1013
1014.      790 FORMAT(T42,7A5,/) STAR1014
1015.      WRITE (6,795) STAR1015
1016.      795 FORMAT(T3,'TRANS',T14,'WDDOT',T24,'WDDOT',T33,'VEHICLE',T45,'T/W' STAR1016
1017.      1,T53,'DELPH0',T63,'DELPHD',T73,'PROP-O',T83,'PROP-F',T92,'PROP-TOT STAR1017
1018.      2',T104,'PENG',T114,'PENG') STAR1018
1019.      WRITE (6,800) STAR1019
1020.      800 FORMAT(T4,'TIME',T14,'OXID',T24,'FUEL',T33,'WEIGHT',T44,'RATIO', STAR1020
1021.      1T54,'OXID',T64,'FUEL',T74,'INCR',T84,'INC',T94,'CUM',T104, STAR1021
1022.      2'OXID',T114,'FUEL',/) STAR1022
1023.      DO 820 N=1,NPTS STAR1023
1024.      WRITE (6,805)TIMEA(N) STAR1024
1025.      805 FORMAT(T2,F6,2) STAR1025
1026.      IF (N,EG,NPTS) GO TO 815 STAR1026
1027.      WRITE (6,810)WDDOTO(N),WDDOTH(N),VWGTNU(N),FTOW(N),DLPHDO(N),DLPHD STAR1027
1028.      1(N),PCWGTO(N),PCWGTH(N),PROWGT(N),PENG0(N),PENG(N) STAR1028
1029.      810 FORMAT(T12,F8,3,T22,F8,3,T32,F10,2,T44,F3,3,T53,F6,2,T63,F6,2,T71, STAR1029
1030.      1F8,3,T81,F8,3,T91,F10,3,T103,F6,2,T113,F6,2) STAR1030
1031.      815 CONTINUE STAR1031
1032.      820 CONTINUE STAR1032
1033.      C STAR1033
1034.      C WRITE OUT THE DELTA=P ACCELERATION DATA ARRAY AS F(T) STAR1034
1035.      C STAR1035

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Fig. B-1 STAR Program Listing (Cont'd)

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1036.      NMA=NELP*11                               STAR1036
1037.      GO TO (825,875,900),SYSNUM                STAR1037
1038.      825 WRITE (6,830)                          STAR1038
1039.      830 FORMAT(141)                             STAR1039
1040.      WRITE (6,835)(ST(I),I=1,7)                 STAR1040
1041.      835 FORMAT(T23,7A6,T66,'- OXYGEN SUPPLY SYSTEM') STAR1041
1042.      WRITE (6,840)                               STAR1042
1043.      840 FORMAT(140,T38,'DELTA-P TO SUPPLY ACCELERATION HEAD') STAR1043
1044.      WRITE (6,845)(CPD(K),K=NELP,NMA)           STAR1044
1045.      845 FORMAT(140,T2,'DELTA',T8 ,F4,1,' INCH',T19,F4,1,' INCH',T30,F4,1, STAR1045
1046.      1' INCH',T40,F4,1,' INCH',T50,F4,1,' INCH',T60,F4,1,' INCH',T70, STAR1046
1047.      2F4,1,' INCH',T80,F4,1,' INCH',T90,F4,1,' INCH',T100,F4,1,' INCH',T STAR1047
1048.      3110,F4,1,' INCH',T120,F4,1,' INCH')       STAR1048
1049.      WRITE (6,850)                               STAR1049
1050.      850 FORMAT(T2,'TIME',T8 ,' MAIN LINE',T19,' MAIN LINE',T30,'MAIN LINE', STAR1050
1051.      1,T40,' MAIN LINE',T50,' MAIN LINE',T60,' MAIN LINE',T70 , 'MAIN LINE', STAR1051
1052.      2T80 , 'MAIN LINE',T90,' MAIN LINE',T100,' MAIN LINE',T110,' MAIN LINE' STAR1052
1053.      3,T120,' MAIN LINE'//)                     STAR1053
1054.      DO 870 N=1,NPTS                             STAR1054
1055.      WRITE (6,855)TIMEA(N)                       STAR1055
1056.      855 FORMAT(T2,F5,2)                         STAR1056
1057.      IF (N,EQ,NPTS) GO TO 865                    STAR1057
1058.      WRITE (6,860)(JLPACO(I,N),I=NELP,NMA)       STAR1058
1059.      860 FORMAT(T9 ,F8,3,T19,F8,3,T31,F8,3,T41,F8,3,T51,F8,3,T61,F8,3, STAR1059
1060.      1T71,F8,3,T81,F8,3,T91,F8,3,T101,F8,3,T111,F8,3,T121,F8,3) STAR1060
1061.      865 CONTINUE                                STAR1061
1062.      870 CONTINUE                                STAR1062
1063.      875 CONTINUE                                STAR1063
1064.      IF (SYSNUM,EQ,1) GO TO 895                  STAR1064
1065.      WRITE (6,830)                                STAR1065
1066.      WRITE (6,880)(ST(I),I=1,7)                 STAR1066
1067.      880 FORMAT(T23,7A6,T66,'- HYDROGEN SUPPLY SYSTEM') STAR1067
1068.      WRITE (6,840)                                STAR1068
1069.      WRITE (6,845)(HPC(K),K=NELP,NMA)           STAR1069
1070.      WRITE (6,850)                                STAR1070
1071.      DO 890 N=1,NPTS                             STAR1071
1072.      WRITE (6,855)TIMEA(N)                       STAR1072
1073.      IF (N,EQ,NPTS) GO TO 885                    STAR1073
1074.      WRITE (6,860)(JLPACH(I,N),I=NELP,NMA)       STAR1074
1075.      885 CONTINUE                                STAR1075
1076.      890 CONTINUE                                STAR1076
1077.      895 CONTINUE                                STAR1077
1078.      C                                           STAR1078
1079.      C WRITE OUT THE DELTA-P LINE LOSS DATA ARRAY AS F(T) STAR1079
1080.      C                                           STAR1080
1081.      GO TO (900,925,900),SYSNUM                  STAR1081
1082.      900 WRITE (6,830)                             STAR1082
1083.      WRITE (6,835)(ST(I),I=1,7)                 STAR1083
1084.      WRITE (6,935)                                 STAR1084
1085.      905 FORMAT(140,T26,'DELTA-P DUE TO LINE FRICTION AND CONFIGURATION LOSSTAR1085
1086.      1SES')                                       STAR1086
1087.      WRITE (6,845)(OPD(K),K=NELP,NMA)           STAR1087
1088.      WRITE (6,850)                                STAR1088
1089.      DO 920 N=1,NPTS                             STAR1089
1090.      WRITE (6,855)TIMEA(N)                       STAR1090
1091.      IF (N,EQ,NPTS) GO TO 915                    STAR1091
1092.      WRITE (6,910)(JLPLNO(I,N),I=NELP,NMA)       STAR1092
1093.      910 FORMAT(T9 ,E8,4,T19,E8,4,T31,E8,4,T41,E8,4,T51,E8,4,T61,E8,4, STAR1093

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Fig. B-1 STAR Program Listing (Cont'd)

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1094.      1771,F0,4,T01,E0,4,T01,E0,4,T101,E0,4,T111,E0,4,T121,E0,4)..... STAR1094
1095.      915 CONTINUE STAR1095
1096.      920 CONTINUE STAR1096
1097.      925 CONTINUE STAR1097
1098.      IF (SYSNUM,E0,1) GO TO 940 STAR1098
1099.      WRITE (6,830) STAR1099
1100.      WRITE (6,880)(ST(I),I=1,7) STAR1100
1101.      WRITE (6,905) STAR1101
1102.      WRITE (6,845)(4PD(K),K=NELP,NMA) STAR1102
1103.      WRITE (6,850) STAR1103
1104.      DO 935 N=1,NPTS STAR1104
1105.      WRITE (6,855)TIMEA(N) STAR1105
1106.      IF (N,EQ,NPTS) GO TO 930 STAR1106
1107.      WRITE (6,910)(DLPLNH(I,N),I=NELP,NMA) STAR1107
1108.      930 CONTINUE STAR1108
1109.      935 CONTINUE STAR1109
1110.      940 CONTINUE STAR1110
1111.      C STAR1111
1112.      C WRITE OUT THE ENGINE FEEDLINE PRESSURE DROPS STAR1112
1113.      C STAR1113
1114.      IF (SYSNUM,E0,2) GO TO 975 STAR1114
1115.      WRITE (6,830) STAR1115
1116.      WRITE (6,945)(ST(I),I=1,7) STAR1116
1117.      945 FORMAT(T23,7A6,T66,'-OXYGEN ENGINE FEEDLINE SYSTEM') STAR1117
1118.      WRITE (6,950) STAR1118
1119.      950 FORMAT(1H0,T13,'DELTA-P TO SUPPLY ACCELERATION HEAD',T64,'DELTA-P STAR1119
1120.      1DUE TO LINE FRICTION AND CONFIGURATION LOSSES',//T2,'DELTA',T13, STAR1120
1121.      2'ENGINE',T26,'ENGINE',T39,'ENGINE',T52,'ENGINE',T65,'ENGINE',T78, STAR1121
1122.      3'ENGINE',T91,'ENGINE',T104,'ENGINE',/T2,'TIME',T13,'LINE NO 1', STAR1122
1123.      4T26,'LINE NO 2',T39,'LINE NO 3',T52,'LINE NO 4',T65,'LINE NO 1', STAR1123
1124.      5T78,'LINE NO 2',T91,'LINE NO 3',T104,'LINE NO 4') STAR1124
1125.      DO 970 N=1,NPTS STAR1125
1126.      WRITE (6,855)TIMEA(N) STAR1126
1127.      IF (N,EQ,NPTS) GO TO 970 STAR1127
1128.      IF (NEL,EQ,4) GO TO 960 STAR1128
1129.      DO 955 I=NELP,4 STAR1129
1130.      DLPACO(I,N)=0. STAR1130
1131.      DLPLNO(I,N)=0. STAR1131
1132.      955 CONTINUE STAR1132
1133.      960 WRITE (6,965)(DLPACO(I,N),I=1,4),(DLPLNO(I,N),I=1,4) STAR1133
1134.      965 FORMAT(10X,8G13,8) STAR1134
1135.      970 CONTINUE STAR1135
1136.      IF (SYSNUM,E0,1) GO TO 1000 STAR1136
1137.      975 WRITE (6,830) STAR1137
1138.      WRITE (6,980)(ST(I),I=1,7) STAR1138
1139.      980 FORMAT(T23,7A6,T66,'-HYDROGEN ENGINE FEEDLINE SYSTEM') STAR1139
1140.      WRITE (6,950) STAR1140
1141.      DO 995 N=1,NPTS STAR1141
1142.      WRITE (6,855)TIMEA(N) STAR1142
1143.      IF (N,EQ,NPTS) GO TO 995 STAR1143
1144.      IF (NEL,EQ,4) GO TO 990 STAR1144
1145.      DO 985 I=NELP,4 STAR1145
1146.      DLPACH(I,N)=0. STAR1146
1147.      DLPLNH(I,N)=0. STAR1147
1148.      985 CONTINUE STAR1148
1149.      990 WRITE (6,965)(DLPACH(I,N),I=1,4),(DLPLNH(I,N),I=1,4) STAR1149
1150.      995 CONTINUE STAR1150
1151.      1000 CONTINUE STAR1151

```

Fig. B-1 STAR Program Listing (Cont'd)

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1152. C STAR1152
1153. C WRITE OUT THE ULLAGE PRESSURE REQUIREMENTS AS F(T) STAR1153
1154. C STAR1154
1155. GO TO (1005,1030,1005),SYSNUM STAR1155
1156. 1005 WRITE (6,830) STAR1156
1157. WRITE (6,835)(ST(I),I=1,7) STAR1157
1158. WRITE (6,1010)VOP STAR1158
1159. 1010 FORMAT(1H0,T30,'ULLAGE PRESSURE REQUIRED FOR',I3,' ENGINE OPERATION STAR1159
1160. 1N') STAR1160
1161. WRITE (6,845)(OPD(K),K=NELP,NMA) STAR1161
1162. WRITE (6,850) STAR1162
1163. DO 1025 N=1,NPTS STAR1163
1164. WRITE (6,855)TIMEA(N) STAR1164
1165. IF (N.EQ,NPTS) GO TO 1020 STAR1165
1166. WRITE (6,1015)(PULLO(I,N),I=NELP,NMA) STAR1166
1167. 1015 FORMAT(T9,F8,3,T19,F8,3,T31,F8,3,T41,F8,3,T51,F8,3,T61,F8,3, STAR1167
1168. T71,F8,3,T81,F8,3,T91,F8,3,T101,F8,3,T111,F8,3,T121,F8,3) STAR1168
1169. 1020 CONTINUE STAR1169
1170. 1025 CONTINUE STAR1170
1171. 1030 CONTINUE STAR1171
1172. IF (SYSNUM.EQ,1) GO TO 1045 STAR1172
1173. WRITE (6,830) STAR1173
1174. WRITE (6,880)(ST(I),I=1,7) STAR1174
1175. WRITE (6,1010)VOP STAR1175
1176. WRITE (6,845)(OPD(K),K=NELP,NMA) STAR1176
1177. WRITE (6,850) STAR1177
1178. DO 1040 N=1,NPTS STAR1178
1179. WRITE (6,855)TIMEA(N) STAR1179
1180. IF (N.EQ,NPTS) GO TO 1035 STAR1180
1181. WRITE (6,1015)(PULLH(I,N),I=NELP,NMA) STAR1181
1182. 1035 CONTINUE STAR1182
1183. 1040 CONTINUE STAR1183
1184. 1045 CONTINUE STAR1184
1185. C STAR1185
1186. C WRITE OUT THE MINIMUM ULLAGE PRESSURE REQUIRED, THE PRESSURE ON STAR1186
1187. C THE TANK BOTTOMS AND THE LINE HEAD PRESSURES STAR1187
1188. C STAR1188
1189. WRITE (6,785) STAR1189
1190. WRITE (6,790)(ST(I),I=1,7) STAR1190
1191. WRITE (6,1050) STAR1191
1192. 1050 FORMAT(T2,'PRESSURE AND VOLUME VALUES FOR FLUID VAPOR,MIN,ULLAGE,STAR1192
1193. 1TANK BOTTOM,LINE HEAD,ULLAGE VOLUME,TANK HEAD HEIGHT AND ULLAGE WEGSTAR1193
1194. 2IGHT',/) STAR1194
1195. WRITE (6,1055) STAR1195
1196. 1055 FORMAT(T3,'TRANS',T13,'ULLVAP',T21,'ULLVAP',T29,'MINULL',T37,'MINSTAR1196
1197. 1ULL',T45,'TNKBOT',T53,'TNKBOT',T61,'LINHEA',T69,'LINHEA',T78,'ULLVSTAR1197
1198. 2OL',T87,'ULLVOL',T95,'TNKHED',T103,'TNKHED',T112,'ULLWGT',T121, STAR1198
1199. 3'ULLWGT') STAR1199
1200. WRITE (6,1060) STAR1200
1201. 1060 FORMAT(T4,'TIME',T14,'OXID',T22,'FUEL',T30,'OXID',T38,'FUEL',T46STAR1201
1202. 1,'OXID',T54,'FUEL',T62,'OXID',T70,'FUEL',T79,'OXID',T88,'FUEL',STAR1202
1203. 2T96,'OXID',T104,'FUEL',T113,'OXID',T122,'FUEL') STAR1203
1204. WRITE (6,1065) STAR1204
1205. 1065 FORMAT(T5,'SEC',T14,'PSIA',T22,'PSIA',T30,'PSIA',T38,'PSIA',T46,'PSTAR1205
1206. 1SIA',T54,'PSIA',T62,'PSIA',T70,'PSIA',T78,'CU,FT',T87,'CU,FT', STAR1206
1207. 2T97,'FT',T105,'FT',T114,'LBS',T122,'LBS') STAR1207
1208. DO 1085 N=1,NPTS STAR1208
1209. WRITE (6,1070)TIMEA(N) STAR1209

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Fig. B-1 STAR Program Listing (Cont'd)

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1210, 1070 FORMAT(T2,F6.2) STAR1210
1211, IF (N,EG,NPTS) GO TO 1080 STAR1211
1212, I=NELP STAR1212
1213, WRITE (6,1075)PUVAP0,PUVAPH,PULLRO(I,N),PULLRH(I,N),PTKBT0(I,N),PTSTAR1213
1214, 1KETH(I,N),PHOLN0(N),PHOLNH(N),LLVL02(N),ULVLH2(N),HEAD02(N),HEADH2STAR1214
1215, 2(N),PTLGO(K),PTLGH(N) STAR1215
1216, 1075 FORMAT(T13,F6.3,T21,F6.3,T29,F6.2,T37,F6.2,T45,F6.2,T53,F6.2,T61, STAR1216
1217, 1F6.2,T69,F6.3,T77,F7.1,T86,F7.1,T95,F6.2,T103,F5.2,T111,F7.1,T120, STAR1217
1218, 2F7.1) STAR1218
1219, 1080 CONTINUE STAR1219
1220, 1085 CONTINUE STAR1220
1221, C STAR1221
1222, C WRITE OUT MINIMUM REQUIRED ULLAGE PRESSURES STAR1222
1223, C STAR1223
1224, GO TO (1090,1110,1090),SYSNUM STAR1224
1225, 1090 WRITE (6,830) STAR1225
1226, WRITE (6,835)(ST(N),N=1,7) STAR1226
1227, WRITE (6,1095)VOP STAR1227
1228, 1095 FORMAT(IH0,T20,'MINIMUM REQUIRED ULLAGE PRESSURE FOR','I3,' ENGINE STAR1228
1229, 1OPERATION PER MAIN FEED LINE') STAR1229
1230, WRITE (6,845)(OPD(K),K=NELP,NMA) STAR1230
1231, WRITE (6,850) STAR1231
1232, DO 1100 N=1,NPTS STAR1232
1233, WRITE (6,855)TIMEA(N) STAR1233
1234, IF (N,EG,NPTS) GO TO 1100 STAR1234
1235, WRITE (6,1015)(PULLRO(I,N),I=NELP,NMA) STAR1235
1236, 1100 CONTINUE STAR1236
1237, 1105 CONTINUE STAR1237
1238, 1110 CONTINUE STAR1238
1239, IF (SYSNUM,EG,1) GO TO 1125 STAR1239
1240, WRITE (6,830) STAR1240
1241, WRITE (6,880)(ST(N),N=1,7) STAR1241
1242, WRITE (6,1095)VOP STAR1242
1243, WRITE (6,845)(OPD(K),K=NELP,NMA) STAR1243
1244, WRITE (6,850) STAR1244
1245, DO 1120 N=1,NPTS STAR1245
1246, WRITE (6,855)TIMEA(N) STAR1246
1247, IF (N,EG,NPTS) GO TO 1115 STAR1247
1248, WRITE (6,1015)(PULLRH(I,N),I=NELP,NMA) STAR1248
1249, 1115 CONTINUE STAR1249
1250, 1120 CONTINUE STAR1250
1251, 1125 CONTINUE STAR1251
1252, C STAR1252
1253, C WRITE OUT THE TANK BOTTOM PRESSURES STAR1253
1254, C STAR1254
1255, GO TO (1130,1150,1130),SYSNUM STAR1255
1256, 1130 WRITE (6,830) STAR1256
1257, WRITE (6,835)(ST(N),N=1,7) STAR1257
1258, WRITE (6,1135)VOP STAR1258
1259, 1135 FORMAT(IH0,T20,'TANK BOTTOM PRESSURE VALUES FOR','I3,' ENGINE OPERASTAR1259
1260, 1TION PER MAIN FEED LINE') STAR1260
1261, WRITE (6,845)(OPD(K),K=NELP,NMA) STAR1261
1262, WRITE (6,850) STAR1262
1263, DO 1140 N=1,NPTS STAR1263
1264, WRITE (6,855)TIMEA(N) STAR1264
1265, IF (N,EG,NPTS) GO TO 1140 STAR1265
1266, WRITE (6,1015)(PTKBT0(I,N),I=NELP,NMA) STAR1266
1267, 1140 CONTINUE STAR1267

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Fig. B-1 STAR Program Listing (Cont'd)

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1268. 1145 CONTINUE STAR1268
1269. 1150 CONTINUE STAR1269
1270. IF (SYSNUM, EQ, 1) GO TO 1165 STAR1270
1271. WRITE (6, 830) STAR1271
1272. WRITE (6, 880)(ST(N), N=1, 7) STAR1272
1273. WRITE (6, 1135) NOP STAR1273
1274. WRITE (6, 845)(HPD(K), K=NELP, NMA) STAR1274
1275. WRITE (6, 850) STAR1275
1276. DO 1160 N=1, NPPTS STAR1276
1277. WRITE (6, 855) TIMEA(N) STAR1277
1278. IF (N, EQ, NPPTS) GO TO 1155 STAR1278
1279. WRITE (6, 1015)(PTKBTW(I, N), I=NELP, NMA) STAR1279
1280. 1155 CONTINUE STAR1280
1281. 1160 CONTINUE STAR1281
1282. 1165 CONTINUE STAR1282
1283. C STAR1283
1284. C WRITE OUT RECOMPUTED ENGINE PRESSURES STAR1284
1285. C STAR1285
1286. GO TO (1170, 1190, 1170), SYSNUM STAR1286
1287. 1170 WRITE (6, 830) STAR1287
1288. WRITE (6, 835)(ST(N), N=1, 7) STAR1288
1289. WRITE (6, 1175) NOP STAR1289
1290. 1175 FORMAT(1H0, T20, 'RECOMPUTED ENGINE PRESSURES FOR', I3, ' ENGINE OPERA STAR1290
1291. TION PER MAIN FEED LINE') STAR1291
1292. WRITE (6, 845)(OPD(K), K=NELP, NMA) STAR1292
1293. WRITE (6, 850) STAR1293
1294. DO 1185 N=1, NPPTS STAR1294
1295. WRITE (6, 855) TIMEA(N) STAR1295
1296. IF (N, EQ, NPPTS) GO TO 1180 STAR1296
1297. WRITE (6, 1015)(PENNUO(I, N), I=NELP, NMA) STAR1297
1298. 1180 CONTINUE STAR1298
1299. 1185 CONTINUE STAR1299
1300. 1190 CONTINUE STAR1300
1301. IF (SYSNUM, EQ, 1) GO TO 1205 STAR1301
1302. WRITE (6, 830) STAR1302
1303. WRITE (6, 880)(ST(N), N=1, 7) STAR1303
1304. WRITE (6, 1175) NOP STAR1304
1305. WRITE (6, 845)(HPD(K), K=NELP, NMA) STAR1305
1306. WRITE (6, 850) STAR1306
1307. DO 1200 N=1, NPPTS STAR1307
1308. WRITE (6, 855) TIMEA(N) STAR1308
1309. IF (N, EQ, NPPTS) GO TO 1195 STAR1309
1310. WRITE (6, 1015)(PENNUH(I, N), I=NELP, NMA) STAR1310
1311. 1195 CONTINUE STAR1311
1312. 1200 CONTINUE STAR1312
1313. 1205 CONTINUE STAR1313
1314. C STAR1314
1315. C WRITE OUT FEED SYSTEM WEIGHTS STAR1315
1316. C STAR1316
1317. WRITE (6, 830) STAR1317
1318. WRITE (6, 1210)(ST(I), I=1, 7) STAR1318
1319. 1210 FORMAT(T23, T46, T66, '- FEED SYSTEM WEIGHTS', // T16, 'MAIN', T30, 'ENGINE STAR1319
1320. 1E FEEDLINE WEIGHTS', T65, 'TOTAL', T85, 'ENGINE', T97, 'MAIN', // T14, 'FEED STAR1320
1321. 2LINE', T64, 'ENGINE MAIN FEEDLINE FEEDLINE TOTAL', // STAR1321
1322. 3T2, 'PROPELLANT DIAMETER', T26, 'LINE', T36, 'LINE', T46, 'LINE', T56, STAR1322
1323. 4'LINE', T63, 'FEEDLINE FEEDLINE INSULATION INSULATION FEED SYST STAR1323
1324. 5EM', // T14, '(INCHES)', T26, 'NO 1', T36, 'NO 2', T46, 'NO 3', T56, 'NO 4', STAR1324
1325. 6'63, 'WEIGHT', T74, 'WEIGHT', T85, 'WEIGHT', T97, 'WEIGHT', T110, 'WEIGHT') STAR1325

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Fig. B-1 STAR Program Listing (Cont'd)


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1326,      WRITE (6,665)                                STAR1325
1327,      IF (SYSDUM,EQ,2) GO TO 1220                  STAR1327
1328,      DO 1215 I=VELP,NSIZE                          STAR1328
1329,      WRITE (6,1230)O2(1),O2(2),OPD(1),(WELQ(I,J),J=1,4),WELQ(I),WMLQ(I) STAR1329
1330,      1),WELQ(I),WMLQ(I),WLOTT(I)                  STAR1330
1331,      1215 CONTINUE                                  STAR1331
1332,      WRITE (6,665)                                STAR1332
1333,      1220 DO 1225 I=VELP,NSIZE                    STAR1333
1334,      WRITE (6,1230)W2(1),W2(2),WPD(1),(WELH(I,J),J=1,4),WELH(I),WMLH(I) STAR1334
1335,      1),WELH(I),WMLH(I),WLHTT(I)                STAR1335
1336,      1225 CONTINUE                                  STAR1336
1337,      1230 FORMAT(T2,2A6,F7,3,2X,G10,5,3X,G10,5,2X,G10,5,3X,G10,5) STAR1337
1338,      WRITE (6,665)                                STAR1338
1339,      WRITE (6,1235)ICASE                          STAR1339
1340,      1235 FORMAT(T10,'END OF CASE',I3)           STAR1340
1341,      C                                             STAR1341
1342,      IF (IGOODN,EQ,1) GO TO 10                    STAR1342
1343,      C                                             STAR1343
1344,      CONTINUE                                      STAR1344
1345,      WRITE (6,830)                                STAR1345
1346,      WRITE (6,1245)                                STAR1346
1347,      1245 FORMAT(T5,'*** NORMAL PROGRAM TERMINATION HAS OCCURRED ***') STAR1347
1348,      CALL EXIT                                    STAR1348
1349,      END                                          STAR1349

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Fig. B-1 STAR Program Listing (Cont'd)

```

1,  C
2,  SUBROUTINE INIVOL
3,  C
4,  INCLUDE DIMN,LIST
5,  C
6,  C          CALCULATE TOTAL VOLUME
7,  C          L02 SECTION
8,  C          VOLUME OF UPPER (SMALL) HEMISPHERE SECTION
9,  C          V1 = HSPHER (R1,R2)
10, C          A1 = AHSPHR (R1,R2)
11, C          VOLUME OF CONIC SECTION
12, C          V2 = FRCONC (R2,L2-L1,R4)
13, C          A2 = AREAFR (R2,L2-L1,R4)
14, C          VOLUME OF CYLINDRICAL SECTION
15, C          V3 = CYLNDR (R4,L3-L2)
16, C          A3 = ARACYL (R4,L3-L2)
17, C          VOLUME OF LOWER (LARGE) HEMISPHERICAL SECTION (L02)
18, C          V4 = HSPHER (R3,R4)
19, C          A4 = AHSPHR (R3,R4)
20, C          L02 SECTION
21, C          VOLUME BETWEEN CYLINDER AND SPHEROID
22, C          V5 = CYLSP4 (R3,R4)
23, C          VOLUME OF LONG CYLINDRICAL SECTION
24, C          V6 = CYLNDR (R4,L4-L3-R3)
25, C          A6 = ARACYL (R4,L4-L3)
26, C          VOLUME OF LOWER (LARGE) HEMISPHERICAL SECTION (LH2)
27, C          V7 = HSPHER (R5,R4)
28, C          A7 = AHSPHR (R5,R4)
29, C          TOTAL VOLUME OF UPPER PORTION (L02)
30, C          VT02 = V1+V2+V3+V4
31, C          TOTAL VOLUME OF LOWER PORTION (LH2)
32, C          VTH2 = V5 + V6 + V7
33, C          TOTAL VOLUME BOTH SECTIONS
34, C          VTOT = VT02+VTH2
35, C          ATOT = A1 + A2 + A3 + A4 + A6 + A7
36, C          ASKIN = ATOT - A4
37, C          ADOME = A4
38, C          RETURN
39, C          END
INIV0001
INIV0002
INIV0003
INIV0004
INIV0005
INIV0006
INIV0007
INIV0008
INIV0009
INIV0010
INIV0011
INIV0012
INIV0013
INIV0014
INIV0015
INIV0016
INIV0017
INIV0018
INIV0019
INIV0020
INIV0021
INIV0022
INIV0023
INIV0024
INIV0025
INIV0026
INIV0027
INIV0028
INIV0029
INIV0030
INIV0031
INIV0032
INIV0033
INIV0034
INIV0035
INIV0036
INIV0037
INIV0038
INIV0039

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Fig. B-2 INIVOL Program Listing

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1. C SUBROUTINE ULLHED (VL02,VLH2) ULLH0001
2. ULLH0002
3. C INCLUDE DIMV,LIST ULLH0003
4. INCLUDE UCONST,LIST ULLH0004
5. ULLH0005
6. C ULLH0006
7. 10 FORMAT ('0'20X'ULLAGE VOLUME ;S NEGATIVE'/) ULLH0007
8. C ULLH0008
9. C CALCULATE HEAD AND ULLAGE VOLUME ULLH0009
10. C ULLAGE VOLUME (LC2) ULLH0010
11. UVL02 = VT02-VL02 ULLH0011
12. IF (UVL02,LT,0.) WRITE (10T,10) ULLH0012
13. C CALCULATE HEAD (LC2) ULLH0013
14. C LARGE HEMISPHERE ULLH0014
15. IF (VL02-V4) 15,20,20 ULLH0015
16. 15 CALL ELIPSG (VL02,R3,R4,HD02) ULLH0016
17. GO TO 45 ULLH0017
18. C CYLINDRICAL SECTION ULLH0018
19. 20 IF (VL02-(V4+V3)) 25,25,30 ULLH0019
20. 25 HD02 = R3 + (VL02-V4) / (PI*R4*R4) ULLH0020
21. GO TO 45 ULLH0021
22. C CONIC SECTION ULLH0022
23. 30 IF (VL02-(V4+V3+V2)) 35,35,40 ULLH0023
24. 35 HL = L2 - L1 ULLH0024
25. R42 = R4 - R2 ULLH0025
26. VD = (PI/3,0)*HL / R42*R4*R4*R4 - (VL02-V4-V3) ULLH0026
27. HD02 = (PI*R4*HL - (3,0*(PI*HL)*2*R42*VD)*(1./3,)) / (PI*R42) ULLH0027
28. HD02 = R3 + L3 + L2 + HD02 ULLH0028
29. GO TO 45 ULLH0029
30. C SMALL HEMISPHERE ULLH0030
31. 40 CALL ELIPSG (UVL02,R1,R2,H) ULLH0031
32. HD02 = R3 + L3-L1 + R1-H ULLH0032
33. C ULLAGE VOLUME (LH2) ULLH0033
34. 45 UVLH2 = VT42 - VLH2 ULLH0034
35. IF (UVLH2,LT,0.) WRITE (10T,10) ULLH0035
36. C CALCULATE HEAD (LH2) ULLH0036
37. C LOWER HEMISPHERICAL SECTION ULLH0037
38. IF (VLH2-V7) 50,55,55 ULLH0038
39. 50 CALL ELIPSG (VLH2,R5,R4,HDH2) ULLH0039
40. GO TO 70 ULLH0040
41. 55 IF (VLH2-(V7+V6)) 60,60,65 ULLH0041
42. C CYLINDRICAL SECTION ULLH0042
43. 60 HDH2 = R5 + (VLH2 - V7) / (PI*R4*R4) ULLH0043
44. GO TO 70 ULLH0044
45. C SECTION BETWEEN CYLINDER AND SPHEROID ULLH0045
46. 65 VHP = VLH2 - (V7+V6) ULLH0046
47. CALL CYMSPH (VHP,R3,R4,H) ULLH0047
48. HDH2 = R5 + L4 = (L3+R3) + H ULLH0048
49. 70 CONTINUE ULLH0049
50. RETURN ULLH0050
51. END ULLH0051

```

Fig. B-3 ULLHED Program Listing

```

1.      SUBROUTINE FLORES(10,D,S1,S2,RES)                                FLOOR001
2.      C                                                                FLOOR002
3.      C THIS SUBROUTINE COMPUTES ONLY THE FLOW RESISTANCE COEFFICIENTS FLOOR003
4.      C DUE TO CONFIGURATION - FRICTION LOSSES ARE COMPUTED IN MAIN PROGRAM FLOOR004
5.      PI=3.1415927                                                    FLOOR005
6.      C=57.29578                                                       FLOOR006
7.      P=D/12.                                                          FLOOR007
8.      GO TO (10,15,20,40,45,60,65,85,100,110,115,125,135,140,145,150,145, FLOOR008
9.      1,155,155,160,165,135,145),10                                   FLOOR009
10.     C SUMP                                                            FLOOR010
11.     10 RES=0.157                                                    FLOOR011
12.     RETURN                                                            FLOOR012
13.     C STRAIGHT LINE SECTION                                          FLOOR013
14.     15 RES=0.                                                       FLOOR014
15.     RETURN                                                            FLOOR015
16.     C CURVED LINE SECTION                                            FLOOR016
17.     20 THETA=(S1/S2)*C                                              FLOOR017
18.     TEST=THETA-90.                                                  FLOOR018
19.     RES90=0.158*(S2/P)**(-0.8406)                                   FLOOR019
20.     IF (ABS(TEST).GT.1.) GO TO 25.                                  FLOOR020
21.     RES=RES90                                                       FLOOR021
22.     RETURN                                                            FLOOR022
23.     25 IF (TEST.LT.0.) GO TO 30                                     FLOOR023
24.     RES=0.145*RES90*THETA**0.431                                   FLOOR024
25.     RETURN                                                            FLOOR025
26.     30 IF (THETA.LT.60.) GO TO 35                                   FLOOR026
27.     RES=RES90*0.0147*THETA**0.616                                   FLOOR027
28.     RETURN                                                            FLOOR028
29.     35 RES=RES90*0.0047*THETA**0.793                               FLOOR029
30.     RETURN                                                            FLOOR030
31.     C COMPOUND 'U' ELBOW (LENGHT STRAIGHT SECTION LT B*D)          FLOOR031
32.     40 SL=S1-PI*S2                                                  FLOOR032
33.     RES=0.2153*(S2/P)**(-0.8406)                                   FLOOR033
34.     RES=RES+0.02*(SL/P)                                            FLOOR034
35.     RETURN                                                            FLOOR035
36.     C NINETY-DEGREE OFFSET BEND                                     FLOOR036
37.     45 SL=S1-PI*S2                                                  FLOOR037
38.     RESL00=0.248*(S2/P)**(-1.307)                                   FLOOR038
39.     RESL08=0.322*(S2/P)**(-1.025)                                   FLOOR039
40.     50 BLOD=SL/P                                                    FLOOR040
41.     IF (BLOD.LT.8.) GO TO 55                                       FLOOR041
42.     RES=RESL08                                                       FLOOR042
43.     RETURN                                                            FLOOR043
44.     55 DIF=RESL08-RESL00                                            FLOOR044
45.     DIFL=BLOD/8.                                                    FLOOR045
46.     RES=RESL00+DIF*DIFL                                             FLOOR046
47.     RETURN                                                            FLOOR047
48.     C 'Z'-BEND                                                       FLOOR048
49.     60 SL=S1-PI*S2                                                  FLOOR049
50.     RESL00=0.48*(S2/P)**(-1.128)                                   FLOOR050
51.     RESL08=0.332*(S2/P)**(-1.022)                                   FLOOR051
52.     GO TO 50                                                         FLOOR052
53.     C GRADUAL EXPANSION                                             FLOOR053

```

Fig. B-4 FLORES Program Listing

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54.      65 RES=(1.-S2**2.)*2.                                FLOR0054
55.      D=D/12.                                             FLOR0055
56.      ARG=P*(1./S2=1.)/(2.*S1)                          FLOR0056
57.      THETA=C*ATAN(ARG)                                  FLOR0057
58.      IF (THETA,GT,5.) GO TO 70                          FLOR0058
59.      CK=0.013*THETA                                     FLOR0059
60.      GO TO 80                                           FLOR0060
61.      70 IF (THETA,GT,24.) GO TO 75                      FLOR0061
62.      CK=0.065+0.0513*(THETA-5.)                       FLOR0062
63.      GO TO 80                                           FLOR0063
64.      75 CK=1.04                                         FLOR0064
65.      80 RES=CK*RES                                       FLOR0065
66.      RETURN                                             FLOR0066
67.      C GRADUAL CONTRACTION                               FLOR0067
68.      85 ARG=D*(1.-1./S2)/(24.*S1)                       FLOR0068
69.      THETA=C*ATAN(ARG)                                  FLOR0069
70.      IF (THETA,GT,15.) GO TO 90                        FLOR0070
71.      RES=0.                                             FLOR0071
72.      RETURN                                             FLOR0072
73.      90 IF (THETA,GT,22.5) GO TO 95                    FLOR0073
74.      RES=0.05                                          FLOR0074
75.      RETURN                                             FLOR0075
76.      95 RES=(1.-S2**2.)*2.                                FLOR0076
77.      RETURN                                             FLOR0077
78.      C SINGLE LEG OF DIVERGING BRANCH                   FLOR0078
79.      100 WRITE (6,105)                                   FLOR0079
80.      105 FORMAT(T2,'S/R FLORES = DIVERGING BRANCH OPTION NOT IMPLEMENTED') FLOR0080
81.      RES=0.                                             FLOR0081
82.      RETURN                                             FLOR0082
83.      C VENTURI                                           FLOR0083
84.      110 S1=S1/2.                                       FLOR0084
85.      GO TO 85                                           FLOR0085
86.      C FLOWMETER                                         FLOR0086
87.      115 WRITE (6,120)                                   FLOR0087
88.      120 FORMAT(T2,'S/R FLORES = FLOWMETER OPTION NOT IMPLEMENTED') FLOR0088
89.      RES=0.                                             FLOR0089
90.      RETURN                                             FLOR0090
91.      C GATE VALVE                                        FLOR0091
92.      125 WRITE (6,130)                                   FLOR0092
93.      130 FORMAT(T2,'S/R FLORES = GATE VALVE OPTION NOT IMPLEMENTED') FLOR0093
94.      RES=0.                                             FLOR0094
95.      RETURN                                             FLOR0095
96.      C BUTTERFLY VALVE OR PRESSURE-VOLUME COMPENSATOR FLOR0096
97.      135 RES=0.94*D**(-0.676)                          FLOR0097
98.      RETURN                                             FLOR0098
99.      C POPPET VALVE                                     FLOR0099
100.     140 RES=4.9*D**(-0.599)                             FLOR0100
101.     RETURN                                             FLOR0101
102.     C BALL VISOR VALVE, U-PIN TIE ROD BELLOWS OR INTERNAL BALL-STRUT BEL FLOR0102
103.     145 RES=0.325*D**(-0.292)                          FLOR0103
104.     RETURN                                             FLOR0104
105.     C DISCONNECT                                       FLOR0105
106.     150 RES=0.3                                         FLOR0106
107.     RETURN                                             FLOR0107
108.     C PIN OR HINGE JOINT BELLOWS OR EXT. GIMBAL BELLOWS W/O LINER FLOR0108
109.     155 RES=0.23*D**(-0.607)                          FLOR0109
110.     RETURN                                             FLOR0110
111.     C EXT. GIMBAL BELLOWS WITH LINER                   FLOR0111

```

Fig. B-4 FLORES Program Listing (Cont'd)

```
112.      160 RES=0,079*3*(-0,594)                                FLOR0112
113.      RETURN                                                FLOR0113
114.      C      INTERNAL GIMBAL BELLOWS W/O LINER                FLOR0114
115.      165 RES=0,111*3*(-0,55)                                FLOR0115
116.      RETURN                                                FLOR0116
117.      END                                                    FLOR0117
```

Fig. B-4 FLORES Program Listing (Cont'd)

1.		SUBROUTINE PVAPOR(T,I,P)	PVAP0001
2.		GO TO (10,15,20,15,25,30,35,30,35,40,20,45,50,55,60,65),I	PVAP0002
3.	10	P=EXP(12,04=1519,/T)	PVAP0003
4.		RETURN	PVAP0004
5.	15	P=10,**(2,9303=79,821/T+.011628*T)	PVAP0005
6.		RETURN	PVAP0006
7.	20	P = EXP(11,63-1374,/T)	PVAP0007
8.		IF(P,GT,200.) P = EXP(13,43=1763,/T)	PVAP0008
9.		RETURN	PVAP0009
10.	25	P = ,825*EXP(11,63-1374,/T)+.175*EXP(12,04=1519,/T)	PVAP0010
11.		IF(P,GT,200.) P = ,825*EXP(13,43=1763,/T)+.175*EXP(12,04=1519,/T)	PVAP0011
12.		RETURN	PVAP0012
13.	30	P = EXP(11,83-1839,/T)	PVAP0013
14.		RETURN	PVAP0014
15.	35	P = 10,**(5,73=1050,/T)	PVAP0015
16.		RETURN	PVAP0016
17.	40	P = EXP(12,3579=3168,7/T)	PVAP0017
18.		RETURN	PVAP0018
19.	45	P = EXP(14,45=5090,/T)	PVAP0019
20.		RETURN	PVAP0020
21.	50	P = EXP(16,54098=7,3483*(1000,/T))	PVAP0021
22.		RETURN	PVAP0022
23.	55	P = EXP(13,4055=6,65*(1000,/T))	PVAP0023
24.		RETURN	PVAP0024
25.	60	PLOGMM = 7,4837-1,8*1197,/T	PVAP0025
26.		P = ,01934*(10,**PLOGMM)	PVAP0026
27.		RETURN	PVAP0027
28.	65	PLOGMM = 8,2875=1,8*1996,/T	PVAP0028
29.		P = ,01934*(10,**PLOGMM)	PVAP0029
30.		RETURN	PVAP0030
31.		END	PVAP0031

Fig. B-5 PVAPOR Program Listing

```

1.      SUBROUTINE ZFIND(T,P,N,V)                                ZFIN0001
2.      DIMENSION G(3,17),S(17)                                ZFIN0002
3.      DIMENSION A(17,6),TS(17)                               ZFIN0003
4.      DATA (YS(K),K=1,16)                                    ZFIN0004
5.      1 /150., 30., 140., 30.,140.,190.,220.,190.,          ZFIN0005
6.      2 220.,300.,140.,370.,475.,480.,450.,450./           ZFIN0006
7.      DATA(G(1,I),I=1,17)/277.85,59.8,259.13,59.8,260.,343.2,387.,343.2,ZFIN0007
8.      1,387.,221.8,259.13,730.,776.4,1094.,749.5,1155.,9.37/  ZFIN0008
9.      DATA(G(2,I),I=1,17)/743.78,187.7,822.8,187.7,795.,673.1,719.,673.1,ZFIN0009
10.     1 1,719.,581.,822.8,1652.,1470.,1696.,771.,1470.,33.82/  ZFIN0010
11.     DATA(G(3,I),I=1,17)/48.31,766.8,40.67,766.8,42.01,96.35,28.62, ZFIN0011
12.     1 96.35,28.62,55.81,40.67,90.77,16.78,37.0,11.90,33.50,386.3/ ZFIN0012
13.     DATA S/5HLO2 ,5HLH2 ,5HLF2 ,5HLH2 ,5HFLOX ,5HCH4 ,5HOF2 , ZFIN0013
14.     1 5HCH4 ,5HOF2 ,5H82H6 ,5HLF2 ,5HMH3 ,5HN204 ,5HA-50 , ZFIN0014
15.     2 5HCLF-5,5HMHF-5,5HHE / ZFIN0015
16.     DATA(A( 1,J),J=1,6)/.2142592E1,-.3228322E-1,.3563987E-3, ZFIN0016
17.     1 -.1895669E-5,.4823166E-8,-.5002793E-11/ ZFIN0017
18.     DATA(A( 2,J),J=1,6)/-.4458459E1,.6350202,-.2863016E-1, ZFIN0018
19.     1 .6260332E-3,-.6704223E-5,.2763409E-7/ ZFIN0019
20.     DATA(A( 3,J),J=1,6)/.19209203E1,-.4590045E-1,.7505833E-3, ZFIN0020
21.     1 -.5522453E-5,.1900218E-7,-.2526448E-10/ ZFIN0021
22.     DATA(A( 4,J),J=1,6)/-.4458459E1,.6350202,-.2863016E-1, ZFIN0022
23.     1 .6260332E-3,-.6704223E-5,.2763409E-7/ ZFIN0023
24.     DATA(A( 5,J),J=1,6)/.18476612E1,-.4140008E-1,.6702877E-3, ZFIN0024
25.     1 -.4895455E-5,.1674002E-7,-.2217407E-10/ ZFIN0025
26.     DATA(A( 6,J),J=1,6)/.17005803E1,-.1669025E-1,.1536145E-3, ZFIN0026
27.     1 -.6691577E-6,.13609972E-8,-.11357811E-11/ ZFIN0027
28.     DATA(A( 7,J),J=1,6)/.15219822E2,-.28012465,.22001021E-2, ZFIN0028
29.     1 -.86119226E-5,.16835339E-7,-.1326416E-10 / ZFIN0029
30.     DATA(A( 8,J),J=1,6)/.17005803E1,-.1669025E-1,.1536145E-3, ZFIN0030
31.     1 -.6691577E-6,.13609972E-8,-.11357811E-11/ ZFIN0031
32.     DATA(A( 9,J),J=1,6)/.15219822E2,-.28012465,.22001021E-2, ZFIN0032
33.     1 -.86119226E-5,.16835339E-7,-.1326416E-10 / ZFIN0033
34.     DATA(A(10,J),J=1,6)/-.81449807E-1,.15004836E-1,-.91954274E-4, ZFIN0034
35.     1 .27813987E-6,-.42739698E-9,.25170512E-12/ ZFIN0035
36.     DATA(A(11,J),J=1,6)/.19209203E1,-.4590045E-1,.7505833E-3, ZFIN0036
37.     1 -.5522453E-5,.1900218E-7,-.2526448E-10/ ZFIN0037
38.     DATA(A(12,J),J=1,6)/.39233318E1,-.3455291E-1,.16306507E-3, ZFIN0038
39.     1 -.38452432E-6,.45572795E-9,-.21979859E-12/ ZFIN0039
40.     DATA(A(13,J),J=1,6)/.70122306E1,-.57413097E-1,.21967497E-3, ZFIN0040
41.     1 -.42198721E-6,.40864988E-9,-.1606916E-12/ ZFIN0041
42.     DATA(A(14,J),J=1,6)/.86405843E1,-.72176161E-1,.2724231E-3, ZFIN0042
43.     1 -.5137489E-6,.4844758E-9,-.18308062E-12/ ZFIN0043
44.     DATA(A(15,J),J=1,6)/.54858839E1,-.44806287E-1,.17789492E-3, ZFIN0044
45.     1 -.35089558E-6,.34539726E-9,-.13832016E-12/ ZFIN0045
46.     DATA(A(16,J),J=1,6)/.49407545E1,-.39649950E-1,.15955648E-3, ZFIN0046
47.     1 -.32115667E-6,.32356706E-9,-.13068156E-12/ ZFIN0047
48.     IF (N,EQ,17) GO TO 10 ZFIN0048
49.     IF (T,GT,650.,OR,T,LT,25.) GO TO 55 ZFIN0049
50.     IF (T,GT,TS(N)+100.,OR,T,LT,TS(N)) GO TO 19 ZFIN0050
51.     C**** TEST TO SEE IF SAT,D COMP,Y,Z APPLIES **** ZFIN0051
52.     CALL PVAPOR(T,N,TRYP) ZFIN0052
53.     TRY=TRYP-Z ZFIN0053

```

Fig. B-6 ZFIND Program Listing


```

54.      IF (ABS(TRY).LT.5.) GO TO 60.      ZFIND054
55.      10 CONTINUE      ZFIND055
56.      C*****REDLICH-KWONG*****AGO-GO*****ZFIND056
57.      VF=G(3,N)*T/(P*144.)      ZFIND057
58.      IF (N,EQ,2,OR,N,EQ,4) GO TO 45      ZFIND058
59.      AS=.4278*G(3,N)*G(3,N)/(G(2,N)*144.)*G(1,N)**2,5      ZFIND059
60.      BS=.0867*G(3,N)*G(1,N)/(G(2,N)*144.)      ZFIND060
61.      IN=0      ZFIND061
62.      N2=0      ZFIND062
63.      E=.00001      ZFIND063
64.      V=VF      ZFIND064
65.      15 Y=G(3,N)*T/(V-BS)-AS/(T*.5*V*(V+BS))=P*144,      ZFIND065
66.      IF (ABS(Y).LT.E) GO TO 30      ZFIND066
67.      C*****FIRST DERIVATIVE OF REDLICH-KWONG RESPECT TZFIND067
68.      YP=-G(3,N)      ZFIND068
69.      1 *T/((V-BS)*(V-BS))+AS*(2.*V+BS)/(T*.5*V*V*(V+BS)*(V+BS))      ZFIND069
70.      IN=IN+1      ZFIND070
71.      N2=N2+1      ZFIND071
72.      IF(N2,EQ,25) E=2.*E      ZFIND072
73.      IF(N2,EQ,25) N2=0      ZFIND073
74.      IF (IN,GT,1000) GO TO 35      ZFIND074
75.      V=V-Y/YP      ZFIND075
76.      IF (V,GT,0.) GO TO 25      ZFIND076
77.      OLQV=V+Y/YP      ZFIND077
78.      DELTA=Y/YP      ZFIND078
79.      FACTOR=.05      ZFIND079
80.      20 V=OLQV-FACTOR*DELTA      ZFIND080
81.      FACTOR=FACTOR*.9      ZFIND081
82.      IF (V,LT,0.) GO TO 20      ZFIND082
83.      25 CONTINUE      ZFIND083
84.      GO TO 15      ZFIND084
85.      30 CONTINUE      ZFIND085
86.      GO TO 50      ZFIND086
87.      35 CONTINUE      ZFIND087
88.      WRITE (6,40)T,P,S(N),V,VF      ZFIND088
89.      40 FORMAT(1X,34HREDLICH = KWONG      FLUNKED T = ,F4,2,2X,4HP = ,      ZFIND089
90.      1 F7,2,      ZFIND090
91.      2 5H FOR ,A5,2X,4HV = ,E10,5,2X,8HRETURNED,E10,5)      ZFIND091
92.      V=VF      ZFIND092
93.      GO TO 50      ZFIND093
94.      45 TT=T+0,5      ZFIND094
95.      V=PTDENS(P ,TT)      ZFIND095
96.      V=1./V      ZFIND096
97.      50 V=V/VF      ZFIND097
98.      RETURN      ZFIND098
99.      55 V=1.      ZFIND099
100.     RETURN      ZFIND100
101.     60 CONTINUE      ZFIND101
102.     V=A(N,1)+A(N,2)*T+A(N,3)*T*T+A(N,4)*T*T*T+A(N,5)*T**4+A(N,6)*T**5ZFIND102
103.     RETURN      ZFIND103
104.     END      ZFIND104

```

Fig. B-6 ZFIND Program Listing (Cont'd)

```
1,      FUNCTION FINDR(N)                                FIND0001
2,      DIMENSION G(17)                                FIND0002
3,      DATA  G / 48.31,766.8,40.67,766.8,42.01,96.35,28.62,96.35,28.62, FIND0003
4,      155.81,40.67,90.77,16.78,37.0,11.90,33.90,346.3/ FIND0004
5,      FINDR=G(N)                                       FIND0005
6,      RETURN                                           FIND0006
7,      END                                              FIND0007
```

Fig. B-7 FINDR Program Listing

```

1.      FUNCTION PTDENS(PRES,TEMP)                                PTDEN0001
2.      DIMENSION PS(20),TS(20),JP(28),MX(28),LOC(30),BP(28),DP(28),BT(30) PTDEN0002
3.      1,DT(28),R(886)                                           PTDEN0003
4.      DIMENSION AA(109),AB( 97),AC(108),AD(106),AE(106),AF(108),AG(101) PTDEN0004
5.      1 ,AH(111),AI( 41)                                         PTDEN0005
6.      EQUIVALENCE( R,AA),( R( 110),AB),( R( 207),AC),( R( 315),AD) PTDEN0006
7.      1      ,( R( 421),AE),( R( 527),AF),( R( 635),AG),( R( 736),AH) PTDEN0007
8.      2      ,( R( 847),AI)                                       PTDEN0008
9.      DATA PS/1,022,2,4,8,14,25,43,69,99,128,151,165,176,,    PTDEN0009
10.     1162,,185,,186,5,187,25,187,46875,187,506,187,6385/      PTDEN0010
11.     DATA TS/24,845,27,07,29,81,33,07,36,18,39,96,44,12,48,33,51,97,54, PTDEN0011
12.     179,56,72,57,80,50,57,58,99,59,18,59,29,59,34,59,353,59,356,59,4/ PTDEN0012
13.     DATA LOC/1,23,78,105,141,155,183,201,225,240,267,321,341,377,401, PTDEN0013
14.     1 425,437,453,459,494,534,546,586,682,722,752,800,848,866,878/ PTDEN0014
15.     DATA JP/2,5,3,4,2,4,3,4,3,3,3,4,4,4,3,3,4,4,5,8,4,5,12,5,3,6,6,6/ PTDEN0015
16.     DATA MX/0,3,1,2,0,2,1,2,1,1,1,2,2,2,1,1,2,2,3,6,2,3,10,3,1,4,4,4/ PTDEN0016
17.     DATA BP/0,,200,,100,, 0,,0,,0,, -4,,0,,2642,28,1469,6,881,76,0,,0, PTDEN0017
18.     1,-44,088,587,84,293,92,73,48,-14,696,293,92,36,74,-7,348,293,92, PTDEN0018
19.     2180,,0,,0,,29,392,102,872,29,392/ PTDEN0019
20.     DATA DP/800,,1200,0,200,0,1000,0,100,0,1000,0,7,0,1000,0,1175,68, PTDEN0020
21.     1 587,64,293,92,293,92,293,92,58,784,146,96,146,96,73,48,29,392, PTDEN0021
22.     2 73,48,36,74,14,696,73,48,10,0,7,348,1,4695,14,696,14,696,29,392/ PTDEN0022
23.     DATA BT/180,0,180,0,500,0,500,0,1300,0,1300,0,2500,0,2500,0,36,0, PTDEN0023
24.     1 36,0,27,0,27,0,108,0,108,0,57,6,86,4,46,4,86,4,72,0,72,0,72,0, PTDEN0024
25.     2 59,4,59,4,30,0,23,4,39,6,52,2,64,8,5000,,5000,/ PTDEN0025
26.     DATA DT/30,0,30,0,100,0,100,0,200,0,200,0,500,0,500,0,36,0,18,0, PTDEN0026
27.     1 9,0,9,0,9,0,14,4,7,2,7,2,7,2,7,2,3,6,3,6,,2,1,8,1,8,6,0,5,4,3,6, PTDEN0027
28.     2 1,8,3,6/ PTDEN0028
29.     DATA AA/0,,.8376,0,,.7052,0,,.6114,0,,.5412,0,,.4862,0,,.4419,0,,.4 PTDEN0029
30.     1053,0,,.3746,0,,.3483,0,,.3255,0,,.3056,,.2652,1,41,2,315,2,924,3,3 PTDEN0030
31.     296,,2314,1,179,1,979,2,584,3,052,,1998,1,023,1,739,2,309,2,765,,17 PTDEN0031
32.     366,,9058,1,554,2,087,2,526,,1577,,8147,1,407,1,905,2,325,,1424,,74 PTDEN0032
33.     414,1,286,1,754,2,154,,1297,,6809,1,186,1,626,2,008,,1192,,63,1,102 PTDEN0033
34.     5,1,516,1,881,,1101,,5865,1,029,1,421,1,769,,1021,,5489,,9656,1,338 PTDEN0034
35.     6,1,671,,0953,,5159,,91,1,264,1,584,,-03747,,03747,,1114,,-03125,,0 PTDEN0035
36.     73125,,09302,,-02679,,02679,,07985,,-02345,,02345,,06995,,-02085,,0 PTDEN0036
37.     82085,,06224,,-01877,,01877,,05606,,-01706,,01706,,05099,,-01565,,0 PTDEN0037
38.     91565,,04677,,-01445,,01445,,04282,,00464,,3605,,6912,,9949,,00341/ PTDEN0038
39.     DATA AB/3021,,5825,,8432,,0026,,2601,,5038,,7325,,002,,2285,,4441, PTDEN0039
40.     1,6479,,00161,,2037,,3972,,581,,00131,,1838,,3592,,5267,,0011,,1674 PTDEN0040
41.     2,,3279,,4818,,0009,,1530,,3017,,4439,,00027,,1422,,2793,,4116,0,, PTDEN0041
42.     301445,0,,01252,0,,01105,0,,009892,0,,008951,0,,008174,0,,007 PTDEN0042
43.     4521,,000267,,1422,,2793,,4116,,000189,,123,,2432,,3592,,000144,,1 PTDEN0043
44.     5092,,2154,,3187,,00012,,09785,,1933,,2864,2,8E-5,,08864,,1753,,260 PTDEN0044
45.     61,8,1E-5,,08101,,1604,,2382,6,9E-5,,07459,,1478,,2196,,-0003009,,0 PTDEN0045
46.     7002256,,0007521,,-000251,,0001882,,0006272,,000215,,0001611,,0005 PTDEN0046
47.     8373,,-0001878,,0001402,,0004686,,-0001656,,0001221,,0004119,,-0001 PTDEN0047
48.     9452,,0001042,,0003599,6,9E-6,,07459,,1478,,2196,4,6E-6,,06226/ PTDEN0048
49.     DATA AC/1236,,1839,3,1E-6,,05342,,1061,,1532,9,E-7,,04677,,09301, PTDEN0049
50.     11387,-3,6E-6,,04155,,08272,,1235,-1,32E-5,,0373,,07436,,1111,5,27, PTDEN0050
51.     25,489,2,68,4,501,4,845,5,107,3,616,4,126,4,483,2,857,3,466,3,895,2 PTDEN0051
52.     3,319,2,935,3,395,4,994,5,143,5,27,4,533,4,743,4,886,3,958,4,27,4,5 PTDEN0052
53.     401,3,307,3,752,4,059,2,698,3,243,3,616,2,226,2,796,3,236,1,886,2,4 PTDEN0053

```

Fig. B-8 PTDENS Program Listing

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54. 535.2,857,1.639,2.15,2.588,1.453,1.924,2.319,5.033,5.112,5.183,4.81PTJDEJ054
55. 66.4,91,4.994,4.558,4.676,4.764,4.248,4.405,4.533,3.88,4.094,4.246,PTJDEJ055
56. 73,442,3,743,3,958,2,953,3,361,3,633,2,481,2,975,3,307,2,093,2,616,PTJDEJ056
57. 83,002,1,804,2,309,2,698,1,588,2,059,2,462,1,423,1,856,2,226,1,293,PTJDEJ057
58. 91,691,2,058,1,187,1,555,1,886,1,1,1,441,1,754,1,026,1,344,1,639/ PTJDEJ058
59. DATAAD/,9627,1,262,1,546,1,9076,1,189,1,453,4,742,4,853,4,946,5,031PTJDEJ059
60. 1,4,43,4,584,4,709,4,816,4,024,4,279,4,417,4,558,3,165,3,778,4,05,4PTJDEJ060
61. 2,248,1,43,2,988,3,595,3,88,-,0233,5581,1,189,1,804,-,015,503,1,0PTJDEJ061
62. 35,1,588,-,0099,4591,945,1,423,-,0065,4231,8618,1,293,-,0042,3PTJDEJ062
63. 4928,7943,1,187,-,0025,3669,7379,1,1,0015,3445,6898,1,026,-,PTJDEJ063
64. 50007,3249,6483,9627,-,0001,3075,612,9076,-,07704,02568,130PTJDEJ064
65. 67,2384,-,06785,02262,1144,2079,-,00066,02022,1018,1844,-,05PTJDEJ065
66. 7484,01828,09179,1659,-,05004,01668,0836,1508,-,04602,01534,PTJDEJ066
67. 8,07677,1383,3,887,3,986,4,105,3,447,3,646,3,792,2,91,3,226,3,442,PTJDEJ067
68. 92,323,2,76,3,051,1,857,2,317,2,67,1,549,1,963,2,326,1,34,1,701/ PTJDEJ068
69. DATAAE/2,035,1,189,1,497,1,804,7859,1,309,1,857,6864,1,106,1,549PTJDEJ069
70. 1,6141,9689,1,34,5581,8735,1,189,1675,3524,5577,7859,153,PTJDEJ070
71. 23178,4955,6864,1409,2902,4479,6141,1307,2674,4127,5581,-PTJDEJ071
72. 3,03228,03224,09858,1675,-,02974,02971,09043,153,-,02756,027PTJDEJ072
73. 454,08359,1409,-,02568,02568,07819,1307,1,226,1,807,2,329,2,67PTJDEJ073
74. 54,2,91,1,052,1,481,1,941,2,326,2,616,9378,1,279,1,656,2,019,2,323PTJDEJ074
75. 61,8526,1,141,1,456,1,774,2,089,7859,1,047,1,309,1,583,1,857,0997PTJDEJ075
76. 75,2084,33279,461,6115,7847,9864,1,226,09478,1962,3063,426PTJDEJ076
77. 84,5585,7052,8693,1,052,08981,1855,2878,3977,5164,6451,78PTJDEJ077
78. 951,9388,0859,176,2717,3734,4817,5972,7207,8526,08199/ PTJDEJ078
79. DATAAF/1675,2599,3524,455,5577,6718,7859,-,01936,01932,05PTJDEJ079
80. 1888,09975,-,01756,01753,05323,08981,-,01615,01611,04882,081PTJDEJ080
81. 299,3,304,3,422,3,541,3,659,3,777,3,044,3,29,3,45,3,572,3,667,2,74,PTJDEJ081
82. 33,102,3,304,3,449,3,557,2,322,2,88,3,141,3,315,3,447,1,861,2,621,2PTJDEJ082
83. 4,959,3,17,3,313,1,551,2,329,2,76,3,014,3,179,1,358,2,045,2,546,2,8PTJDEJ083
84. 548,3,044,1,226,1,807,2,329,2,674,2,91,6293,2,42,2,726,2,849,2,937PTJDEJ084
85. 6,3,005,3,061,3,11,3,153,3,191,3,227,3,259,9338,1,076,1,265,1,599,PTJDEJ085
86. 72,202,2,506,2,659,2,768,2,85,2,918,2,976,3,026,8297,9234,1,03,1,PTJDEJ086
87. 8159,1,322,1,542,1,835,2,136,2,356,2,509,2,618,2,709,759,8323,91PTJDEJ087
88. 921,1,001,1,103,1,22,1,359,1,523,1,713,1,916,2,106,2,267,7053/ PTJDEJ088
89. DATAAG/767,8326,9039,9807,1,066,1,16,1,265,1,383,1,513,1,655,1PTJDEJ089
90. 1,803,6621,7161,7728,8331,8976,9636,1,04,1,12,1,206,1,299,1,4PTJDEJ090
91. 2,1,507,6259,6745,725,778,8337,8927,9537,1,019,1,089,1,163,1PTJDEJ091
92. 3,242,1,325,5941,6412,6883,7355,7826,8372,8921,9469,1,005,1PTJDEJ092
93. 4,07,1,135,1,2,-,000743,04849,09854,0,0,-,000787,04023,08466,PTJDEJ093
94. 5,1315,1915,-,000437,03393,07032,1077,1534,-,000257,02941,06PTJDEJ094
95. 6027,09278,1275,-,000177,02599,05289,0808,1098,-,000122,0233PTJDEJ095
96. 7,0472,07177,09714,-,8,3E-5,02112,04206,06465,08719,-6,5E-5,PTJDEJ096
97. 801932,0381,05868,07931,0,01172,02363,-,000111,009736,0198,PTJDEJ097
98. 9-5,9E-5,008154,01648,-3,6E-5,007021,01414,-2,4E-5,006166/ PTJDEJ098
99. DATAAH/0124,-1,5E-5,005498,01104,-1,1E-5,004962,009954,-9,E-6PTJDEJ099
100. 1,004521,009053,-7,E-6,004153,008321,-2,2E-5,003846,007715,1PTJDEJ100
101. 2664,248,0,0,0,0,1469,2418,3397,0,0,0,1315,2117,3091,PTJDEJ101
102. 3,4233,5318,0,1195,1891,2684,3626,4811,6115,1098,1717,24PTJDEJ102
103. 4,3166,4051,5124,1017,1578,2183,2841,3568,4387,09486,146PTJDEJ103
104. 53,2009,2592,322,3903,08892,1377,1865,2407,295,3565,5712PTJDEJ104
105. 6,727,9725,0,0,0,5124,6559,8514,1,116,0,0,4755,5827,73PTJDEJ105
106. 729,9604,1,252,1,718,4387,5333,6477,7994,1,068,1,534,4145,49PTJDEJ106
107. 856,5914,706,8535,1,082,3903,4653,5491,6447,7575,8985,373PTJDEJ107
108. 94,4399,5151,5986,6928,802,3565,4181,4898,5616,6487/ PTJDEJ108
109. DATAAI/7358,08892,1865,295,4181,5616,7358,08373,1743,273PTJDEJ109
110. 11,3822,5044,6439,07931,1649,2502,3545,461,5814,-1,32E-5,PTJDEJ110
111. 20373,07436,111,-2,97E-5,0337,06734,1007,-5,14E-5,03051,0612PTJDEJ111

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Fig. B-8 PTDENS Program Listing (Cont'd)

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112.      32,.09175,-.0001453,.0001042,.0003599,-.000124,8,541E-5,.0003076,-9PTDE0112
113.      4,95E-5,6,714E-5,.0002542,0,/PTDE0113
114.      P=PRESPTDE0114
115.      IF(P,LT,1,0) P=1,0PTDE0115
116.      T=TEMPPTDE0116
117.      IF (T,LT,180,0) GO TO 45PTDE0117
118.      IF (T,GE,1300,0) GO TO 25PTDE0118
119.      IF (T,GE,480,0) GO TO 15PTDE0119
120.      IF (P,GE,800,) GO TO 10PTDE0120
121.      N=1PTDE0121
122.      GO TO 155PTDE0122
123.      10 N=2PTDE0123
124.      GO TO 155PTDE0124
125.      15 IF (P,GE,300,0) GO TO 20PTDE0125
126.      N=3PTDE0126
127.      GO TO 155PTDE0127
128.      20 N=4PTDE0128
129.      GO TO 155PTDE0129
130.      25 IF (T,GE,2500,0) GO TO 35PTDE0130
131.      IF (P,GE,100,0) GO TO 30PTDE0131
132.      N=5PTDE0132
133.      GO TO 155PTDE0133
134.      30 N=6PTDE0134
135.      GO TO 155PTDE0135
136.      35 IF(T,GE,6000,0) T=5999.99999PTDE0136
137.      IF (P,GE,10,0) GO TO 40PTDE0137
138.      N=7PTDE0138
139.      N1=30PTDE0139
140.      GO TO 155PTDE0140
141.      40 N=8PTDE0141
142.      N1=29PTDE0142
143.      GO TO 155PTDE0143
144.      45 TZ=24,84+0,00317*PPTDE0144
145.      IF(T,LT,TZ) T=TZPTDE0145
146.      IF (P,LT,881,76) GO TO 60PTDE0146
147.      IF (P,LT,2645,28) GO TO 50PTDE0147
148.      N=9PTDE0148
149.      GO TO 155PTDE0149
150.      50 IF (P,LT,1469,6) GO TO 55PTDE0150
151.      N=10PTDE0151
152.      GO TO 155PTDE0152
153.      55 N=11PTDE0153
154.      GO TO 155PTDE0154
155.      60 IF (T,GE,59,4) GO TO 75PTDE0155
156.      N=12PTDE0156
157.      IF (P,GE,187,6385) GO TO 155PTDE0157
158.      DO 65 I=2,20PTDE0158
159.      IF (P-PS(I)) 70,70,65PTDE0159
160.      65 CONTINUEPTDE0160
161.      I=20PTDE0161
162.      70 TM=TS(I-1)+(TS(I)-TS(I-1))*(P-PS(I-1))/(PS(I)-PS(I-1))PTDE0162
163.      IF (T,GE,TM) GO TO 125PTDE0163
164.      GO TO 155PTDE0164
165.      75 IF (T,LT,108,0) GO TO 85PTDE0165
166.      IF (P,LT,132,264) GO TO 80PTDE0166
167.      N=13PTDE0167
168.      GO TO 155PTDE0168
169.      80 N=14PTDE0169

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Fig. B-8 PTDENS Program Listing (Cont'd)

170,	GO TO 155	PTDE0170
171,	85 IF (P,LT,587,84) GO TO 90	PTDE0171
172,	N=15	PTDE0172
173,	GO TO 155	PTDE0173
174,	90 IF (T,LT,72,0) GO TO 120	PTDE0174
175,	IF (T,LT,86,4) GO TO 105	PTDE0175
176,	IF (P,LT,293,92) GO TO 95	PTDE0176
177,	N=16	PTDE0177
178,	GO TO 155	PTDE0178
179,	95 IF (P,LT,73,48) GO TO 100	PTDE0179
180,	N=17	PTDE0180
181,	GO TO 155	PTDE0181
182,	100 N=18	PTDE0182
183,	GO TO 155	PTDE0183
184,	105 IF (P,LT,293,92) GO TO 110	PTDE0184
185,	N=19	PTDE0185
186,	GO TO 155	PTDE0186
187,	110 IF (P,LT,36,74) GO TO 115	PTDE0187
188,	N=20	PTDE0188
189,	GO TO 155	PTDE0189
190,	115 N=21	PTDE0190
191,	GO TO 155	PTDE0191
192,	120 IF (P,LT,293,92) GO TO 125	PTDE0192
193,	N=22	PTDE0193
194,	GO TO 155	PTDE0194
195,	125 IF (P,LT,180,0) GO TO 130	PTDE0195
196,	N=23	PTDE0196
197,	GO TO 155	PTDE0197
198,	130 IF (P,GE,29,0) GO TO 140	PTDE0198
199,	IF (P,LT,2,9392) GO TO 135	PTDE0199
200,	N=24	PTDE0200
201,	GO TO 155	PTDE0201
202,	135 N=25	PTDE0202
203,	GO TO 155	PTDE0203
204,	140 IF (T,GE,64,8) GO TO 150	PTDE0204
205,	IF (P,GE,102,0) GO TO 145	PTDE0205
206,	N=26	PTDE0206
207,	GO TO 155	PTDE0207
208,	145 N=27	PTDE0208
209,	GO TO 155	PTDE0209
210,	150 N=28	PTDE0210
211,	155 IF(T,LE,5000,)N1=N	PTDE0211
212,	FP=(P-BP(N))/OP(N)	PTDE0212
213,	JP=FP	PTDE0213
214,	IF(IP,GT,MX(N)) IP=MX(N)	PTDE0214
215,	FI=IP	PTDE0215
216,	F=FP-FI	PTDE0216
217,	FP=1,0-F	PTDE0217
218,	FT=(T-BT(N1))/JT(N)	PTDE0218
219,	IT=FT	PTDE0219
220,	FI=IT	PTDE0220
221,	FF=FY-FI	PTDE0221
222,	FT=1,0-FF	PTDE0222
223,	I=IT*JP(N)+IP+LOC(N1)	PTDE0223
224,	J=I+JP(N)	PTDE0224
225,	PTDENS=FP*FT*R(I)+F*FT*R(I+1)+FP*FF*R(J)+F*FF*R(J+1)	PTDE0225
226,	RETURN	PTDE0226
227,	END	PTDE0227

Fig. B-8 PTDENS Program Listing (Cont'd)

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1.      SUBROUTINE WTCTRL(P,I,IM,II,D,S1,S2,S3,IV,IF,WT,WI)      WTCT0001
2.      REAL MINTHK                                             WTCT0002
3.      DIMENSION RHOL(10),RHOI(10),MINTHK(20)                  WTCT0003
4.      DIMENSION FTU(5,2)                                       WTCT0004
5.      DATA (FTU(J,1),J=1,5)/255000.,75000.,52600.,210000.,240000./ WTCT0005
6.      DATA (FTU(J,2),J=1,5)/305000.,94000.,63840.,219600.,288320./ WTCT0006
7.      DATA(RHOL(J),J=1,5)/501,12,176,26,169,34,511,49,276,48/ WTCT0007
8.      DATA(RHOI(J),J=1,6)/2,34,2,45,0,59,0,67,2,20,1,0/     WTCT0008
9.      DATA(MINTHK(J),J=1,15)/.02,.025,.028,.02,.16,.035,.058, WTCT0009
10.     1      .065,.042,.02,.049,.083,.095,.049,.035/         WTCT0010
11.     WT=0.                                                    WTCT0011
12.     WT=0.                                                    WTCT0012
13.     GO TO (10,15,15,15,15,15,15,15,25,15,25,25,35,35,45,50,55,65,70,70 WTCT0013
14.     ,70,75,80),I
15.     C      SUMP                                             WTCT0014
16.     10     WT=0.                                             WTCT0015
17.     RETURN                                                  WTCT0016
18.     C      EQUIVALENT LINE SECTIONS OR VENTURI             WTCT0017
19.     15     IF (IM.LE,5) GO TO 20                             WTCT0018
20.     IF (IM.EQ,6) GO TO 85                                    WTCT0019
21.     IF (IM.EQ,7) GO TO 90                                    WTCT0020
22.     20     CONTINUE                                          WTCT0021
23.     ST=FTU(IM,IF)                                           WTCT0022
24.     THKL=P*D*2.5/(2.*ST)                                     WTCT0023
25.     J=0                                                      WTCT0024
26.     IF(P.GE,1000.) J=5                                        WTCT0025
27.     IF(P.GE,3000.) J=10                                      WTCT0026
28.     IF(THKL.LE,MINTHK(IM+J)) THKL=MINTHK(IM+J)             WTCT0027
29.     WGTFT=3,1416*D*THKL*RHOL(IM)/144.                      WTCT0028
30.     WT=S1*WGTFT                                             WTCT0029
31.     C      COMPUTE INSULATION WEIGHT                         WTCT0030
32.     WI=3,1415927*S1*RHOI(II)*(D+S3/2.)/144.                WTCT0031
33.     RETURN                                                  WTCT0032
34.     25     WRITE (6,30)I                                       WTCT0033
35.     30     FORMAT(T2,'S/R WTCTRL = OPTION ',I3,' NOT IMPLEMENTED'//) WTCT0034
36.     WT=0.                                                    WTCT0035
37.     RETURN                                                  WTCT0036
38.     35     IDV=IV+1                                           WTCT0037
39.     40     WT=CFTW(D,P,IDV)                                   WTCT0038
40.     RETURN                                                  WTCT0039
41.     45     IDV=4                                              WTCT0040
42.     GO TO 40                                                WTCT0041
43.     50     IDV=1                                              WTCT0042
44.     GO TO 40                                                WTCT0043
45.     C      U-PIN TIE ROD BELLWS                             WTCT0044
46.     55     IB=1                                              WTCT0045
47.     60     WT=CBWT(D,P,IB)                                   WTCT0046
48.     RETURN                                                  WTCT0047
49.     C      PIN OR HINGE JOINT BELLWS                       WTCT0048
50.     65     IB=2                                              WTCT0049
51.     GO TO 60                                                WTCT0050
52.     C      EXTERNAL OR INTERNAL GIMBAL BELLWS              WTCT0051
53.     70     IB=3                                              WTCT0052

```

Fig. B-9 WTCTRL Program Listing

54.		GO TO 60	WTCT0054
55.	C	PRESSURE=VOLUME COMPENSATOR	WTCT0055
56.	75	IB=4	WTCT0056
57.		GO TO 60	WTCT0057
58.	C	INTERNAL BALL=STRUT BELLOWS	WTCT0058
59.	80	IB=5	WTCT0059
60.		GO TO 60	WTCT0060
61.	C	COMPUTE WEIGHT OF VACUUM=JACKETED CRCS LINE (321/347)	WTCT0061
62.	85	A=0.217684	WTCT0062
63.		B=-6.69016E=03	WTCT0063
64.		GO TO 95	WTCT0064
65.	C	COMPUTE WEIGHT OF VACUUM=JACKETED ALUMINUM (2219)	WTCT0065
66.	90	A=0.359277	WTCT0066
67.		B=-2.00888E=02	WTCT0067
68.	95	WT=S1/(A+B*D)	WTCT0068
69.		RETURN	WTCT0069
70.		END	WTCT0070

Fig. B-9 WTCTRL Program Listing (Cont'd)


```

1.      FUNCTION CFTW (D,P,IDV)                                CFTW0001
2.      C .....                                              CFTW0002
3.      REAL K1,K2,K3,K4                                     CFTW0003
4.      C .....                                              CFTW0004
5.      DIMENSION K1(4),K2(4),K3(4),K4(4),C1(4),C2(4),C3(4),C4(4) CFTW0005
6.      C .....                                              CFTW0006
7.      DATA K1/0.040,0.057,0.073,0.090/                 CFTW0007
8.      DATA K2/0.057,0.073,0.090,0.107/                 CFTW0008
9.      DATA K3/1.000,2.500,3.300,5.500/                 CFTW0009
10.     DATA K4/2.500,3.300,5.500,7.700/                 CFTW0010
11.     DATA C1/1.750,3.950,5.730,8.910/                 CFTW0011
12.     DATA C2/3.950,5.730,8.910,12.35/                 CFTW0012
13.     DATA C3/0.800,1.500,2.500,3.500/                 CFTW0013
14.     DATA C4/1.500,2.500,3.500,4.500/                 CFTW0014
15.     C .....                                              CFTW0015
16.     C .....                                              CFTW0016
17.     SET IDV TO EXTRA HEAVY IF NOT INPUT                 CFTW0017
18.     IF (IDV .EQ. 0) IDV = 4                               CFTW0018
19.     IF (D.LE.1.) GO TO 15                                 CFTW0019
20.     IF (P.GT.300.0.AND.D.GT.3.5) GO TO 10              CFTW0020
21.     IF (P.GT.1000.0.AND.D.LE.3.5) GO TO 10            CFTW0021
22.     CFTW = K1(IDV)*D*D*D + C1(IDV)                      CFTW0022
23.     RETURN                                               CFTW0023
24.     10 CFTW = K2(IDV)*D*D*D + C2(IDV)                   CFTW0024
25.     RETURN                                               CFTW0025
26.     15 IF (P.GE.1000.) GO TO 20                          CFTW0026
27.     CFTW = K3(IDV)*D + C3(IDV)                          CFTW0027
28.     RETURN                                               CFTW0028
29.     20 CFTW = K4(IDV)*D + C4(IDV)                       CFTW0029
30.     END                                                  CFTW0030

```

Fig. B-10 CFTW Program Listing

1.	FUNCTION CBWT(D,P,IB)	CBWT0001
2.	REAL M	CBWT0002
3.	DIMENSION C1(5),C2(5),M(5)	CBWT0003
4.	DATA C1/.07384,,1255,,1006,14.26,,09489/	CBWT0004
5.	DATA C2/.10301,,1731,,1262,18.499,,12892/	CBWT0005
6.	DATA M/2.05,2.305,2.55,1.111,2.354/	CBWT0006
7.	CBWT=C1(IB)*D**M(IB)	CBWT0007
8.	IF(P,LE,150,) RETURN	CBWT0008
9.	IF (P,LT,300,) GO TO 10	CBWT0009
10.	CBWT=CBWT*C2(IB)/C1(IB)	CBWT0010
11.	RETURN	CBWT0011
12.	10 CBWT=CBWT+(P=150,)*CBWT*(C2(IB)/C1(IB)=1,)/150.	CBWT0012
13.	RETURN	CBWT0013
14.	END	CBWT0014

Fig. B-11 CBWT Program Listing

1.	C		GOMT0001
2.		FUNCTION CONE (R,H)	GOMT0002
3.	C		GOMT0003
4.		INCLUDE UCONST,LIST	GOMT0004
5.	C		GOMT0005
6.	C	VOLUME OF CONE (CIRCULAR)	GOMT0006
7.		CONE = PI*R*R*H / 3.0	GOMT0007
8.		RETURN	GOMT0008
9.	C	VOLUME OF CYLINDER (RIGHT=CIRCULAR)	GOMT0009
10.		ENTRY CYLNDR (R,H)	GOMT0010
11.		CONE = PI*R*R*H	GOMT0011
12.		RETURN	GOMT0012
13.	C	VOLUME BETWEEN CYLINDER AND SPHEROID	GOMT0013
14.	C	RROT IS ALONG AXIS OF ROTATION	GOMT0014
15.		ENTRY CYLSPH (RROT,R)	GOMT0015
16.		CONE = PI*R*R*RROT / 3.0	GOMT0016
17.		RETURN	GOMT0017
18.	C	VOLUME OF FRUSTRUM OF CONE (CIRCULAR)	GOMT0018
19.		ENTRY FRCONC (R,H,R2)	GOMT0019
20.		CONE = PI*H*(R*R + R2*R2 + R*R2) / 3.0	GOMT0020
21.		RETURN	GOMT0021
22.	C	VOLUME OF HEMISPHERE OR HALF OF SPHEROID	GOMT0022
23.	C	RROT IS ON AXIS OF ROTATION	GOMT0023
24.		ENTRY HSPHER (RROT,R)	GOMT0024
25.		CONE = PI/203*R*R*RROT	GOMT0025
26.		RETURN	GOMT0026
27.	C	VOLUME OF SPHERE OR SPHEROID	GOMT0027
28.	C	RROT IS ALONG AXIS OF ROTATION	GOMT0028
29.		ENTRY SPHERE (RROT,R)	GOMT0029
30.		CONE = 2.0*PI/203*R*R*RROT	GOMT0030
31.		RETURN	GOMT0031
32.	C		GOMT0032
33.	C	AREA OF CYLINDER	GOMT0033
34.		ENTRY ARACYL (R,H)	GOMT0034
35.		CONE = 2.0*PI*R*H	GOMT0035
36.		RETURN	GOMT0036
37.	C		GOMT0037
38.	C	AREA OF FRUSTRUM	GOMT0038
39.		ENTRY AREAFR (R,H,R2)	GOMT0039
40.		CONE = PI*(R+R2)*SQRT (H*H+(R-R2)*2)	GOMT0040
41.		RETURN	GOMT0041
42.	C		GOMT0042
43.	C	AREA OF HALF OF SPHEROID	GOMT0043
44.	C	RROT ALONG AXIS OF ROTATION	GOMT0044
45.		ENTRY ARSPHR (RROT,R)	GOMT0045
46.		IF (RROT,LE,R) GO TO 10	GOMT0046
47.	C	ROTATED ABOUT MAJOR AXIS	GOMT0047
48.	C	E = ECCENTRICITY FOR ELLIPSE	GOMT0048
49.		E = SQRT (RROT*RROT - R*R)/RROT	GOMT0049
50.		CONE = PI*R*(R+RROT*ASIN(E)/E)	GOMT0050
51.		RETURN	GOMT0051
52.	10	IF (RROT,EQ,R) GO TO 15	GOMT0052
53.	C	ROTATED ABOUT MINOR AXIS	GOMT0053

Fig. B-12 GOMTRY Program Listing

```

54,      E = SQRT (R*R - RROT*RRROT) / R          GOMT0054
55,      CONE = PI*(R*R+(RRROT*RRROT/(2,*E))*LOG((1,*E)/(1,-E))) GOMT0055
56,      RETURN                                     GOMT0056
57,      C      AREA OF HEMISPHERE                 GOMT0057
58,      15 CONE = 2,*PI*R*R                       GOMT0058
59,      RETURN                                     GOMT0059
60,      END                                       GOMT0060

```

Fig. B-12 GOMTRY Program Listing (Cont'd)

1.	C		SPHS0001
2.		SUBROUTINE SPHSEG (PVOL,RAD,H)	SPHS0002
3.	C		SPHS0003
4.		INCLUDE UCONST,LIST	SPHS0004
5.	C		SPHS0005
6.		DIMENSION Y(3)	SPHS0006
7.	C		SPHS0007
8.	C	CALC. VOL. OF TOTAL HEMISPHERE	SPHS0008
9.		TVOL = PI203 * RAD**3	SPHS0009
10.		GO TO 10	SPHS0010
11.	C	ENTRY FOR ELLIPTICAL SPHEROID	SPHS0011
12.	C	RAD ALONG AXIS OF ROTATION	SPHS0012
13.		ENTRY ELIPSG (PVOL,RAD,RPD,H)	SPHS0013
14.	C		SPHS0014
15.		TVOL = PI203*RPD*RPD*RAD	SPHS0015
16.	10	CONTINUE	SPHS0016
17.		XM = PVOL / TVOL	SPHS0017
18.		IF (XM.GT.0.) GO TO 15	SPHS0018
19.		WRITE (6,40)XM	SPHS0019
20.		RETURN	SPHS0020
21.	15	CONTINUE	SPHS0021
22.		PHI3 = ACOS (1.0-XM) / 3.0	SPHS0022
23.		DO 20 I=1,3	SPHS0023
24.		XI = I - 1	SPHS0024
25.		Y(I) = RAD*(1.0 + 2.0*COS (PHI3 + XI*PI203))	SPHS0025
26.	20	CONTINUE	SPHS0026
27.		DO 25 I=1,3	SPHS0027
28.		K = I	SPHS0028
29.		IF (Y(I).GT.0..AND.Y(I).LT.RAD) GO TO 30	SPHS0029
30.	25	CONTINUE	SPHS0030
31.		WRITE (6,35)Y	SPHS0031
32.		RETURN	SPHS0032
33.	30	H = Y(K)	SPHS0033
34.		RETURN	SPHS0034
35.	C		SPHS0035
36.	C	RAD ALONG AXIS OF ROTATION	SPHS0036
37.		ENTRY CYMSPH (PVOL,RAD,RPD,H)	SPHS0037
38.	C		SPHS0038
39.	C	TO CALC. HEAD IN A VOLUME BETWEEN A CYLINDER AND	SPHS0039
40.	C	SPHEROID	SPHS0040
41.		D = 3.0*RAJ*RAJ*PVOL / (PI*RPD*RPD)	SPHS0041
42.		H = RAD - (RAD**3 - D)**(1./3.)	SPHS0042
43.		RETURN	SPHS0043
44.	C		SPHS0044
45.		35 FORMAT ('0' 10X 'COULD NOT FIND H FOR HEMISPHERE' 3F15.4/)	SPHS0045
46.		40 FORMAT ('0' 10X 'ERROR INPUT TO SPHSEG' F15.7)	SPHS0046
47.	C		SPHS0047
48.		END	SPHS0048

Fig. B-13 SPHSEG Program Listing

APPENDIX C
SOPSA PROGRAM AND SUBROUTINE DICTIONARY

This appendix contains an alphabetic listing of all the alphanumeric names (variables, subroutines, functions, etc.) used in the SOPSA program. Following each entry in the list is a set of line numbers. These are the lines on which the entry appears in the program listing (Appendix A). Similar tables are presented for statement numbers and transfer statements used in the program.

Following each entry and each line number is a set of flags. These flags indicate the type of entry and how the entry is used each time it appears. The heading of each table explains the meaning of these flags. The name of the COMMON block is also listed in the error flag field for any variable name appearing in a named COMMON block.

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Table C-1

STAR DICTIONARY

THE FIRST FLAG INDICATES THE NATURE OF THE ALPHABETIC ENTITY

= UNDIMENSIONED VARIABLE
 DMVR = DIMENSIONED VARIABLE
 FCTN = FUNCTION NAME
 LBCM = NAME OF LABELED COMMON
 SBRT = SUBROUTINE NAME
 SWVR = SWITCH VARIABLE
 NMLT = NAMELIST NAME

VARIABLE TABLE
 THE FOLLOWING TWO CHARACTER FLAGS INDICATE THAT THE ENTITY IS IN THE CORRESPONDING TYPE OF STATEMENT

AB = ABNORMAL
 CM = COMMON
 CP = COMPLEX
 DA = DATA
 DM = DIMENSION
 DP = DBL PRECISION
 EQ = EQUIVALENCE
 EX = EXTERNAL
 FA = FORMAL ARGUMENT
 IN = INTEGER
 LG = LOGICAL
 PR = PARAMETER
 RL = REAL
 NL = NAMELIST

THE FLAGS FOLLOWING THE LINE NUMBERS (ON WHICH THE ENTITY WAS REFERENCED) INDICATE THE NATURE OF THE REFERENCE

A = SET EQUAL, DEFINED, ASSIGNED
 B = REFERENCED, CALLED
 C = CALLING SEQUENCE
 D = SUBSCRIPT
 E = SPECIFICATION
 J = DO PARAMETER
 H = I-O UNIT
 I = READ
 O = WRITE
 L = LIST

A6A	LBCM	CM	CM	CM	CM		76E	77E	78E	79E									
ABC	DMVR	DM	EQ	EQ	EQ	**	64E	65E	65E	65E	65E	65E	65E	65E	65E	65E	65E	65E	65E
ADH	DMVR	DM					65E	65E	65E	65E	65E	65E	65E	65E	65E	65E	65E	65E	65E
ADD	DMVR	DM					63E	422A	809B										
ADOME		CM					63E	394A	757B										
AMAX1	FCTN					DIMEN	17E	9250											
ASKIN		CM				DIMEN	746B	798B											
ATOT		CM				DIMEN	17E	9250											
A1		CM				DIMEN	17E												
A2		CM				DIMEN	17E												
A3		CM				DIMEN	17E												
A4		CM				DIMEN	17E												
A6		CM				DIMEN	17E												
A7		CM				DIMEN	17E												
BBB	LBCM	CM					80E												
CCC	LBCM	CM					81E												
CONGP							531A	547B	563B	570A	584B	602B							
D							530A	541C	544B	557C	560B	569A	580C	583B	596C	599B			
DDD	LBCM	CM					82E												
DELTIM							490A	491B	493B	494B	495B								
DFWGT	DMVR	DM					27E	488A	489B	494B	509B	586B	602B						
DFWGT0	DMVR	DM					27E	487A	487B	493B	506B	547B	563B						
DIA							750A	761C	773A	783C	802A	813C	825A	835C					
DIFWGT	DMVR	DM	CM			FFF	26E	86E	489A	491B	495B								
DIMEN	LBCM	CM					17E												
DLPACH	DMVR	DM	EQ				43E	65E	453A	463A	631B	639B	719B	733B	10850	1157A	11600		
DLPACO	DMVR	DM	EQ				43E	65E	436A	444A	630B	636B	712B	732B	10690	1141A	11440		
DLPDHD	DMVR	DM	CM			FFF	26E	86E	521A	639B	10380								
DLPDHD0	DMVR	DM	CM			FFF	26E	86E	520A	636B	10380								
DLPDHD1	DMVR	DM	EQ				44E	65E	586A	602A	631B	639B	719B	733B	11180	1158A	11600		
DLPDHD2	DMVR	DM	EQ				44E	65E	547A	563A	630B	636B	712B	732B	11030	1142A	11440		
E							729B	730B											
EFE	LBCM	CM					84E												
EQLR	DMVR	CM				DIMEN	17E	471A											
EQLR1	DMVR	DM					28E	1551	471B	9480									
EXIT	SBRT						1359B												
FEET	DA						93A	471B											
FFF	LBCM	CM	CM	CM			86E	88E	89E										
FIFRAC	DMVR	DM	CM			AAA	29E	76E	299I	500B	10140								
FINDR	FCTN						688B												
FLORES	SBRT						541B	557B	580B	596B									
FNOM	DMVR	DM	CM			DDD	32E	82E	260I	500B	9180								
FTOW	DMVR	DM	CM			FFF	26E	86E	507A	501B	502A	520B	521B	673B	675B	702B	704B	10380	
GC	DMVR	DM	CM	DA		CCC	32E	81E	93A	436B	444B	455B	463B						

STAR DICTIONARY (CONT'D)

GGG	LBCM	CM	CM	90E	91E														
HCAYP		CM		EEE	84E	568A	581A	581B	583A	583B	584B	584B	597A	597B	599A	599B	60JB	602B	
HDDUM		CM		EEE	84E	449A	455B	463B											
HDH2		CM		DIMEN	17E	478B	516B	521B											
HDLQUM		CM		EEE	84E	567A	586B	602B											
HDO2		CM		DIMEN	17E	477B	515B	520B											
HDTINC		CM		EEE	84E														
HEADCH2	DMVR	DM	CM	GGG	30E	90E	516A	675B	12240										
HEAD1H		CM		FFF	89E	478A	9250												
HEAD10		CM		FFF	89E	477A	9250												
HEAD02	DMVR	DM	CM	GGG	30E	90E	515A	673B	12240										
HKPD	DMVR	DM	CM	DDD	31E	82E	584A	600A	9610	9630									
HPD	DMVR	DM	CM	DDD	31E	82E	225I	408B	416B	449B	567B	569B	802B	825B	9610	9630	10830	11130	
					11870	12540	12850	13160	13450										
HPDUM		CM		EEE	84E	448A	455B	461A	463B										
HPIPEL	DMVR	DM	CM	DDD	31E	82E	413A	422B	448B	583B	9610								
HYHTLN	DMVR	DM	CM	DDD	39E	82E	240I	521B	704B	9290									
H2	DMVR	DM	DA		61E	94A	13450	13450											
I					109D	109L	177J	178D	178D	178D	178D	178D	178D	180D	181D	182D	182D	183D	
					188J	189D	189D	189D	189D	189D	189D	191D	192D	193D	193D	194D	205J	207D	
					207D	207D	207D	207D	207D	209D	210D	211D	211D	212D	216J	217D	217D	217D	
					217D	217D	217D	219D	220D	221D	222D	281D	281L	289D	289L	291D	291L	291L	
					299D	299L	376J	377D	378D	384D	389D	404J	405D	406D	412D	413D	427J	429D	
					430D	431B	436D	444D	448D	449D	450B	455D	463D	470J	471D	471D	525J	528D	
					530D	532B	536D	538D	539D	540D	544D	545D	547D	561D	563D	567D	569D	571B	
					575D	577D	578D	579D	583D	584D	586D	600D	602D	623J	636D	636D	635D	639D	
					639D	639D	653J	657D	657D	657D	658D	658D	661D	661D	662D	662D	668J	668J	
					669D	670D	673D	673D	675D	675D	675D	676D	676D	676D	677D	677D	677D	677D	
					686A	687D	689D	693D	709J	712D	712D	712D	712D	715D	715D	715D	715D	722J	
					723D	724D	737D	737D	738D	738D	739D	739D	739D	739D	743D	743D	743D	743D	
					746D	746D	746D	747D	750D	757D	763D	766D	787D	788D	792D	793D	794D	794D	
					794D	795D	795D	795D	796D	796D	795D	798D	798D	798D	798D	799D	802D	809D	817D
					818D	839D	840D	844D	845D	846D	846D	846D	847D	847D	847D	847D	848D	848D	848D
					901D	901L	973J	974D	974D	974D	974D	974D	974D	974D	983J	984D	984D	984D	
					984D	984D	984D	984D	991J	992D	992D	992D	992D	992D	992D	992D	100J	10010	10010
					1001D	1001D	1001D	1001D	1001D	1001D	1024D	1024L	1051D	1051L	1069D	1069L	1077D	1077L	
					1085D	1085L	1094D	1094L	1103D	1103L	1111D	1111L	1118D	1118L	1127D	1127L	1140J	1141D	
					1142D	1144D	1144L	1144D	1144L	1149D	1149L	1156J	1157D	1158D	1160D	1160L	1160D	1160L	
					1168D	1168L	1177D	1177L	1185D	1185L	1192D	1192L	1201D	1201L	1223A	1224D	1224D	1224D	
					1224D	1246D	1246L	1259D	1259L										
ICASE					99A	111A	111B	1350D											
ID					377A	378A	379B	382B	383B	405A	405A	407B	410B	411B	538A	541C	554A	557C	
					577A	580C	593A	596C	753A	757B	761B	760B	761C	775A	782B	782B	783C	805A	
					809B	812B	812B	813C	827A	834B	834B	835C							
IDEFH	DMVR	DM			57E	217I	219B	220B	221B	222A	405B	577B	827B	10010					
IDELO	DMVR	DM			54E	189I	191B	192B	193B	194A	377B	538B	775B	9840					
IDH	DMVR	DM			58E	211A	812B												
IDHE	DMVR	DM			58E	221A	834B												
IDMLH	DMVR	DM			56E	207I	209B	210B	211B	212A	406B	593B	805B	9920					
IDMLO	DMVR	DM			53E	178I	180B	181B	182B	183A	373B	554B	753B	9740					
IDO	DMVR	DM			58E	182A	760B												
IDOE	DMVR	DM			58E	193A	782B												
IDV					752A	760A	761C	778A	782A	783C	804A	812A	813C	830A	834A	835C			
IGOON		CM		88B	80E	351I	1353B												
II					759A	761C	777A	783C	807A	813C	829A	835C							
IIEFH	DMVR	DM			57E	217I	829B	10010											
IIELO	DMVR	DM			54E	189I	777B	9840											

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IMSC-A991396

STAR DICTIONARY (CONT'D)

IIIMLH	DMVR	DM	56E	207I	807B	9920														
IIIMLO	DMVR	DM	53E	178I	755B	9740														
IIN		DA	96A																	
IM			754A	761C	776A	783C	806A	813C	821A	835C										
IMELH	DMVR	DM	57E	217I	824B	10010														
IMELO	DMVR	DM	54E	189I	776B	9840														
IMMLH	DMVR	DM	55E	207I	806B	9920														
IMMLO	DMVR	DM	55E	178I	754B	9740														
INIVOL	SBRT		472B																	
IOT		DA	96A																	
IP	DMVR	DM	52E	114A	121I	123B	150B	157B	200B	227B	243B	253B	264B	276B	283B	294B				
IPASS			301B	312B	323B	334B	345B													
ITEMP			854A	854B	855B															
J			181A	182B	183B	192A	193B	194B	210A	211B	212B	220A	221B	222B						
			361J	362D	362D	362D	362D	363D	363D	363D	363D	363D	363D	435J	435D	436D				
			443J	444D	444D	454J	455D	455D	462J	463D	463D	486J	487D	487D	487D	488D				
			468D	488D	489D	489D	489D	490D	490D	491D	492D	493D	493D	494D	494D	495D				
			496D	500D	500D	500D	501D	502D	506D	506D	506D	507D	509D	509D	509D	510D				
			513D	514D	515D	516D	520D	520D	521D	521D	546J	547D	547D	562J	563D	563D				
			585J	586D	586D	601J	602D	602D	613J	617D	617D	618D	618D	618D	618D	620D				
			620D	621D	621D	621D	621D	624J	627D	628D	630D	630D	631D	631D	632D	632D				
			633D	633D	636D	636D	636D	636D	636D	636D	636D	639D	639D	639D	639D	639D				
			654J	656D	656D	657D	657D	657D	657D	658D	658D	658D	658D	658D	660D	661D				
			661D	661D	661D	662D	662D	662D	662D	671J	673D	673D	673D	673D	673D	675D				
			675D	675D	676D	676D	677D	677D	683J	685D	687D	689D	690D	690D	692D	693D				
			694D	694D	703J	702D	702D	704D	704D	710J	712D	712D	712D	712D	712D	712D				
			715D	715D	715D	715D	715D	715D	725J	729D	730D	732D	732D	733D	733D	734D				
			734D	735D	735D	737D	737D	737D	737D	738D	738D	738D	738D	739D	739D	740D				
			740D	774J	775D	776D	777D	779D	780D	781D	782D	826J	827D	829D	829D	831D				
			832D	833D	834D	1340D	1340L	1345D	1345L	225L	959J	960B	961D	961D	961D	961D				
			113J	114D	121D	121L	197D	197L	225D	225L	959J	960B	961D	961D	961D	961D				
			961D	961D	963D	963D	963D	963D	1055D	1055L	1080D	1080L	1098D	1098L	1113D	1113L				
			1172D	1172L	1187D	1187L	1241D	1241L	1254D	1254L	1272D	1272L	1285D	1285L	1303D	1303L				
			1316D	1316L																
LOADH1	RL	CM	AAA	74E	79E	250I	356B	9250												
LOADH2	RL	CM	AAA	74E	79E	356A	474C	511B												
LOADO1	RL	CM	AAA	74E	79E	250I	355B	9250												
LOADO2	RL	CM	AAA	74E	79E	355A	474C	508B												
L1	RL			15E																
L2	RL			15E																
L3	RL			15E																
L4	RL			15E																
MID			187A	188J	215A	216J	374A	375A	375J	402A	403A	404J	536A	537J	575A	576J				
			751J	753D	754D	755D	756D	758D	759D	760D	772A	774J	803J	805D	805D	807D				
			808D	810D	811D	812D	824A	826J	971A	983J	995A	1000J								
			56E	205I	215B	402B	575B	824B	995B											
			53E	176I	187B	374B	536B	772B	973B											
			205I	206J	403B	592J	803J	991J												
			176I	177J	375B	553J	751J	973J												
			98B																	
MPTS		CM	80E	360A	361J	435J	443J	454J	462J	486J	546J	562J	585J	601J	615J	624J				
			654J	671J	683J	700J	710J	725J												
			307D	307L	309D	309L	318D	318L	320D	320L	329D	329L	331D	331L	340D	340L				
			342D	342L	629J	630D	630D	631D	631D	631D	731J	732D	732D	733D	733D	948D	948L			
			1013J	1014D	1014D	1014D	1014D	1014D	1014D	1014D	1014D	1014D	1014D	1014D	1014D	1014D	1014D			
			1035D	1037B	1037D	1038D	1038D	1038D	1038D	1038D	1038D	1038D	1038D	1038D	1038D	1065J				
			1066D	1068B	1069D	1082J	1083D	1084B	1085D	1100J	1101D	1102B	1103D	1115J	1115D	1117B				
			1118D	1136J	1137D	1138B	1141D	1142D	1144D	1144D	1152J	1153D	1154B	1157D	1158D	1160D				

STAR DICTIONARY (CONT'D)

				1160D	1174J	1175D	1176B	1177D	1189J	1193D	1191B	1192D	1219J	1220D	1222B	1224D	1224D	1237D	1237L	1243J	1244D	
				1245B	1246D	1252D	1252L	1256J	1257D	1258B	1259D	1268D	1268L	1274J	1275D	1275B	1277D	1283D	1283L	1287J	1288D	
				1289B	1290D	1290D	1290D	1299L	1305J	1306D	1307B	1309D	1314D	1314L	1318J	1319D	1320B	1321D	1421	146B	147B	
NEL				147B	1761	184J	2051	214J	374B	375B	377B	378B	384B	385B	402B	403B	405B	406B	412B	413B	431B	
				450B	532B	571B	629J	731J	769J	821J	960B	977J	994J	1139B	1155B	147A	393J	421J	623J	653J	668J	
NELP				685B	709J	722J	1047B	1055D	1069D	1083D	1085D	1098D	1103D	1113D	1118D	1172D	1177D	1187D	1192D	1223B	1241D	
				1246D	1254D	1259D	1272D	1277D	1285D	1290D	1303D	1309D	1316D	1321D	1339J	1344J	1421	502B	537J	538D	539D	
NGST				540D	553J	554D	555D	556D	576J	577D	576D	579D	592J	593D	594D	595D	176D	176L	186J	187D	189D	
NID				189D	189D	189D	189D	189D	189D	189D	191D	192D	193D	193D	194D	205D	205L	214J	215D	217D	217D	
				217D	217D	217D	217D	217D	217D	217D	219D	220D	221D	221D	222D	372J	374B	374D	375B	377B	377D	
NL				377D	378B	380D	384B	384D	385B	388D	390D	393J	394D	394D	400J	402B	402D	403B	405B	405D	406B	
				406B	408D	412B	412D	413B	416D	418D	421J	422D	422D	422D	769J	772D	773D	775D	776D	777D	779D	
				780D	780D	787D	788D	821J	824D	825D	827D	828D	829D	831D	832D	833D	834D	839D	840D	977J	978D	
				979D	984D	984D	984D	984D	984D	984D	984D	984D	984D	984D	984D	984D	984D	994J	995D	996D		
				1001D	1001D	1001D	1001D	1001D	1001D	1001D	1001D	1001D	1001D	1001D	1001D	1001D	1001D	1001D	1001D	1001D	1001D	
NMA				1047A	1055D	1069D	1080D	1085D	1098D	1103D	1113D	1118D	1172D	1177D	1187D	1192D	1241D	1246D	1254D	1259D	1272D	
				1277D	1285D	1290D	1303D	1309D	1316D	1321D	1339J	1344J	1421	146B	80E	1421	444B	463B	563B	602B	913D	
NML				1169D	1186D	1238D	1253D	1269D	1284D	1300D	1315D	1315D	1315D	1315D	1315D	1315D	1315D	1315D	1315D	1315D	1315D	
NOP	CM		BBB	80E	1421	444B	463B	563B	602B	913D	1169D	1186D	1238D	1253D	1269D	1284D	1300D	1315D	1315D	1315D	1315D	
				80E	1421	491B	493B	494B	495B	503B	506B	509B	918D									
NOP1	CM		BBB	33E	73E	76E	3091	620B	1014D													
NPSPH	DMVR	DM	HL	CM	AAA	33E	73E	76E	3071	617B	1014D											
NPSPO	DMVR	DM	HL	CM	AAA	33E	73E	76E	3071	617B	1014D											
NPTS	CM		BBB	60E	1421	2811	2891	2911	2991	3071	3091	3181	3201	3291	3311	3401	3421	360B	1013J	1034J	1037B	
				1065J	1068B	1082J	1084B	1100J	1102B	1115J	1117B	1136J	1138B	1152J	1154B	1174J	1176B	1189J	1191B	1219J	1222B	
				1243J	1245B	1256J	1258B	1274J	1276B	1287J	1289B	1305J	1307B	1318J	1320B	80E	146A	1971	2251	372J	393J	
NSIZE	CM		BBB	400J	421J	427J	526J	623J	653J	668J	709J	722J	905D	959J	1339J	1344J	64E	529A	542A	542B	544A	
				544B	544B	545B	547B	558A	558B	560A	560B	561B	563B	64E	529A	542A	542B	544A	544B	545B	547B	
OCAYP	CM		EEE	64E	529A	542A	542B	544A	544B	545B	547B	558A	558B	560A	560B	561B	563B	64E	430A	436B	444B	
ODDUM	CM		EEE	64E	528A	547B	563B	64E	528A	547B	563B	64E	528A	547B	563B	64E	528A	547B	563B	64E	528A	
ODLQUM	CM		EEE	64E	528A	547B	563B	64E	528A	547B	563B	64E	528A	547B	563B	64E	528A	547B	563B	64E	528A	
ODTINC	CM		EEE	64E	528A	547B	563B	64E	528A	547B	563B	64E	528A	547B	563B	64E	528A	547B	563B	64E	528A	
OKPD	DMVR	DM	CM	DDD	31E	82E	545A	561A	9610	9630												
OPO	DMVR	DM	CM	DDD	31E	82E	1971	380B	388B	430B	524B	530B	750B	773B	9610	9630	1055D	1098D	1172D	1241D		
				1272D	1272D	1303D	1340D	1340D	1340D	1340D	1340D	1340D	1340D	1340D	1340D	1340D	1340D	1340D	1340D	1340D	1340D	
OPDUM	CM		EEE	84E	429A	436B	442A	444B														
OPIPEL	DMVR	DM	CM	DDD	31E	82E	390A	394B	429B	544B	9610											
OXHTLN	DMVR	DM	CM	DDD	39E	82E	2401	520B	702B	925D												
O2	DMVR	DM	DA		61E	94A	1340D	1340D														
PCWGTH	DMVR	DM	CM	FFF	27E	86E	494A	1038D														
PCWGTO	DMVR	DM	CM	FFF	27E	86E	493A	1038D														
PDES					747A	761C	783C	799A	813C	835C												
PDESH	DMVR	DM			60E	798A	799B															
PDESO	DMVR	DM			60E	746A	747B															
PDLH					2401	798C	9410															
PDLQ					2401	746C	9410															
PENGH	DMVR	DM	CM	FFF	33E	86E	620A	621B	621A	639B	1031D											
PENGO	DMVR	DM	CM	FFF	33E	86E	617A	618B	618A	636B	1031D											
PENHNL	DMVR	DM	CM	DDD	14E	82E	3221	621B	621B	1014D												

STAR DICTIONARY (CONT'D)

PENMND	DMVR	DM	CM	DDD	34E	82E	318I	618B	618B	10140									
PENMUH	DMVR	DM			45E	738A	740B	740B											
PENMUO	DMVR	DM			45E	737A	739B	739B											
PENNUH	DMVR	DM	EQ		45E	65E	715A	738B		13210									
PENNUO	DMVR	DM	EQ		45E	65E	712A	737B		13080									
RENTOL		CM		DDD	82E	273I	636B	639B		9250									
RHDLNH	DMVR	DM			47E	704A	715B	12240											
RHDLNO	DMVR	DM			47E	702A	712B	12240											
PI	DMVR	DM	DA		32E	96A	436B	444B		455B	463B								
PI203		DA			96A														
PMAXH	DMVR	DM			60E	724A	740B	740A		798C									
PMAXO	DMVR	DM			59E	723A	739B	739A		746C									
PNCXGT		CM		EEE	84E	483A	495A	495B		498B									
PPDGH	DMVR	DM	CM	AAA	37E	77E	331I	660B		10140									
PPDGO	DMVR	DM	CM	AAA	37E	77E	329I	656B		10140									
PPVAPH		CM		FFF	88E														
PPVAPO		CM		FFF	88E														
PROXGT	DMVR	DM			42E	496A	10380												
PSVAPH		CM		FFF	88E	650C	651B												
PSVAPO		CM		FFF	88E	647C	648B												
PTBTMH	DMVR	DM			59E	670A	677B	677A		798C									
PTBTMO	DMVR	DM			59E	669A	676B	676A		746C									
PTDENS	FCTN				693B														
PTKATE	DMVR	DM	EQ		47E	65E	675A	677B		677B	715B	12240	12900						
PTKATO	DMVR	DM	EQ		47E	65E	673A	676B		676B	712B	12240	12770						
PULLH	DMVR	DM	EQ		46E	65E	639A	661B		661B	662B	11920							
PULLO	DMVR	DM	EQ		46E	65E	636A	657B		657B	658B	11770							
PULLRH	DMVR	DM	EQ		48E	65E	661A	662A		675B	693C	12240	12590						
PULLRO	DMVR	DM	EQ		48E	65E	657A	658A		673B	687C	689B	12240	12460					
PULMNH	DMVR	DM			48E	660A	661B	662B		662B									
PULMNO	DMVR	DM			48E	656A	657B	658B		658B									
PUVAPH		CM		FFF	88E	651A	660B	12240											
PUVAPO		CM		FFF	88E	648A	656B	12240											
PVAPH		CM		EEE	84E	613C	614B												
PVAPO		CM		EEE	84E	610C	611B												
PVAFOR	SBRT				610B	613B	647B	650B											
PVPENH		CM		EEE	84E	614A	620B												
PVPENO		CM		EEE	84E	611A	617B												
RES					541C	542B	557C	558B		580C	581B	596C	597B						
RHOHY	DMVR	DM	DA		32E	95A	356B	509B		521B	586B	602B	675B	704B					
RHOLHG					693A	694B													
RHOLUG					689A	690B													
RHOX	DMVR	DM	CM DA	CCC	32E	81E	95A	355B		506B	520B	547B	563B	673B	702B				
RHOY		CM		CCC	81E														
ROX					689A	689B													
SPEC					384A	385A	386B	412A		413A	414B								
SP1					539A	541C	555A	557C		578A	580C	594A	596C	756A	757A	757B	761C	779A	783C
SP1ELH	DMVR	DM			808A	809A	809B	813C		831A	835C								
SP1ELO	DMVR	DM			57E	217I	412B	578B		831B	10010								
SP1ELH	DMVR	DM			54E	189I	384B	539B		779B	9840								
SP1ELO	DMVR	DM			56E	207I	413B	594B		808B	9920								
SP2					53E	178I	385B	555B		756B	9740								
SP2ELH	DMVR	DM			540A	541C	556A	557C		579A	580C	595A	596C	758A	761C	780A	783C	810A	813C
SP2ELO	DMVR	DM			832A	835C													
SP2ELH	DMVR	DM			58E	217I	579B	832B		10010									
SP2ELO	DMVR	DM			55E	189I	543B	780B		9840									
SP2ELH	DMVR	DM			56E	207I	595B	810B		9920									
SP2ELO	DMVR	DM			53E	178I	556B	758B		9740									

STAR DICTIONARY (CONT'D)

SPJ					759A	761C	781A	783C	811A	813C	833A	835C							
SP3ELH	DMVR	DM			49E	217I	833B	10010											
SP3ELO	DMVR	DM			49E	189I	781B	9840											
SP3MLH	DMVR	DM			49E	207I	811B	9920											
SP3MLO	DMVR	DM			49E	178I	759B	9740											
ST	DMVR	DM	CM	DDD	39E	82E	109I	9010	10240	10510	10770	10940	11110	11270	11490	11680	11850	12010	
SUM					12370	12520	12680	12830	12990	13140	13290								
					373A	380A	380B	386A	386B	388A	389B	390B	401A	408A	408B	414A	414B	416A	
					416B	418B	748A	762A	762B	765B	770A	784A	784B	787B	789B	800A	814A	814B	
					817B	822A	836A	836B	839B	841B									
SUMH					626A	631A	633B	633B	733A	735B									
SUMI					749A	763A	763B	766B	771A	785A	785B	788B	790B	801A	815A	815B	818B	823A	
					837A	837B	840B	842B											
SUMIT					768A	790A	790B	793B	820A	842A	842B	845B							
SUMMH	DMVR	DM			59E	628A	633B	633A	639B	715B	738B								
SUMMO	DMVR	DM			59E	627A	632B	632A	636B	712B	737B								
SUMNH	DMVR	DM			60E	730A	735B	735A	738B										
SUMNO	DMVR	DM			60E	729A	734B	734A	737B										
SUMO					625A	630A	632B	632B	732A	734B	734B								
SUMT					767A	789A	789B	792B	819A	841A	841B	844B							
SYSNUM		IN	CM	BBB	72E	80E	142I	290B	308B	319B	330B	341B	368B	396B	428B	447B	527B	566B	
					616B	619B	635B	638B	655B	659B	672B	674B	684B	691B	701B	703B	711B	714B	
					745B	797B	907B	967B	987B	1048B	1075B	1092B	1109B	1125B	1147B	1166B	1183B	1235B	
					1250B	1266B	1281B	1297B	1312B	1338B									
TGGHT	DMVR	DM	CM	AAA	35E	78E	342I	692B	10140										
TGGOT	DMVR	DM	CM	AAA	35E	78E	340I	685B	10140										
TENINH	DMVR	DM	CM	DDD	36E	82E	273I	612B	9250										
TENINO	DMVR	DM	CM	DDD	36E	82E	273I	609B	9250										
TIMEA	DMVR	DM	CM	AAA	29E	76E	281I	362B	362B	363B	363B	490B	490B	506B	506B	509B	509B	10140	
					10350	10660	10830	11010	11160	11370	11530	11750	11900	12200	12440	12570	12750	12880	
					13060	13190													
TLIGSH	DMVR	DM	CM	AAA	37E	77E	273I	649B	692B										
TLIGSO	DMVR	DM	CM	AAA	37E	77E	273I	646B	685B										
TMPULH					692A	693C													
TMPULC					685A	687C	689B												
TOTMLH					144I	422B	461B	599B	9630										
TOTMLO					144I	394B	442B	560B	9630										
TSVAPH		CM		AAA	77E	649A	650C												
TSVAPO		CM		AAA	77E	646A	647C												
TVAPH		CM		EEE	84E	612A	613C												
TVAPO		CM		EEE	84E	609A	610C												
ULLHED	SBRT				474B	512B													
ULVH2		CM		GGG	90E														
ULVLH2	DMVR	DM	CM	GGG	38E	91E	514A	694B	12240										
ULVLIH		CM		FFF	89E	476A	9250												
ULVLI0		CM		FFF	89E	475A	9250												
ULVLO2	DMVR	DM	CM	GGG	38E	91E	513A	690B	12240										
ULV02		CM		GGG	90E														
UVLH2		CM		DIMEN	17E	476B	514B												
UVLO2		CM		DIMEN	17E	475B	513B												
VLH2					485A	509A	509B	510B	511B										
VLO2					484A	506A	506B	507B	508B										
VLOH2	DMVR	DM			38E	510A													
VLOG2	DMVR	DM			38E	507A													
VRM42					511A	512C													
VRM02					508A	512C													
VTH2		CM		DIMEN	17E														
VTD1		CM		DIMEN	17E														

Table C-1
STAR DICTIONARY (CONT'D)

VT02		CM		DIMEN	17E														
VWGTCH		CM		EEE	84E	482A	491A	491B	492B										
VWGTN	DMVR	DM	CM	CCC	32E	81E	250I	482B	9180										
VWGTNU	DMVR	DM	CM	FFF	26E	86E	492A	500B	10380										
V1		CM		DIMEN	17E														
V2		CM		DIMEN	17E														
V3		CM		DIMEN	17E														
V4		CM		DIMEN	17E														
V5		CM		DIMEN	17E														
V6		CM		DIMEN	17E														
V7		CM		DIMEN	17E														
W000TH	DMVR	DM	CM	FFF	40E	86E	363A	455B	463B	10380									
W000TO	DMVR	DM	CM	FFF	40E	86E	362A	436B	444B	10380									
W000NH	DMVR	DM	CM	DDD	39E	82E	260I	363B	488B	9180									
W000NO	DMVR	DM	CM	DDD	39E	82E	260I	362B	487B	9180									
W0TFRH	DMVR	DM	CM	AAA	29E	76E	291I	363B	363B	488B	483B	10140							
W0TFR0	DMVR	DM	CM	AAA	29E	76E	289I	362B	362B	487B	487B	10140							
WELH	DMVR	DM	EQ		61E	65E	839A	13450											
WELHT	DMVR	DM	EQ		61E	65E	844A	846B	13450										
WELIH	DMVR	DM			51E	840A													
WELIHT	DMVR	DM			51E	845A	847B	13450											
WELIO	DMVR	DM			50E	788A													
WELIOT	DMVR	DM			50E	793A	795B	13400											
WEL0	DMVR	DM	EQ		62E	65E	787A	13400											
WEL0T	DMVR	DM	EQ		62E	65E	792A	794B	13400										
WGT					761C	762B	783C	784B	813C	814B	835C	836B							
WI					761C	763B	783C	785B	813C	815B	835C	837B							
WLHT	DMVR	DM	EQ		61E	65E	846A	848B											
WLHTT	DMVR	DM			51E	848A	13450												
WLIHT	DMVR	DM			51E	847A	848B												
WLIOT	DMVR	DM			50E	799A	796B												
WLOT	DMVR	DM	EQ		62E	65E	794A	796B											
WLOTT	DMVR	DM			50E	796A	13400												
WMLH	DMVR	DM	EQ		61E	65E	817A	846B	13450										
WMLIH	DMVR	DM			51E	818A	847B	13450											
WMLIO	DMVR	DM			50E	766A	795B	13400											
WML0	DMVR	DM	EQ		62E	65E	765A	794B	13400										
WTCTRL	SBRT				761B	783B	813B	835B											
WTULGH	DMVR	DM	CM	GGG	41E	90E	694A	12240											
WTULGO	DMVR	DM	CM	GGG	41E	90E	690A	12240											
Z					687C	689B													
ZFIND	SBRT				667B														
ZLPACH	DMVR	DM	CM	FFF	42E	86E													
ZLPACC	DMVR	DM	CM	FFF	42E	86E													
ZLPLNH	DMVR	DM	CM	FFF	42E	86E													
ZLPLNO	DMVR	DM	CM	FFF	42E	86E													

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Table C-1

STAR DICTIONARY (CONT'D)

S T A T E M E N T N U M B E R T A B L E

THE FIRST ENTRY FOLLOWING THE STATEMENT NUMBER
IS THE NUMBER OF THE LINE ON WHICH IT WAS DEFINED

THE FLAGS FOLLOWING THE LINE NUMBERS (ON WHICH THE
STATEMENT NUMBER WAS REFERENCED) INDICATE THE NATURE
OF THE REFERENCE

D = DEFINED U = ASSIGNED X = GOTO (UNCNDTNL)
S = FORMAT NUMBER V = DO Y = IF (ARITHMETIC)
T = NONSTNDRD RTN W = GOTO (CNDTNL)

10	109	109D	1353X																	
15	110	109S	110D																	
20	115	113V	115D																	
25	122	121S	122D																	
30	143	142S	143D	176S	205S	351S														
35	150	123X	150D																	
40	157	150X	157D																	
45	184	178S	184D	189S	207S	217S														
50	185	177V	180X	185D																
55	195	188V	191X	195D																
60	196	186V	196D																	
65	200	157X	200D																	
70	213	206V	209X	213D																
75	223	216V	219X	223D																
80	224	214V	224D																	
85	227	200X	227D																	
90	243	227X	243D																	
95	253	243X	253D																	
100	261	144S	155S	197S	225S	240S	250S	260S	261D	273S	281S	289S	291S	299S	307S	309S	318S			
		320S	329S	331S	340S	342S														
105	264	253X	264D																	
110	276	264X	276D																	
115	283	276X	283D																	
120	292	290X	292D																	
125	294	283X	294D																	
130	301	294X	301D																	
135	310	308X	310D																	
140	312	301X	312D																	
145	321	319X	321D																	
150	323	312X	323D																	
155	332	330X	332D																	
160	334	323X	334D																	
165	343	341X	343D																	
170	345	334X	345D																	
175	352	345X	352D																	
180	364	361V	364D																	
185	382	379X	382D																	
190	388	383X	388D																	
195	389	376V	381X	382X	387X	389D														
200	391	372V	391D																	
205	395	393V	395D																	
210	400	368X	400D																	
215	410	407X	410D																	
220	416	411X	416D																	
225	417	404V	409X	410X	415X	417D														
230	419	400V	419D																	
235	423	421V	423D																	
240	427	396X	427D																	
245	429	428W	428W	429D																

Table C-1

STAR DICTIONARY (CONT'D)

250	437	435V	437D	
255	442	431X	442D	
260	445	443V	445D	
265	446	438X	446D	
270	448	428W	448D	
275	456	454V	456D	
280	461	450X	461D	
285	464	462V	464D	
290	465	457X	465D	
295	466	427V	447X	466D
300	471	470V	471D	
305	506	501X	506D	
310	522	486V	522D	
315	528	527W	527W	528D
320	543	537V	543D	
325	548	546V	548D	
330	553	532X	553D	
335	559	553V	559D	
340	564	562V	564D	
345	565	549X	565D	
350	567	527W	567D	
355	582	576V	582D	
360	587	585V	587D	
365	592	571X	592D	
370	598	592V	598D	
375	603	601V	603D	
380	604	588X	604D	
385	605	526V	566X	605D
390	617	616W	616W	617D
395	620	616W	620D	
400	622	615V	619X	622D
405	634	629V	634D	
410	636	635W	635W	636D
415	639	635W	639D	
420	641	624V	638X	641D
425	642	623V	642D	
430	656	655W	655W	656D
435	660	655W	660D	
440	663	654V	659X	663D
445	664	653V	664D	
450	673	672W	672W	673D
455	675	672W	675D	
460	678	671V	674X	678D
465	679	668V	679D	
470	685	684W	684W	685D
475	692	684W	692D	
480	695	691X	695D	
485	696	683V	696D	
490	702	701W	701W	702D
495	704	701W	704D	
500	705	700V	703X	705D
505	712	711W	711W	712D
510	715	711W	715D	
515	717	710V	714X	717D
520	718	709V	718D	
525	736	731V	736D	
530	741	725V	741D	
535	764	751V	764D	

540	786	774V	786D														
545	791	769V	791D														
550	797	745X	797D														
555	816	803V	816D														
560	838	826V	838D														
565	843	821V	843D														
570	849	722V	797X	849D													
575	858	857S	858D														
580	860	859S	860D														
585	880	879S	880D														
590	896	855X	896D														
595	903	902S	903D														
600	906	905S	906D														
605	908	907W	908D														
610	909	908S	909D														
615	911	907W	911D														
620	912	911S	912D														
625	914	907W	914D														
630	915	914S	915D														
635	917	910X	913X	917D													
640	919	918S	919D														
645	927	925S	927D														
650	942	941S	942D														
655	947	946S	947D														
660	949	948S	949D														
665	953	945S	952S	953D	966S	1337S	1343S	1349S									
670	955	954S	955D														
675	963	960X	963D														
680	964	961S	963S	964D													
685	965	959V	962X	965D													
695	969	968S	969D														
700	971	970S	971D	982S	990S	999S											
705	974	973V	974D														
710	976	974S	976D	984S	992S	1001S											
715	980	979S	980D														
720	984	983V	984D														
725	986	977V	986D														
730	987	967X	967D														
735	989	988S	989D														
740	992	991V	992D														
745	997	996S	997D														
750	1001	1000V	1001D														
755	1003	994V	1003D														
760	1004	987X	1004D														
765	1007	1006S	1007D														
770	1010	1009S	1010D														
775	1016	1014S	1016D														
780	1018	1013V	1018D														
785	1023	900S	944S	1005S	1022S	1023D	1200S										
790	1025	901S	1024S	1025D	1201S												
795	1027	1026S	1027D														
800	1031	1030S	1031D														
805	1036	1035S	1036D														
810	1040	1038S	1040D														
815	1042	1037X	1042D														
820	1043	1034V	1043D														
825	1049	1048W	1048W	1049D													
830	1050	1049S	1050D	1076S	1093S	1110S	1126S	1148S	1167S	1184S	1236S	1251S	1267S	1282S	1293S	1313S	1328S

Table C-1
STAR DICTIONARY (CONT'D)

Table C-1

STAR DICTIONARY (CONT'D)

		1356S														
835	1092	1051S	1052D	1094S	1168S	1237S	1268S	1299S								
840	1054	1053S	1054D	1079S												
845	1056	1055S	1056D	1080S	1098S	1113S	1172S	1187S	1241S	1254S	1272S	1285S	1303S	1316S		
850	1061	1060S	1061D	1081S	1099S	1114S	1173S	1188S	1242S	1255S	1273S	1286S	1304S	1317S		
855	1067	1066S	1067D	1083S	1101S	1116S	1137S	1153S	1175S	1190S	1244S	1257S	1275S	1288S	1306S	1319S
860	1070	1069S	1070D	1085S												
865	1072	1068X	1072D													
870	1073	1065V	1073D													
875	1074	1048W	1074D													
880	1078	1077S	1078D	1111S	1185S	1252S	1283S	1314S								
885	1086	1084X	1086D													
890	1087	1082V	1087D													
895	1088	1075X	1088D													
900	1093	1092W	1092W	1093D												
905	1096	1095S	1096D	1112S												
910	1104	1103S	1104D	1118S												
915	1106	1102X	1106D													
920	1107	1100V	1107D													
925	1108	1092W	1108D													
930	1119	1117X	1119D													
935	1120	1115V	1120D													
940	1121	1109X	1121D													
945	1128	1127S	1128D													
950	1130	1129S	1130D	1151S												
955	1143	1140V	1143D													
960	1144	1139X	1144D													
965	1145	1144S	1145D	1160S												
970	1146	1136V	1138X	1146D												
975	1148	1125X	1148D													
980	1150	1149S	1150D													
985	1159	1156V	1159D													
990	1160	1155X	1160D													
995	1161	1152V	1154X	1161D												
1000	1162	1147X	1162D													
1005	1167	1166W	1166W	1167D												
1010	1170	1169S	1170D	1166S												
1015	1178	1177S	1178D	1192S	1246S	1259S	1277S	1290S	1308S	1321S						
1020	1180	1176X	1180D													
1025	1181	1174V	1181D													
1030	1182	1166W	1182D													
1035	1193	1191X	1193D													
1040	1194	1189V	1194D													
1045	1195	1183X	1195D													
1050	1203	1202S	1203D													
1055	1207	1206S	1207D													
1060	1212	1211S	1212D													
1065	1216	1215S	1216D													
1070	1221	1220S	1221D													
1075	1227	1224S	1227D													
1080	1230	1222X	1230D													
1085	1231	1219V	1231D													
1090	1236	1235W	1235W	1236D												
1095	1239	1238S	1239D	1253S												
1100	1247	1245X	1247D													
1105	1248	1243V	1248D													
1110	1249	1235W	1249D													
1115	1260	1253X	1260D													

Table C-1
 STAR DICTIONARY (CONT'D)

1120	1261	1256V	1261D
1125	1262	1250X	1262D
1130	1267	1266W	1266W 1267D
1135	1270	1269S	1270U 1284S
1140	1278	1276X	1278D
1145	1279	1274V	1279D
1150	1280	1266W	1280D
1155	1291	1289X	1291D
1160	1292	1287V	1292D
1165	1293	1281X	1293D
1170	1298	1297W	1297W 1298D
1175	1301	1300S	1301D 1315S
1180	1309	1307X	1309D
1185	1310	1305V	1310D
1190	1311	1297W	1311D
1195	1322	1320X	1322D
1200	1323	1318V	1323D
1205	1324	1312X	1324D
1210	1330	1329S	1330D
1215	1342	1339V	1342D
1220	1344	1338X	1344D
1225	1347	1344V	1347D
1230	1348	1340S	1345S 1348D
1235	1351	1350S	1351D
1245	1358	1357S	1358D

Table C-1

STAR DICTIONARY (CONT'D)

TRANSFER TABLE

ONLY THOSE ENTITIES WHICH ARE REFERENCED ARE PRINTED OUT, THE COMPLETE LIST FOLLOWS

DO	GOTO (UNCONDITIONAL)			CALL							RETURN (NON-STANDARD)				INPUT	STOP					
IF (LOGICAL)	GOTO (ARITHMETIC)			FUNCTION REFERENCE							ASSIGN	OUTPUT	INTERNAL SUBPROGRAM								
IF (ARITHMETIC)	GOTO (CONDITIONAL)			RETURN (STANDARD)							TAPES										
DO	113	177	186	188	206	214	216	361	372	376	393	400	404	421	427	435	443	454	462	470	486
	526	537	546	553	562	576	585	592	601	615	623	624	629	653	654	668	671	683	700	709	710
	722	725	731	751	769	774	803	821	826	959	973	977	983	991	994	1000	1013	1034	1065	1082	1100
IF(L)	1115	1136	1140	1152	1156	1174	1189	1219	1243	1256	1274	1287	1305	1318	1339	1344					
	123	150	157	180	191	200	209	219	227	243	253	264	276	283	290	294	301	308	312	319	323
	330	334	341	345	368	374	375	377	378	379	382	383	384	385	396	402	403	405	406	407	410
	411	412	413	431	447	450	501	502	532	566	571	618	619	621	632	633	638	657	658	659	661
	662	674	676	677	691	703	714	734	735	739	740	745	757	760	782	797	809	812	834	855	960
	967	987	1037	1068	1075	1084	1102	1109	1117	1125	1138	1139	1147	1154	1155	1176	1183	1191	1222	1245	1250
GOTO(UC)	1258	1276	1281	1289	1307	1312	1320	1338	1353												
	123	150	157	180	191	200	209	219	227	243	253	264	276	283	290	294	301	308	312	319	323
	330	334	341	345	368	379	381	382	383	387	396	407	409	410	411	415	431	438	447	450	457
	501	532	549	566	571	588	619	638	659	674	691	703	714	745	797	855	910	913	960	962	967
	987	1037	1068	1075	1084	1102	1109	1117	1125	1138	1139	1147	1154	1155	1176	1183	1191	1222	1245	1250	1258
GOTO(C)	1276	1281	1289	1307	1312	1320	1338	1353													
CALL	428	527	616	635	655	672	684	701	711	907	1048	1092	1166	1235	1266	1297					
FCT REF	98	472	474	512	541	557	580	596	610	613	647	650	687	761	783	813	835	1359			
INPUT	688	693	746	798																	
	109	121	142	144	155	176	178	189	197	205	207	217	225	240	250	260	273	281	289	291	299
OUTPUT	307	309	318	320	329	331	340	342	351												
	857	859	879	900	901	902	905	908	911	914	918	925	941	944	945	946	948	952	954	961	963
	966	968	970	974	979	982	984	988	990	992	996	999	1001	1005	1006	1009	1014	1022	1024	1026	1030
	1035	1038	1049	1051	1053	1055	1060	1066	1069	1076	1077	1079	1080	1081	1083	1085	1093	1094	1095	1098	1099
	1101	1103	1110	1111	1112	1113	1114	1116	1118	1126	1127	1129	1137	1144	1148	1149	1151	1153	1167	1167	1168
	1169	1172	1173	1175	1177	1184	1185	1186	1187	1168	1190	1192	1200	1201	1202	1206	1211	1213	1220	1224	1236
	1237	1238	1241	1242	1244	1246	1251	1252	1253	1254	1255	1257	1259	1267	1268	1269	1272	1273	1275	1277	1282
	1283	1284	1285	1286	1288	1290	1298	1299	1300	1303	1304	1306	1308	1313	1314	1315	1316	1317	1319	1321	1328
	1329	1337	1340	1343	1345	1349	1350	1356	1357												

Table C-2

INIVOL DICTIONARY

THE FIRST FLAG INDICATES THE NATURE OF THE ALPHABETIC ENTITY

- UNDIMENSIONED VARIABLE
- DMVR ▪ DIMENSIONED VARIABLE
- FCTN ▪ FUNCTION NAME
- LBCM ▪ NAME OF LABELED COMMON
- SBRT ▪ SUBROUTINE NAME
- SWVR ▪ SWITCH VARIABLE
- NMLT ▪ NAMELIST NAME

VARIABLE TABLE
THE FOLLOWING TWO CHARACTER FLAGS INDICATE THAT THE ENTITY IS IN THE CORRESPONDING TYPE OF STATEMENT

- AB ▪ ABNORMAL
- CM ▪ COMMON
- CP ▪ COMPLEX
- DA ▪ DATA
- DM ▪ DIMENSION
- DP ▪ D3L PRECISN
- EQ ▪ EQUIVALENCE
- EX ▪ EXTERNAL
- FA ▪ FORML AGUMT
- IN ▪ INTEGER
- LG ▪ LOGICAL
- PR ▪ PARAMETER
- RL ▪ REAL
- NL ▪ NAMELIST

THE FLAGS FOLLOWING THE LINE NUMBERS (ON WHICH THE ENTITY WAS REFERENCED) INDICATE THE NATURE OF THE REFERENCE

- A ▪ SET EQUAL, DEFINED, ASSIGNED
- B ▪ REFERENCED, CALLED
- C ▪ CALLING SEQUENCE
- D ▪ SUBSCRIPT
- E ▪ SPECIFICATION
- J ▪ DO PARAMETER
- H ▪ I-O UNIT
- I ▪ READ
- O ▪ WRITE
- L ▪ LIST

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ADOME	CM	DIMEN	12E	46A														
ARACYL	FCTN		25B	34B														
AREAFR	FCTN		22B															
ARSPHR	FCTN		19B	28B	37B													
ASKIN	CM	DIMEN	12E	45A														
ATOT	CM	DIMEN	12E	44A	45B													
A1	CM	DIMEN	12E	19A	44B													
A2	CM	DIMEN	12E	22A	44B													
A3	CM	DIMEN	12E	25A	44B													
A4	CM	DIMEN	12E	28A	44B	45B	46B											
A6	CM	DIMEN	12E	34A	44B													
A7	CM	DIMEN	12E	37A	44B													
CYLNDR	FCTN		24B	33B														
CYLSPH	FCTN		31B															
DIMEN	LBCM	CM	12E															
EQLR	DMVR	CM	12E															
FRONE	FCTN		21B															
H2H2	CM	DIMEN	12E															
H002	CM	DIMEN	12E															
HSPHER	FCTN		18B	27B	36B													
INIVOL	SBRT		2A															
L1	RL		10E	21C	22C													
L2	RL		10E	21C	22C	24C	25C											
L3	RL		10E	24C	25C	33C	34C											
L4	RL		10E	33C	34C													
R1			18C	19C														
R2			18C	19C	21C	22C												
R3			27C	28C	31C	33C												
R4			21C	22C	24C	25C	27C	28C	31C	33C	34C	36C	37C					
R5			36C	37C														
UVLH2	CM	DIMEN	12E															
UVLO2	CM	DIMEN	12E															
VTH2	CM	DIMEN	12E	41A	43B													
VTOT	CM	DIMEN	12E	43A														
VT02	CM	DIMEN	12E	39A	43B													
V1	CM	DIMEN	12E	18A	39B													
V2	CM	DIMEN	12E	21A	39B													
V3	CM	DIMEN	12E	24A	39B													
V4	CM	DIMEN	12E	27A	39B													
V5	CM	DIMEN	12E	31A	41B													
V6	CM	DIMEN	12E	33A	41B													
V7	CM	DIMEN	12E	36A	41B													

Table C-2
INIVOL DICTIONARY

T R A N S F E R T A B L E													
ONLY THOSE ENTITIES WHICH ARE REFERENCED ARE PRINTED OUT, THE COMPLETE LIST FOLLOWS													
DO	GOTO (UNCONDITIONAL)	CALL	RETURN (NON-STANDARD)	INPUT	STOP								
IF (LOGICAL)	GOTO (ARITHMETIC)	FUNCTION REFERENCE	ASSIGN	OUTPUT	INTERNAL SUBPROGRAM								
IF (ARITHMETIC)	GOTO (CONDITIONAL)	RETURN (STANDARD)	TAPES										
FCT REF	18	19	21	22	24	25	27	28	31	33	34	36	37
RTRN(S)	47												
SUB PROG	2												

ULLHED DICTIONARY

THE FIRST FLAG INDICATES THE NATURE OF THE ALPHABETIC ENTITY

- ◻ UNDIMENSIONED VARIABLE
- DMVR = DIMENSIONED VARIABLE
- FCTN = FUNCTION NAME
- LBCM = NAME OF LABELED COMMON
- SBRT = SUBROUTINE NAME
- SWVR = SWITCH VARIABLE
- NMLT = NAMELIST NAME

VARIABLE TABLE

THE FOLLOWING TWO CHARACTER FLAGS INDICATE THAT THE ENTITY IS IN THE CORRESPONDING TYPE OF STATEMENT

- AB = ABNORMAL
- CM = COMMON
- CP = COMPLEX
- DA = DATA
- DM = DIMENSION
- DP = D3L PRECISN
- EQ = EQUIVALENCE
- EX = EXTERNAL
- FA = FORML AGUMT
- IN = INTEGER
- LG = LOGICAL
- PR = PARAMETER
- RL = REAL
- NL = NAMELIST

THE FLAGS FOLLOWING THE LINE NUMBERS (ON WHICH THE ENTITY WAS REFERENCED) INDICATE THE NATURE OF THE REFERENCE

- A = SET EQUAL, DEFINED, ASSIGNED
- B = REFERENCED, CALLED
- C = CALLING SEQUENCE
- D = SUBSCRIPT
- E = SPECIFICATION
- J = DO. PARAMETER
- H = I-O UNIT
- I = READ
- O = WRITE
- L = LIST

ADOME	CM	DIMEN	8E																	
ASKIN	CM	DIMEN	8E																	
ATOT	CM	DIMEN	8E																	
A1	CM	DIMEN	8E																	
A2	CM	DIMEN	8E																	
A3	CM	DIMEN	8E																	
A4	CM	DIMEN	8E																	
A6	CM	DIMEN	8E																	
A7	CM	DIMEN	8E																	
CYMSPH	SBRT		58B																	
DIMEN	LBCM	CM	8E																	
ELIPSG	SBRT		27B	42B	50B															
EGLR	DMVR	CM	8E																	
H			42C	43B	58C	59B														
H0H2	CM	DIMEN	8E	50C	54A	59A														
H002	CM	DIMEN	8E	27C	31A	38A	39A	39B	43A											
HL			35A	37B	38B	38B														
IOT			23H	46H																
L1	RL		6E	35B	43B															
L2	RL		6E	35B	39B															
L3	RL		6E	39B	43B	59B														
L4	RL		6E	59B																
PI			31B	37B	38B	38B	38B	54B												
R1			42C	43B																
R2			36B	42C																
R3			27C	31B	39B	43B	58C	59B												
R4			27C	31B	31B	36B	37B	37B	37B	38B	50C	54B	54B	58C						
R42			36A	37B	38B	38B														
R5			50C	54B	59B															
ULLHED	SBRT		2A																	
UVLH2	CM	DIMEN	8E	45A	46B															
UVL02	CM	DIMEN	8E	22A	23B	42C														
VD			37A	38B																
VHP			57A	58C																
VLH2	FA		2A	45B	49B	50C	52B	54B	57B											
VL02	FA		2A	22B	26B	27C	30B	31B	34B	37B										
VTH2	CM	DIMEN	8E	45B																
VTOT	CM	DIMEN	8E																	
VT02	CM	DIMEN	8E	22B																
V1	CM	DIMEN	8E																	
V2	CM	DIMEN	8E	34B																
V3	CM	DIMEN	8E	30B	34B	37B														
V4	CM	DIMEN	8E	26B	30B	31B	34B	37B												
V5	CM	DIMEN	8E																	
V6	CM	DIMEN	8E	52B	57B															

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Table C-3
ULLHED DICTIONARY (CONT'D)

V7	CM	DIMEN	BE	49B	52B	54B	57B
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Table C-3
 LOCKHEED DICTIONARY (CONT'D)

S T A T E M E N T N U M B E R T A B L E

THE FIRST ENTRY FOLLOWING THE STATEMENT NUMBER THE FLAGS FOLLOWING THE LINE NUMBERS (ON WHICH THE
 IS THE NUMBER OF THE LINE ON WHICH IT WAS DEFINED STATEMENT NUMBER WAS REFERENCED) INDICATE THE NATURE
 OF THE REFERENCE

D = DEFINED U = ASSIGNED X = GOTO (UNCONDNL)
 S = FORMAT NUMBER V = DO Y = IF (ARITHMETIC)
 T = NONSTNRD RTN W = GOTO (CONDNL)

10	18	18D	23S	46S	
15	27	26Y	27D		
20	30	26Y	26Y	30D	
25	31	30Y	30Y	31D	
30	34	30Y	34D		
35	35	34Y	34Y	35D	
40	42	34Y	42D		
45	45	28X	32X	40X	45D
50	50	49Y	50D		
55	52	49Y	49Y	52D	
60	54	52Y	52Y	54D	
65	57	52Y	57D		
70	60	51X	55X	60D	

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Table C-3
 ULLHED DICTIONARY (CONT'D)

T R A N S F E R T A B L E

ONLY THOSE ENTITIES WHICH ARE REFERENCED ARE PRINTED OUT, THE COMPLETE LIST FOLLOWS

DO	GOTO (UNCONDITIONAL)	CALL	RETURN (NON-STANDARD)	INPUT	STOP
IF (LOGICAL)	GOTO (ARITHMETIC)	FUNCTION REFERENCE	ASSIGN	OUTPUT	INTERNAL SUBPROGRAM
IF (ARITHMETIC)	GOTO (CONDITIONAL)	RETURN (STANDARD)	TAPES		

IF(L)	23	46			
IF(A)	26	30	34	49	52
GOTO(UC)	28	32	40	51	55
CALL	27	42	50	58	
RTRN(S)	61				
OUTPUT	23	46			
SUB PROC	2				

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Table C-4

FLORES DICTIONARY

VARIABLE TABLE

THE FIRST FLAG INDICATES THE NATURE OF THE ALPHABETIC ENTITY

- DMVR * DIMENSIONED VARIABLE
- FCTN * FUNCTION NAME
- LBCM * NAME OF LABELED COMMON
- SBRT * SUBROUTINE NAME
- SWVR * SWITCH VARIABLE
- NMLT * NAMELIST NAME

THE FOLLOWING TWO CHARACTER FLAGS INDICATE THAT THE ENTITY IS IN THE CORRESPONDING TYPE OF STATEMENT

- AB * ABNORMAL
- CM * COMMON
- CP * COMPLEX
- DA * DATA
- DM * DIMENSION
- DP * DBL. PRECISN.
- EQ * EQUIVALENCE
- EX * EXTERNAL
- FA * FORML AGUMT
- IN * INTEGER
- LG * LOGICAL
- PR * PARAMETER
- RL * REAL
- NL * NAMELIST

THE FLAGS FOLLOWING THE LINE NUMBERS (ON WHICH THE ENTITY WAS REFERENCED) INDICATE THE NATURE OF THE REFERENCE

- A * SET EQUAL, DEFINED, ASSIGNED
- B * REFERENCED, CALLED
- C * CALLING SEQUENCE
- D * SUBSCRIPT
- E * SPECIFICATION
- J * DO. PARAMETER
- H * I-O UNIT
- I * READ
- O * WRITE
- L * LIST

ABS	FCTN	20B																
ARG		56A	57C	68A	69C													
ATAN	FCTN	57B	69B															
BLOD		40A	41B	45B														
C		6A	17B	57B	69B													
CK		59A	62A	64A	65B													
D	FA	1A	7B	55A	55B	68B	97B	100B	103B	109B	112B	115B						
DIF		44A	46B															
DIFL		45A	46B															
FLORES	SBRT	1A																
ID	FA	1A	8B															
P		7A	19B	33B	34B	38B	39B	40B	50B	51B	56B							
PI		5A	32B	37B	49B													
RES	FA	1A	11A	14A	21A	24A	27A	29A	33A	34A	34B	42A	46A	54A	65A			
		65B	71A	74A	76A	81A	89A	94A	97A	100A	103A	106A	109A	112A	115A			
RESLDO		38A	44B	46B	50A													
RESLDB		39A	42B	44B	51A													
RES9D		19A	21B	24B	27B	29B												
SL		32A	34B	37A	40B	49A												
S1	FA	1A	17B	32B	37B	49B	56B	63B	84A	84B								
S2	FA	1A	17B	19B	32B	33B	37B	39B	39B	49B	50B	51B	54B	56B	66B			
		76B																
TEST		18A	20C	23B														
THETA		17A	18B	24B	26B	27B	29B	57A	58B	59B	61B	62B	69A	70B	73B			

Table C-4

FLORES DICTIONARY (CONT'D)

STATEMENT NUMBER TABLE

THE FIRST ENTRY FOLLOWING THE STATEMENT NUMBER
IS THE NUMBER OF THE LINE ON WHICH IT WAS DEFINED

THE FLAGS FOLLOWING THE LINE NUMBERS (ON WHICH THE
STATEMENT NUMBER WAS REFERENCED) INDICATE THE NATURE
OF THE REFERENCE

D = DEFINED U = ASSIGNED X = GOTO (UNCNDTNL)
S = FORMAT NUMBER V = DO Y = IF (ARITHMETIC)
T = NONSTNDRD RTN W = GOTO (CNDTNL)

10	11	8W	110	
15	14	8W	140	
20	17	8W	170	
25	23	20X	230	
30	26	23X	260	
33	29	26X	290	
40	32	8W	320	
45	37	8W	370	
50	40	40D	52X	
55	44	41X	440	
60	49	8W	490	
65	54	8W	540	85X
70	61	58X	610	
75	64	61X	640	
80	65	60X	63X	65D
83	68	8W	680	
90	73	70X	730	
95	76	73X	760	
100	79	8W	790	
105	80	79S	800	
110	84	8W	840	
115	87	8W	870	
120	88	87S	880	
125	92	8W	920	
130	93	92S	930	
135	97	8W	8W	97D
140	100	8W	1000	
145	103	8W	8W	8W 103D
150	106	8W	1060	
155	109	8W	8W	109D
160	112	8W	1120	
165	115	8W	1150	

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Table C-4
FLORES DICTIONARY (CONT'D)

T R A N S F E R T A B L E

ONLY THOSE ENTITIES WHICH ARE REFERENCED ARE PRINTED OUT, THE COMPLETE LIST FOLLOWS

	DO	IF (LOGICAL)	IF (ARITHMETIC)	GOTO (UNCONDITIONAL)	GOTO (ARITHMETIC)	GOTO (CONDITIONAL)	CALL	FUNCTION REFERENCE	RETURN (STANDARD)	RETURN (NON-STANDARD)	ASSIGN	TAPES	INPUT	STOP
													OUTPUT	INTERNAL SUBPROGRAM
IF(L)	20	23	26	41	58	61	70	73						
GOTO(UC)	20	23	26	41	52	58	60	61	63	70	73	85		
GOTO(C)	8													
FCT REF	20	57	69											
RTRN(S)	12	15	22	25	28	30	35	43	47	66	72	75	77	82
	90	95	98	101	104	107	110							
	113	116												
OUTPUT	79	87	92											
SUB PROG	1													

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Table C-5
PVAPOR DICTIONARY

THE FIRST FLAG INDICATES THE NATURE OF THE ALPHABETIC ENTITY

- UNDIMENSIONED VARIABLE
- DMVR ▪ DIMENSIONED VARIABLE
- FCTN ▪ FUNCTION NAME
- LBCM ▪ NAME OF LABELED COMMON
- SBRT ▪ SUBROUTINE NAME
- SWVR ▪ SWITCH VARIABLE
- NMLT ▪ NAMED LIST NAME

VARIABLE TABLE

THE FOLLOWING TWO CHARACTER FLAGS INDICATE THAT THE ENTITY IS IN THE CORRESPONDING TYPE OF STATEMENT

- AB ▪ ABNORMAL
- CM ▪ COMMON
- CP ▪ COMPLEX
- DA ▪ DATA
- DM ▪ DIMENSION
- DP ▪ DBL PRECISN
- EQ ▪ EQUIVALENCE
- EX ▪ EXTERNAL
- FA ▪ FORML AGUMT
- IN ▪ INTEGER
- LG ▪ LOGICAL
- PR ▪ PARAMETER
- RL ▪ REAL
- NL ▪ NAMED LIST

THE FLAGS FOLLOWING THE LINE NUMBERS (ON WHICH THE ENTITY WAS REFERENCED) INDICATE THE NATURE OF THE REFERENCE

- A ▪ SET EQUAL, DEFINED, ASSIGNED
- B ▪ REFERENCED, CALLED
- C ▪ CALLING SEQUENCE
- D ▪ SUBSCRIPT
- E ▪ SPECIFICATION
- J ▪ DO PARAMETER
- H ▪ I-O UNIT
- I ▪ READ
- O ▪ WRITE
- L ▪ LIST

EXP	FCTN		3B	7B	8B	10B	10B	11B	11B	13B	17B	19B	21B	23B		
I		FA	1A	2B												
P		FA	1A	3A	5A	7A	8B	8A	10A	11B	11A	13A	15A	17A	19A	21A
			23A	26A	29A											
			25A	26B	28A	29B										
			1A													
PLOGMM			1A	3C	5B	5B	7C	8C	10C	10C	11C	11C	13C	15B	17C	19C
PVAPOR	SBRT		21C	23C	25B	28B										
T		FA														

Table C-5
 PVAPOR DICTIONARY (CONT'D)

S T A T E M E N T N U M B E R T A B L E					
THE FIRST ENTRY FOLLOWING THE STATEMENT NUMBER IS THE NUMBER OF THE LINE ON WHICH IT WAS DEFINED		THE FLAGS FOLLOWING THE LINE NUMBERS (ON WHICH THE STATEMENT NUMBER WAS REFERENCED) INDICATE THE NATURE OF THE REFERENCE			
		D = DEFINED	U = ASSIGNED	X = GOTO (UNCONDNL)	
		S = FORMAT NUMBER	V = DO	Y = IF (ARITHMETIC)	
		T = NONSTDRD RTN	W = GOTO (CONDNL)		
10	3	2W	3D		
15	5	2W	2W	5D	
20	7	2W	2W	7D	
25	10	2W	10D		
30	13	2W	2W	13D	
35	15	2W	2W	15D	
40	17	2W	17D		
45	19	2W	19D		
50	21	2W	21D		
55	23	2W	23D		
60	25	2W	25D		
65	28	2W	28D		

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Table C-5
PVAPOR DICTIONARY (CONT'D)

T R A N S F E R T A B L E

ONLY THOSE ENTITIES WHICH ARE REFERENCED ARE PRINTED OUT, THE COMPLETE LIST FOLLOWS

DO	GOTO (UNCONDITIONAL)	CALL	RETURN (NON-STANDARD)	INPUT	STOP
IF (LOGICAL)	GOTO (ARITHMETIC)	FUNCTION REFERENCE	ASSIGN	OUTPUT	
IF (ARITHMETIC)	GOTO (CONDITIONAL)	RETURN (STANDARD)	TAPES	INTERNAL SUBPROGRAM	

IF(L)	8	11										
GOTO(C)	2											
FCT REF	3	7	8	10	10	11	11	13	17	19	21	23
RTRN(S)	4	6	9	12	14	16	18	20	22	24	27	30
SUB PROG	1											

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Table C-6

ZFIND DICTIONARY

THE FIRST FLAG INDICATES THE NATURE OF THE ALPHABETIC ENTITY		VARIABLE TABLE										THE FLAGS FOLLOWING THE LINE NUMBERS (ON WHICH THE ENTITY WAS REFERENCED) INDICATE THE NATURE OF THE REFERENCE										
= UNDIMENSIONED VARIABLE		CORRESPONDING TYPE OF STATEMENT										INDICATE THE NATURE OF THE REFERENCE										
DMVR = DIMENSIONED VARIABLE	FCTN = FUNCTION NAME	AB = ABNORMAL	CM = COMMON	CP = COMPLEX	DA = DATA	DM = DIMENSION	DP = DBL PRECISN	EQ = EQUIVALENCE	EX = EXTERNAL	FA = FORML AGUMT	IN = INTEGER	LG = LOGICAL	PR = PARAMETER	RL = REAL	NL = NAMELIST	A = SET EQUAL, DEFINED, ASSIGNED	B = REFERENCED, CALLED	C = CALLING SEQUENCE	H = I-O UNIT	I = READ	O = WRITE	L = LIST
A	DMVR DM DA DA DA **	3E	16A	18A	20A	22A	24A	26A	28A	30A	32A	34A	36A	38A	40A							
ABS	FCTN	42A	44A	46A	102B	102B	102B	102B	102B	102B												
AS		54B	66B																			
BS		59A	65B	68B																		
DELTA		60A	65B	65B	68B	68B	68B	68B	68B													
F		78A	80B																			
FACTOR		63A	66B	72A	72B																	
G	DMVR DM DA DA DA	79A	80B	81A	81B																	
I		2E	7A	9A	11A	57B	59B	59B	59B	59B	60B	60B	60B	65B	68B							
IN		7D	7L	9D	9L	11D	11L															
J		61A	70A	70B	74B																	
K		16D	16L	18D	18L	20D	20L	22D	22L	24D	24L	26D	26L	28D	28L							
N	FA	30D	30L	32D	32L	34D	34L	36D	36L	38D	38L	40D	40L	42D	42L							
N2		44D	44L	46D	46L																	
OLDV		4D	4L																			
P	FA	1A	48B	50D	50D	52C	57D	59B	58B	59D	59D	59D	59D	60D	60D							
PTDENS FCTN		60D	65D	68D	88D	102D	102D	102D	102D	102D	102D	102D	102D									
PVAPOR SBRT		62A	71A	71B	72B	73B	73A															
S	DMVR DM DA	77A	80B																			
TS	DMVR DM DA	1A	53B	57B	65B	88D	95C															
TRY		2E	13A	88D																		
TRYP		1A	49B	49B	50B	50B	52C	57B	65B	65B	68B	68B	88D	94B	102B							
Y	FA	102B	102B	102B	102B	102B	102B	102B														
VF		53A	54C																			
Y		52C	53B																			
YP		3E	4A	50B	50B																	
ZFIND SBRT		94A	95C																			
V	FA	1A	64A	65B	65B	65B	68B	63B	68B	68B	68B	68B	68B	68B	72A	75B						
VF		76B	77B	80A	82B	88D	92A	92A	96A	96B	97A	97B	99A	102A								
Y		57A	64B	83D	92B	97B																
YP		65A	66C	75B	77B	78B																
ZFIND SBRT		68A	75B	77B	78B																	
ZFIND SBRT		1A																				

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Table C-6
ZFIND DICTIONARY (CONT'D)

STATEMENT NUMBER		TABLE	
THE FIRST ENTRY FOLLOWING THE STATEMENT NUMBER IS THE NUMBER OF THE LINE ON WHICH IT WAS DEFINED		THE FLAGS FOLLOWING THE LINE NUMBERS (ON WHICH THE STATEMENT NUMBER WAS REFERENCED) INDICATE THE NATURE OF THE REFERENCE	
		D = DEFINED	U = ASSIGNED
		S = FORMAT NUMBER	V = DO
		T = NONSTNDRD RTN	W = GOTO (CNDTNL)
		X = GOTO (UNCNDTNL)	Y = IF (ARITHMETIC)
10	55	48X	50X
15	65	65D	84X
20	80	80D	82X
25	83	76X	83D
30	85	66X	85D
35	87	74X	87D
40	89	88S	89D
45	94	58X	94D
50	97	86X	93X
55	99	49X	99D
60	101	54X	101D

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Table C-6
ZFIND DICTIONARY (CONT'D)

T R A N S F E R T A B L E

ONLY THOSE ENTITIES WHICH ARE REFERENCED ARE PRINTED OUT, THE COMPLETE LIST FOLLOWS

DO	GOTO (UNCONDITIONAL)	CALL	RETURN (NON-STANDARD)	INPUT	STOP
IF (LOGICAL)	GOTO (ARITHMETIC)	FUNCTION REFERENCE	ASSIGN	OUTPUT	
IF (ARITHMETIC)	GOTO (CONDITIONAL)	RETURN (STANDARD)	TAPES	INTERNAL SUBPROGRAM	

IF(L)	48	49	50	54	58	66	72	73	74	76	82	
GOTO(UC)	48	49	50	54	58	66	74	76	82	84	86	93
CALL	52											
FCT REF	54	66	95									
RTRN(S)	98	100	103									
OUTPUT	88											
SUB PROG	1											

0ASC, A XREF *XREF, 040090000200
 FAC WARNING

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Table C-7
 FINDR DICTIONARY

THE FIRST FLAG INDICATES THE NATURE OF THE ALPHABETIC ENTITY		VARIABLE TABLE		THE FLAGS FOLLOWING THE LINE NUMBERS (ON WHICH THE ENTITY WAS REFERENCED) INDICATE THE NATURE OF THE REFERENCE	
DMVR	= DIMENSIONED VARIABLE	AB	= ABNORMAL	EX	= EXTERNAL
FCTN	= FUNCTION NAME	CM	= COMMON	FA	= FORML AGUMT
LBCM	= NAME OF LABELED COMMON	CP	= COMPLEX	IN	= INTEGER
SBRT	= SUBROUTINE NAME	DA	= DATA	LG	= LOGICAL
SWVR	= SWITCH VARIABLE	DM	= DIMENSION	PR	= PARAMETER
NMLT	= NAMELIST NAME	DP	= DBL PRECISN	RL	= REAL
		EQ	= EQUIVALENCE	NL	= NAMELIST

FINDR	FCTN	DM	DA	1A	5A
G	DMVR			2E	3A 5B
Z		FA		1A	5D

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Table C-7
 FINDR DICTIONARY (CONT'D)

T R A N S F E R T A B L E					
ONLY THOSE ENTITIES WHICH ARE REFERENCED ARE PRINTED OUT, THE COMPLETE LIST FOLLOWS					
				INPUT	STOP
				OUTPUT	INTERNAL SUBPROGRAM
DO	GOTO (UNCONDITIONAL)	CALL	RETURN (NON-STANDARD)		
IF (LOGICAL)	GOTO (ARITHMETIC)	FUNCTION REFERENCE	ASSIGN		
IF (ARITHMETIC)	GOTO (CONDITIONAL)	RETURN (STANDARD)	TAPES		
RTRN(S)	6				
SUB PROG	1				

PTDENS DICTIONARY

THE FIRST FLAG INDICATES THE NATURE OF THE ALPHABETIC ENTITY

- = UNDIMENSIONED VARIABLE
- DMVR = DIMENSIONED VARIABLE
- FCTN = FUNCTION NAME
- LBGM = NAME OF LABELED COMMON
- SBRT = SUBROUTINE NAME
- SWVR = SWITCH VARIABLE
- NMLT = NAMELIST NAME

VARIABLE TABLE
THE FOLLOWING TWO CHARACTER FLAGS INDICATE THAT THE ENTITY IS IN THE CORRESPONDING TYPE OF STATEMENT

- AB = ABNORMAL
- CM = COMMON
- CP = COMPLEX
- DA = DATA
- DM = DIMENSION
- DP = DBL PRECISION
- EQ = EQUIVALENCE
- EX = EXTERNAL
- FA = FORML ARGUMT
- IN = INTEGER
- LG = LOGICAL
- PR = PARAMETER
- RL = REAL
- NL = NAMELIST

THE FLAGS FOLLOWING THE LINE NUMBERS (ON WHICH THE ENTITY WAS REFERENCED) INDICATE THE NATURE OF THE REFERENCE

- A = SET EQUAL, DEFINED, ASSIGNED
- B = REFERENCED, CALLED
- C = CALLING SEQUENCE
- D = SUBSCRIPT
- E = SPECIFICATION
- J = DO PARAMETER
- H = I-O UNIT
- I = READ
- O = WRITE
- L = LIST

AA	DMVR	DM	EQ	DA	4E	6E	29A												
AB	DMVR	DM	EQ	DA	4E	6E	39A												
AC	DMVR	DM	EQ	DA	4E	6E	49A												
AD	DMVR	DM	EQ	DA	4E	6E	59A												
AE	DMVR	DM	EQ	DA	4E	6E	69A												
AF	DMVR	DM	EQ	DA	4E	6E	79A												
AG	DMVR	DM	EQ	DA	4E	6E	89A												
AH	DMVR	DM	EQ	DA	4E	6E	99A												
AI	DMVR	DM	EQ	DA	4E	6E	109A												
AP	DMVR	DM	DA		2E	17A	212B												
BP	DMVR	DM	DA		2E	23A	214B												
BT	DMVR	DM	DA		2E	20A	212B												
CP	DMVR	DM	DA		2E	26A	218B												
DT	DMVR	DM	DA		2E	26A	218B												
F					216A	217B	225B	225B											
FF					221A	222B	225B	225B											
FI					215A	216B	220A	221B											
FP					212A	213B	216B	217A	225B	225B									
FT					218A	219B	221B	222A	225B	225B									
I					158J	159D	161A	162D	162D	162D	162D	162D	223A	224B	225D	225D			
IP					213A	214B	214A	215B	223B										
IT					219A	220B	223B												
J					224A	225D	225D												
JP	DMVR	DM	DA		2E	15A	223B	224B											
LOC	DMVR	DM	DA		2E	13A	223B												
MX	DMVR	DM	DA		2E	16A	214B	214B											
N					121A	123A	126A	128A	132A	134A	138A	141A	148A	151A	153A	156A	167A	169A	
					172A	177A	180A	182A	185A	188A	191A	193A	196A	200A	202A	206A	208A	210A	
					211B	212D	212D	214D	214D	218D	223D	224D							
N1					139A	142A	211A	218D	223D										
P					114A	115B	115A	120B	125B	131B	137B	144B	146B	147B	150B	157B	159B	162B	
					166B	171B	176B	179B	184B	187B	192B	195B	198B	199B	205B	212B			
PRES			FA		1A	114B													
PS	DMVR	DM	DA		2E	9A	159B	162B	162B	162B									
PTDENS	FCTN				1A	225A													
R	DMVR	DM	EQ	EQ	EQ	EQ	EQ	EQ	EQ	EQ	EQ	EQ	EQ	EQ	EQ	EQ	EQ	EQ	EQ
					2E	6E	6E	6E	6E	6E	6E	6E	6E	6E	6E	6E	6E	6E	6E
T					116A	117B	118B	119B	130B	136B	136A	145B	145A	155B	163B	165B	174B	175B	
					204B	211B	218B												
TEMP			FA		1A	116B													
TM					162A	163B													
YS	DMVR	DM	DA		2E	11A	162B	162B	162B										
TZ					144A	145B	145B												

Table C-8

PTDENS DICTIONARY (CONT'D)

THE FIRST ENTRY FOLLOWING THE STATEMENT NUMBER IS THE NUMBER OF THE LINE ON WHICH IT WAS DEFINED		STATEMENT NUMBER TABLE																			
		THE FLAGS FOLLOWING THE LINE NUMBERS (ON WHICH THE STATEMENT NUMBER WAS REFERENCED) INDICATE THE NATURE OF THE REFERENCE																			
		D = DEFINED			U = ASSIGNED			X = GOTO (UNCNDTNL)													
		S = FORMAT NUMBER			V = DO			Y = IF (ARITHMETIC)													
		T = NONSTNDR. RTN.			W = GOTO (CNDTNL)																
10	123	120X	123D																		
15	125	119X	125D																		
20	128	125X	128D																		
25	130	118X	130D																		
30	134	131X	134D																		
35	136	130X	136D																		
40	141	137X	141D																		
45	144	117X	144D																		
50	150	147X	150D																		
55	153	150X	153D																		
60	155	146X	155D																		
65	160	158V	159Y	160D																	
70	162	159Y	159Y	162D																	
75	165	155X	165D																		
80	169	166X	169D																		
85	171	165X	171D																		
90	174	171X	174D																		
95	179	176X	179D																		
100	182	179X	182D																		
105	184	175X	184D																		
110	187	184X	187D																		
115	190	187X	190D																		
120	192	174X	192D																		
125	195	163X	192X	195D																	
130	198	195X	198D																		
135	202	199X	202D																		
140	204	198X	204D																		
145	208	205X	208D																		
150	210	204X	210D																		
155	211	122X	124X	127X	129X	133X	135X	140X	143X	147X	152X	154X	157X	164X	168X	170X	173X				
		178X	181X	183X	186X	189X	191X	194X	197X	201X	203X	207X	209X	211D							

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Table C-8
PTDENS DICTIONARY (CONT'D)

T R A N S F E R T A B L E																					
ONLY THOSE ENTITIES WHICH ARE REFERENCED ARE PRINTED OUT, THE COMPLETE LIST FOLLOWS																					
DO	GOTO (UNCONDITIONAL)					CALL					RETURN (NON-STANDARD)					INPUT	STOP				
IF (LOGICAL)	GOTO (ARITHMETIC)					FUNCTION REFERENCE					ASSIGN	CUTPUT									
IF (ARITHMETIC)	GOTO (CONDITIONAL)					RETURN (STANDARD)					TAPES	INTERNAL	SUBPROGRAM								
DO	158																				
IF(L)	115	117	118	119	120	125	130	131	136	137	145	146	147	150	155	157	163	165	166	171	174
	175	176	179	184	187	192	195	198	199	204	209	211	214								
IF(A)	159																				
GOTO(UC)	117	118	119	120	122	124	125	127	129	130	131	133	135	137	140	143	146	147	149	150	152
	154	155	157	163	164	165	166	168	170	171	173	174	175	176	178	179	181	183	184	186	187
	189	191	192	194	195	197	198	199	201	203	204	205	207	209							
RTRN(S)	226																				
SUB PROG	1																				

Table C-9

WTCTRL DICTIONARY

VARIABLE TABLE

THE FIRST FLAG INDICATES THE NATURE OF THE ALPHABETIC ENTITY
 = UNDIMENSIONED VARIABLE
 DMVR = DIMENSIONED VARIABLE
 FCTN = FUNCTION NAME
 LBCM = NAME OF LABELED COMMON
 SBRT = SUBROUTINE NAME
 SWVR = SWITCH VARIABLE
 NMLT = NAMELIST NAME

THE FOLLOWING TWO CHARACTER FLAGS INDICATE THAT THE ENTITY IS IN THE CORRESPONDING TYPE OF STATEMENT
 AB = ABNORMAL EX = EXTERNAL
 CM = COMMON FA = FORML AGUMT
 CP = COMPLEX IN = INTEGER
 DA = DATA LG = LOGICAL
 DM = DIMENSION PR = PARAMETER
 DP = DBL PRECISN RL = REAL
 EQ = EQUIVALENCE NL = NAMELIST

THE FLAGS FOLLOWING THE LINE NUMBERS (ON WHICH THE ENTITY WAS REFERENCED) INDICATE THE NATURE OF THE REFERENCE
 A = SET EQUAL, DEFINED, ASSIGNED
 B = REFERENCED, CALLED
 C = CALLING SEQUENCE H = I-O UNIT
 D = SUBSCRIPT I = READ
 E = SPECIFICATION O = WRITE
 J = DO PARAMETER L = LIST

A			62A	66A	68B														
B			63A	67A	68B														
CBWT	FCTN		47B																
CFTW	FCTN		39B																
D		FA	1A	24B	29B	32B	39C	47C	68B										
ETU	DMVR	DM DA DA	4E	5A	6A	23B													
I		FA	1A	13B	340														
IB			46A	47C	50A	53A	56A	59A											
IDV			38A	39C	41A	43A													
IF		FA	1A	23D															
II		FA	1A	32D															
IM		FA	1A	19B	20B	21B	23D	28D	29D	29D									
IV		FA	1A	38B															
J			5D	5L	6D	6L	7D	7L	8D	8L	9D	9L	25A	26A	27A	28D			
			28D																
MINTHK	DMVR	RL DM DA	2E	3E	9A	28B	28B												
P		FA	1A	24B	26B	27B	39C	47C											
RH01	DMVR	OM DA	3E	8A	32B														
RH0L	DMVR	OM DA	3E	7A	29B														
S1			23A	24B															
S1		FA	1A	30B	32B	68B													
S2		FA	1A																
S3		FA	1A	32B															
TNKL			24A	28B	28A	29B													
WGTF			29A	30B															
WI		FA	1A	11A	32A														
WT		FA	1A	12A	16A	30A	36A	39A	47A	68A									
WTCTRL	SBRT		1A																

Table C-9
 WTCTRL DICTIONARY (CONT'D)

STATEMENT NUMBER TABLE		THE FIRST ENTRY FOLLOWING THE STATEMENT NUMBER IS THE NUMBER OF THE LINE ON WHICH IT WAS DEFINED										THE FLAGS FOLLOWING THE LINE NUMBERS (ON WHICH THE STATEMENT NUMBER WAS REFERENCED) INDICATE THE NATURE OF THE REFERENCE									
Line	Statement	Line	Statement	Line	Statement	Line	Statement	Line	Statement	Line	Statement	Line	Statement	Line	Statement	Line	Statement	Line	Statement	Line	Statement
10	16	13W	16D																		
15	19	13W	13W	13W	13W	13W	13W	13W	13W	13W	13W	13W	13W	13W	13W	13W	13W	13W	13W	13W	13W
20	22	19X	22D																		
25	34	13W	13W	13W	34D																
30	35	34S	35D																		
35	38	13W	13W	38D																	
40	39	39D	42X	44X																	
45	41	13W	41D																		
50	43	13W	43D																		
55	46	13W	46D																		
60	47	47D	51X	54X	57X	60X															
65	50	13W	50D																		
70	53	13W	13W	13W	53D																
75	56	13W	56D																		
80	59	13W	59D																		
85	62	20X	62D																		
90	66	21X	66D																		
95	68	64X	68D																		

Table C-9
 WTCCTRL DICTIONARY (CONT'D)

T R A N S F E R T A B L E

ONLY THOSE ENTITIES WHICH ARE REFERENCED ARE PRINTED OUT, THE COMPLETE LIST FOLLOWS

DO	GOTO (UNCONDITIONAL)	CALL	RETURN (NON-STANDARD)	INPUT	STOP
IF (LOGICAL)	GOTO (ARITHMETIC)	FUNCTION REFERENCE	ASSIGN	CUTPUT	
IF (ARITHMETIC)	GOTO (CONDITIONAL)	RETURN (STANDARD)	TAPES	INTERNAL	SUBPROGRAM

IF(L)	19	20	21	26	27	28				
GOTO(UC)	19	20	21	42	44	51	54	57	60	64
GOTO(C)	13									
FCT REF	39	47								
RTRN(S)	17	33	37	40	48	69				
OUTPUT	34									
SUB PROG	1									

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Table C-10
CFTW DICTIONARY

VARIABLE TABLE

<p>THE FIRST FLAG INDICATES THE NATURE OF THE ALPHABETIC ENTITY</p> <p>U = UNDIMENSIONED VARIABLE</p> <p>DMVR = DIMENSIONED VARIABLE</p> <p>FCYN = FUNCTION NAME</p> <p>LBCM = NAME OF LABELED COMMON</p> <p>SBRT = SUBROUTINE NAME</p> <p>SWVR = SWITCH VARIABLE</p> <p>NMLT = NAMELIST NAME</p>	<p>THE FOLLOWING TWO CHARACTER FLAGS INDICATE THAT THE ENTITY IS IN THE CORRESPONDING TYPE OF STATEMENT</p> <p>AB = ABNORMAL EX = EXTERNAL</p> <p>CM = COMMON FA = FORML AGUMT</p> <p>CP = COMPLEX IN = INTEGER</p> <p>DA = DATA LG = LOGICAL</p> <p>DM = DIMENSION PR = PARAMETER</p> <p>DP = DBL PRECISN RL = REAL</p> <p>EQ = EQUIVALENCE NL = NAMELIST</p>	<p>THE FLAGS FOLLOWING THE LINE NUMBERS (ON WHICH THE ENTITY WAS REFERENCED) INDICATE THE NATURE OF THE REFERENCE</p> <p>A = SET EQUAL, DEFINED, ASSIGNED</p> <p>B = REFERENCED, CALLED</p> <p>C = CALLING SEQUENCE H = I-O UNIT</p> <p>D = SUBSCRIPT I = READ</p> <p>E = SPECIFICATION O = WRITE</p> <p>J = DO PARAMETER L = LIST</p>
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CFTW	FCYN		1A	21A	23A	26A	28A							
C1	DMVR	DM DA	5E	11A	21B									
C2	DMVR	DM DA	5E	12A	23B									
C3	DMVR	DM DA	5E	13A	26B									
C4	DMVR	DM DA	5E	14A	28B									
D		FA	1A	18B	19B	20B	21B	21B	21B	23B	23B	23B	26B	28B
IDV		FA	1A	17B	17A	21D	21D	23D	23D	26D	26D	28D	28D	
K1	DMVR	RL DM DA	3E	5E	7A	21B								
K2	DMVR	RL DM DA	3E	5E	8A	23B								
K3	DMVR	RL DM DA	3E	5E	9A	26B								
K4	DMVR	RL DM DA	3E	5E	10A	28B								
P		FA	1A	19B	20B	25B								

Table C-10
CFM DICTIONARY (CONT'D)

S T A T E M E N T N U M B E R T A B L E

THE FIRST ENTRY FOLLOWING THE STATEMENT NUMBER THE FLAGS FOLLOWING THE LINE NUMBERS (ON WHICH THE
IS THE NUMBER OF THE LINE ON WHICH IT WAS DEFINED STATEMENT NUMBER WAS REFERENCED) INDICATE THE NATURE
OF THE REFERENCE

D = DEFINED U = ASSIGNED X = GOTO (UNCNDTL)
S = FORMAT NUMBER V = DO Y = IF (ARITHMETIC)
T = NONSTNDRD RTN W = GOTO (CNDTL)

10	23	19X	20X	23D
15	25	18X	25D	
20	28	25X	28D	

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Table C-10
CFTW DICTIONARY (CONT'D)

T R A N S F E R T A B L E

ONLY THOSE ENTITIES WHICH ARE REFERENCED ARE PRINTED OUT, THE COMPLETE LIST FOLLOWS

DO	GOTO (UNCONDITIONAL)	CALL	RETURN (NON-STANDARD)	INPUT	STOP			
IF (LOGICAL)	GOTO (ARITHMETIC)	FUNCTION REFERENCE	ASSIGN	OUTPUT				
IF (ARITHMETIC)	GOTO (CONDITIONAL)	RETURN (STANDARD)	TAPES	INTERNAL	SUBPROGRAM			
IF(L)	17	18	19	20	25			
GOTO(UC)	18	19	20	25				
RTRN(S)	22	24	27	29				
SUB PROG	1							

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Table C-11

CBWT DICTIONARY

THE FIRST FLAG INDICATES THE NATURE OF THE ALPHABETIC ENTITY

- UNDIMENSIONED VARIABLE
- DMVR ▪ DIMENSIONED VARIABLE
- FCTN ▪ FUNCTION NAME
- LBCM ▪ NAME OF LABELED COMMON
- SBRT ▪ SUBROUTINE NAME
- SWVR ▪ SWITCH VARIABLE
- NMLT ▪ NAMELIST NAME

VARIABLE TABLE

THE FOLLOWING TWO CHARACTER FLAGS INDICATE THAT THE ENTITY IS IN THE CORRESPONDING TYPE OF STATEMENT

- AB ▪ ABNORMAL
- CM ▪ COMMON
- CP ▪ COMPLEX
- DA ▪ DATA
- DM ▪ DIMENSION
- DP ▪ DBL PRECISN
- EQ ▪ EQUIVALENCE
- EX ▪ EXTERNAL
- FA ▪ FORML AGUMT
- IN ▪ INTEGER
- LG ▪ LOGICAL
- PR ▪ PARAMETER
- RL ▪ REAL
- NL ▪ NAMELIST

THE FLAGS FOLLOWING THE LINE NUMBERS (ON WHICH THE ENTITY WAS REFERENCED) INDICATE THE NATURE OF THE REFERENCE

- A ▪ SET EQUAL, DEFINED, ASSIGNED
- B ▪ REFERENCED, CALLED
- C ▪ CALLING SEQUENCE
- D ▪ SUBSCRIPT
- E ▪ SPECIFICATION
- J ▪ DO PARAMETER
- H ▪ I-O UNIT
- I ▪ READ
- O ▪ WRITE
- L ▪ LIST

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CBWT	FCTN		1A	7A	10A	10B	12A	12B	12B
C1	DMVR	DM DA	3E	4A	7B	10B	12B		
C2	DMVR	DM DA	3E	5A	10B	12B			
D		FA	1A	7B					
IB		FA	1A	7D	7D	10D	10D	12D	12D
M	DMVR	RL DM DA	2E	3E	6A	7B			
P		FA	1A	8B	9B	12B			

Table C-11
 CBWT DICTIONARY (CONT'D)

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STATEMENT NUMBER TABLE			
THE FIRST ENTRY FOLLOWING THE STATEMENT NUMBER IS THE NUMBER OF THE LINE ON WHICH IT WAS DEFINED		THE FLAGS FOLLOWING THE LINE NUMBERS (ON WHICH THE STATEMENT NUMBER WAS REFERENCED) INDICATE THE NATURE OF THE REFERENCE	
		D = DEFINED	U = ASSIGNED
		S = FORMAT NUMBER	V = DO
		T = NONSTNDRD RTN	W = GOTO (CNDTNL)
		X = GOTO (UNCNDTNL)	Y = IF (ARITHMETIC)
10	12	9X	120

Table C-11
 CBWT DICTIONARY (CONT'D)

T R A N S F E R T A B L E

ONLY THOSE ENTITIES WHICH ARE REFERENCED ARE PRINTED OUT, THE COMPLETE LIST FOLLOWS

	GOTO (UNCONDITIONAL)	CALL	RETURN (NON-STANDARD)	INPUT	STOP
DO					
IF (LOGICAL)	GOTO (ARITHMETIC)	FUNCTION REFERENCE	ASSIGN	OUTPUT	
IF (ARITHMETIC)	GOTO (CONDITIONAL)	RETURN (STANDARD)	TAPES	INTERNAL SUBPROGRAM	
IF(L)	8	9			
GOTO(UC)	9				
RTRN(S)	8	11	13		
SUB PROG	1				

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Table C-12
GOMETRY DICTIONARY

THE FIRST FLAG INDICATES THE NATURE OF THE ALPHABETIC ENTITY

- UNDIMENSIONED VARIABLE
- DMVR ▪ DIMENSIONED VARIABLE
- FCTN ▪ FUNCTION NAME
- LBCM ▪ NAME OF LABELED COMMON
- SBRT ▪ SUBROUTINE NAME
- SWVR ▪ SWITCH VARIABLE
- NMLT ▪ NAMELIST NAME

VARIABLE TABLE

THE FOLLOWING TWO CHARACTER FLAGS INDICATE THAT THE ENTITY IS IN THE CORRESPONDING TYPE OF STATEMENT

- AB ▪ ABNORMAL
- CM ▪ COMMON
- CP ▪ COMPLEX
- DA ▪ DATA
- DM ▪ DIMENSION
- DP ▪ DBL PRECISN
- EQ ▪ EQUIVALENCE
- EX ▪ EXTERNAL
- FA ▪ FORML AGUMT
- IN ▪ INTEGER
- LG ▪ LOGICAL
- PR ▪ PARAMETER
- RL ▪ REAL
- NL ▪ NAMELIST

THE FLAGS FOLLOWING THE LINE NUMBERS (ON WHICH THE ENTITY WAS REFERENCED) INDICATE THE NATURE OF THE REFERENCE

- A ▪ SET EQUAL, DEFINED, ASSIGNED
- B ▪ REFERENCED, CALLED
- C ▪ CALLING SEQUENCE
- D ▪ SUBSCRIPT
- E ▪ SPECIFICATION
- J ▪ DO PARAMETER
- H ▪ I-O UNIT
- I ▪ READ
- O ▪ WRITE
- L ▪ LIST

C-45

ALOG	FCTN																
ARACYL	FCTN																
AREA FR	FCTN																
ARSPHR	FCTN																
ASIN	FCTN																
CONE	FCTN																
CYLNDR	FCTN																
CYLSPH	FCTN																
E																	
FRCONC	FCTN																
H		FA	FA	FA	FA	FA											
HSPHER	FCTN																
P1																	
P1203																	
R		FA	FA	FA	FA	**											
RROT		FA	FA	FA	FA												
R2		FA	FA														
SPHERE	FCTN																
SQRT	FCTN																

Table C-12
GOMETRY DICTIONARY (CONT'D)

S T A T E M E N T N U M B E R T A B L E			
THE FIRST ENTRY FOLLOWING THE STATEMENT NUMBER IS THE NUMBER OF THE LINE ON WHICH IT WAS DEFINED		THE FLAGS FOLLOWING THE LINE NUMBERS (ON WHICH THE STATEMENT NUMBER WAS REFERENCED) INDICATE THE NATURE OF THE REFERENCE	
10	54	48X	54D
15	60	54X	60D

D = DEFINED U = ASSIGNED X = GOTO (UNCONDNL)
S = FORMAT NUMBER V = DO Y = IF (ARITHMETIC)
T = NONSTNDRO RTN W = GOTO (CONDNL)

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Table C-12
GOMETRY DICTIONARY (CONT'D)

T R A N S F E R T A B L E

ONLY THOSE ENTITIES WHICH ARE REFERENCED ARE PRINTED OUT. THE COMPLETE LIST FOLLOWS

DO	GOTO (UNCONDITIONAL)	CALL	RETURN (NON-STANDARD)	INPUT	STOP
IF (LOGICAL)	GOTO (ARITHMETIC)	FUNCTION REFERENCE	ASSIGN	OUTPUT	
IF (ARITHMETIC)	GOTO (CONDITIONAL)	RETURN (STANDARD)	TAPES	INTERNAL SUBPROGRAM	

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IF(L)	48	54									
GOTO(UC)	48	54									
FCT REF	42	51	52	56	57						
RTRN(S)	10	14	19	23	28	33	38	43	53	58	61
SUB PROG	2	12	17	21	26	31	36	41	47		

Table C-13

SPHSEG DICTIONARY

LOCKHEED MISSILES & SPACE COMPANY

VARIABLE TABLE

THE FIRST FLAG INDICATES THE NATURE OF THE ALPHABETIC ENTITY
 = UNDIMENSIONED VARIABLE
 DMVR = DIMENSIONED VARIABLE
 FCTN = FUNCTION NAME
 LBCM = NAME OF LABELED COMMON
 SBRT = SUBROUTINE NAME
 SWVR = SWITCH VARIABLE
 NMLT = NAMELIST NAME

THE FOLLOWING TWO CHARACTER FLAGS INDICATE THAT THE ENTITY IS IN THE CORRESPONDING TYPE OF STATEMENT
 AB = ABNORMAL EX = EXTERNAL
 CM = COMMON FA = FORML AGUMT
 CP = COMPLEX IN = INTEGER
 DA = DATA LG = LOGICAL
 DM = DIMENSION PR = PARAMETER
 DP = D3L PRECISN RL = REAL
 EQ = EQUIVALENCE NL = NAMELIST

THE FLAGS FOLLOWING THE LINE NUMBERS (ON WHICH THE ENTITY WAS REFERENCED) INDICATE THE NATURE OF THE REFERENCE
 A = SET EQUAL, DEFINED, ASSIGNED
 B = REFERENCED, CALLED
 C = CALLING SEQUENCE H = I-O UNIT
 D = SUBSCRIPT I = READ
 E = SPECIFICATION O = WRITE
 J = DO PARAMETER L = LIST

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ACOS	FCTN	24B															
COS	FCTN	27B															
CYMSPH	SBRT	39A															
D		43A	44B														
ELIPSG	SBRT	15A															
H	FA FA FA	2A	15A	35A	39A	44A											
I		29J	26B	27D	29J	30B	31D	31D									
K		30A	35D														
PHI3		24A	27C														
PI		43B															
PI203		11B	17B	27C													
PVOL	FA FA FA	2A	15A	19B	39A	43B											
RAD	FA FA FA	2A	11B	15A	17B	27B	31B	39A	43B	43B	44B	44B					
RPD	FA FA	15A	17B	17B	39A	43B	43B										
SPHSEG	SBRT	2A															
TVOL		11A	17A	19B													
XI		26A	27C														
XM		19A	20B	21D	24C												
Y	DMVR DM	8E	27A	31B	31B	330	35B										

Table C-13
 SPHSEIG DICTIONARY (CONT'D)

STATEMENT NUMBER TABLE
 THE FIRST ENTRY FOLLOWING THE STATEMENT NUMBER IS THE NUMBER OF THE LINE ON WHICH IT WAS DEFINED THE FLAGS FOLLOWING THE LINE NUMBERS (ON WHICH THE STATEMENT NUMBER WAS REFERENCED) INDICATE THE NATURE OF THE REFERENCE
 D = DEFINED U = ASSIGNED X = GOTO (UNCONDNL)
 S = FORMAT NUMBER V = DO Y = IF (ARITHMETIC)
 T = NONSTNDRU RTN W = GOTO (CONDNL)

10	18	12X	18D
15	23	20X	23D
20	28	25V	28D
25	32	29V	32D
30	39	31X	35D
35	47	33S	47D
40	48	21S	48D

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Table C-13
SPHSEG DICTIONARY (CONT'D)

T R A N S F E R T A B L E

ONLY THOSE ENTITIES WHICH ARE REFERENCED ARE PRINTED OUT. THE COMPLETE LIST FOLLOWS

	GOTO (UNCONDITIONAL)	CALL	RETURN (NON-STANDARD)	INPUT	STOP
DO	GOTO (ARITHMETIC)	FUNCTION REFERENCE	ASSIGN	OUTPUT	
IF (LOGICAL)	GOTO (CONDITIONAL)	RETURN (STANDARD)	TAPES	INTERNAL	SUBPROGRAM
IF (ARITHMETIC)					
DO	25	29			
IF(L)	20	31			
GOTO(UC)	12	20	31		
FCT REF	24	27			
RTRN(S)	22	34	36	45	
OUTPUT	21	33			
SUB PROG	2	15	39		

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APPENDIX D
SOPSA CROSS REFERENCE

This Appendix contains a cross reference listing of all entry points in the SOPSA program. The names of the relocatable elements are listed alphabetically. Beside each element name, the names of the element entry points are listed. Beside each entry point name, the names of all relocatable elements in the SOPSA program which reference this entry point are listed.

Table D-1
SOPSA CROSS REFERENCE LISTING

ARACYL	01	(000635)	(GOMTRY) , INIVOL
AREAFR	01	(000703)	(GOMTRY) , INIVOL
ARSPHR	01	(000757)	(GOMTRY) , INIVOL
CBWT	01	(000057)	(CBWT) , WTCTRL
CFTW	01	(000125)	(CFTW) , WTCTRL
CONE	01	(000244)	(GOMTRY)
CYLNDR	01	(000312)	(GOMTRY) , INIVOL
CYLSPH	01	(000360)	(GOMTRY) , INIVOL
CYMSPH	01	(000254)	(SPHSEG) , ULLHED
ELIPSG	01	(000224)	(SPHSEG) , ULLHED
FINDR	01	(000012)	(FINDR) , STAR
FLORES	01	(000576)	(FLORES) , STAR
FRCONE	01	(000433)	(GOMTRY) , INIVOL
HSPHER	01	(000507)	(GOMTRY) , INIVOL
INIVOL	01	(000162)	(INIVOL) , STAR
PTDENS	01	(000564)	(PTDENS) , STAR, ZFIND
PVAPOR	01	(000316)	(PVAPOR) , ZFIND, STAR
SPHERE	01	(000562)	(GOMTRY)
SPHSEG	01	(000176)	(SPHSEG)
ULLHED	01	(000240)	(ULLHED) , STAR
WTCTRL	01	(000265)	(WTCTRL) , STAR
ZFIND	01	(000403)	(ZFIND) , STAR