



AG A 075476

12

14

DRSMI-

LEVEL 4

9

TECHNICAL REPORT T-79-24-VOL-1

6

CHEMICAL LASER SYSTEMS:
AN ENGINEERING APPROACH
Volume 1 TO CHEMICAL LASER ANALYSIS PROGRAM

U.S. ARMY
MISSILE
RESEARCH
AND
DEVELOPMENT
COMMAND

10

Clark D. Mikkelson Billy J. Walker
Systems Simulation Directorate
Technology Laboratory

11

31 January 1979

320

11161102AH49

DDC
RECEIVED
OCT 25 1979
A



DDC FILE COPY

Redstone Arsenal, Alabama 35809

Approved for public release; distribution unlimited.

393427

JB

DISPOSITION INSTRUCTIONS

**DESTROY THIS REPORT WHEN IT IS NO LONGER NEEDED. DO NOT
RETURN IT TO THE ORIGINATOR.**

DISCLAIMER

**THE FINDINGS IN THIS REPORT ARE NOT TO BE CONSTRUED AS AN
OFFICIAL DEPARTMENT OF THE ARMY POSITION UNLESS SO DESIGNATED
BY OTHER AUTHORIZED DOCUMENTS.**

TRADE NAMES

**USE OF TRADE NAMES OR MANUFACTURERS IN THIS REPORT DOES
NOT CONSTITUTE AN OFFICIAL INDORSEMENT OR APPROVAL OF
THE USE OF SUCH COMMERCIAL HARDWARE OR SOFTWARE.**

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER T-79-24	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) CHEMICAL LASER SYSTEMS ANALYSIS AN ENGINEERING APPROACH VOL I: CHEMICAL LASER ANALYSIS PROGRAM		5. TYPE OF REPORT & PERIOD COVERED Technical Report
7. AUTHOR(s) Clark D. Mikkelsen and Billy J. Walker		6. PERFORMING ORG. REPORT NUMBER
9. PERFORMING ORGANIZATION NAME AND ADDRESS Commander US Army Missile Research and Development Command Attn: DRDMI-TD Redstone Arsenal, Alabama 35809		8. CONTRACT OR GRANT NUMBER(s)
11. CONTROLLING OFFICE NAME AND ADDRESS Commander US Army Missile Research and Development Command Attn: DRDMI-TI Redstone Arsenal, Alabama 35809		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS DA 1L161102AH49 AMCMS 611102.H490011
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		12. REPORT DATE 31 January 1979
		13. NUMBER OF PAGES 316
		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		19a. DECLASSIFICATION/DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report) Approved for public release; distribution unlimited.		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Chemical laser Systems analysis Ejector optimization Supersonic-supersonic ejector Pressure recovery		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The Chemical Laser Analysis Program presented in this report is a computer program for the rapid, parametric evaluation of high energy, chemical laser systems including the combustion chemistry, laser device gas dynamics, various diffuser-ejector pressure recovery subsystems, and system volume/mass estimates. The program does not calculate specific laser power but relies on experimental data for scaling information. The FORTRAN EXTENDED computer program listing, as well as detailed information on program development, organization, and operating procedure are given along with a complete program		

DD

FORM

1 JAN 73 1473

EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

abstract (continued)

nomenclature and two sample cases.



UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

Accession For	
NTIS GRA&I	☒
DDC TAB	
Unannounced	
Justification	
By _____	
Distribution _____	
Availability _____	
Dist	Available for special

CONTENTS

	Page
I. INTRODUCTION.	3
II. PROGRAM ORGANIZATION.	4
III. PROGRAM INPUT DATA.	20
IV. CONCLUSIONS AND RECOMMENDATIONS	25
Appendix A. CHEMICAL LASER ANALYSIS PROGRAM (CLAP)—OVERLAY MAIN.	29
Appendix B. CHEMICAL LASER ANALYSIS PROGRAM (CLAP)—OVERLAY CCS .	48
Appendix C. CHEMICAL LASER ANALYSIS PROGRAM (CLAP)—OVERLAY LDS .	64
Appendix D. CHEMICAL LASER ANALYSIS PROGRAM (CLAP)—OVERLAY PRS .	119
Appendix E. CHEMICAL LASER ANALYSIS PROGRAM (CLAP)—OVERLAY SCS .	164
Appendix F. NOMENCLATURE—OVERLAY MAIN.	226
Appendix G. CHEMICAL LASER ANALYSIS PROGRAM (CLAP)—SAMPLE INPUT/OUTPUT	267

ACKNOWLEDGMENT

The Chemical Laser Analysis Program represents the culmination of 10 years experience in the chemical laser field by personnel at the US Army Missile Research and Development Command. Special credit goes to Dr. B. J. Walker and Dr. R. L. Oglukian who formulated the original code, especially the SYSTEM CALCULATION SECTION, and to Dr. A. L. Addy who, with the author, formulated much of the PRESSURE RECOVERY SECTION. Among those deserving of recognition are Dr. G. F. Morr and Messrs. R. D. Massey, C. L. Adams, and S. L. Pruett who worked on earlier versions of the program.

I. INTRODUCTION

A chemical laser weapons system is a complex device that requires an amalgamation of various scientific disciplines. These include chemical kinetics, optics, fluid dynamics, quantum mechanics, etc. The interaction of these various disciplines are, at best, complicated. However, it remains that if a high energy chemical laser weapons system is to be built successfully, it is necessary that this interaction be understood.

A considerable effort has been made to analyze an entire chemical laser system from an engineering point of view, to describe such a system by a set of governing equations, and finally, to simulate a chemical laser system through solution of the governing equations utilizing the Chemical Laser Analysis Program (CLAP).

The CLAP program was developed primarily from a fluid dynamics viewpoint which essentially means that specific laser power is purposely not calculated, but is obtained from experimental data. This probably enhances the credibility of the results obtained by the use of the program since the calculation of specific power would be closely tied to all the fluid dynamical and reaction kinetics calculation techniques and subject to those uncertainties plus the uncertainties inherent in the specific power calculation itself. CLAP does, however, consider all other aspects of a chemical laser system, including the combustion chemistry, gas dynamics, and mass/volume estimates.

CLAP was designed specifically as a tool for the rapid parametric evaluation of proposed chemical laser systems. Pursuant to this goal, the program was written:

- a) By using simple methods of analysis, in particular, the one-dimensional methods of gas dynamics wherever possible.
- b) For minimum user input requirements with over 22 user controlled options for maximum flexibility.
- c) For use in an interactive mode for minimum turn-around time and maximum user convenience.
- d) In a stacked or series configuration to maximize calculational efficiency and minimize user costs.

Although written to reflect the state-of-the-art in chemical laser technology, the authors realize that most users will wish to modify the code with minimum effort for their own unique studies. To this end the program was written:

- a) With a consistent notation scheme throughout and a single system of units, the SI (metric) system.

b) With a considerable amount of internal documentation such that most any user with a basic knowledge of chemical laser systems can comprehend the background theory and logic.

The CLAP program listed in Appendices A through E was written in FORTRAN EXTENDED for use on Control Data Corporation computers having an INTERCOM Version 4 interactive capability, but is readily adapted to run on other machines in either an interactive or batch mode.

II. PROGRAM ORGANIZATION

A. General

CLAP as listed in Appendices A through E is written in five overlays consisting of the root overlay, MAIN, and four primary overlays, COMBUSTION CHEMISTRY SECTION (CCS), LASER DEVICE SECTION (LDS), PRESSURE RECOVERY SECTION (PRS), and SYSTEM CALCULATION SECTION (SCS). Calculations are performed sequentially through the primary overlays in the following order: (1) CCS, (2) LDS, (3) PRS, and (4) SCS. However, it should be noted that the pressure recovery and system calculation sections are optional. Calculations in a given primary overlay are executed only if the input data are changed for that or a previous overlay.

Block common statements are used to store the output from each primary overlay in the root overlay. In addition, these block common statements serve to pass information between primary overlays through the root overlay. Variables are brought into a given program or subroutine through COMMON or CALL statements only if actually required. A block common-program/subroutine cross reference is included in Table 1.

Each primary overlay has its own input and output subroutines, INCCS, DUTCCS, etc. All input is either by NAMELIST or alphanumeric symbols (e. g., "YES" and "NO"). Furthermore, each input subroutine contains default values for the input variables and the logic to store the latest input data on a separate file, TAPE1, TAPE2, etc., for easy restarts. A list of these and other TAPE/unit definitions are given in Table 2.

All calculations, with the exception of one subroutine, DUTENG, are performed in either dimensionless or the SI system of units following Mechtly [1].

A nomenclature list for each program and subroutine is given in Appendix F. The nomenclature for each primary overlay follows a general scheme whenever possible with the exceptions defined separately.

As an aid to the user, the CLAP code is liberally interspersed with comment statements to identify the purpose of the program or subroutine,

[illegible]

TABLE 1. BLOCK COMMON-PROGRAM/SUBROUTINE

BLOCK COMMON

[illegible]

Q

PROGRAM/SUBROUTINE CROSS REFERENCE

BLOCK COMMON

MAIN3	MAIN4	MAIN5	MAIN6	PRS1	PRS2	PRS3	PRS4	PRS5	PRS6	SCS1	SCS2	SCS3	SCS4	SCS5	SCS6
X	X	X	X	X									X		
					X	X	X	X	X	X	X	X		X	
X															
	X														
				X	X	X	X	X	X						
		X		X		X		X	X						
					X	X	X	X	X						
							X	X	X	X	X	X	X	X	
			X					X		X	X		X	X	X
								X			X	X		X	
													X	X	X
													X	X	
													X	X	
													X	X	
													X	X	
													X	X	
													X	X	
													X	X	
													X	X	
													X	X	
													X	X	
													X	X	

SCS5	SCS6	SCS7	SCS8	SCS9	SCS10	SCS11	SCS12	SCS13	SCS14	SCS15	SCS16	SCS17
X												
X												
X	X	X	X	X	X	X	X	X	X	X	X	X
X												
X	X											
X		X										
X			X									
X				X								
X					X							
X						X						
X							X					
X								X				
X									X			
X										X		
X											X	
X												X

4

TABLE 2. TAPE/UNIT DEFINITIONS

TAPE or Unit No.	Purpose
1	Binary input/output file either read or written from subroutine INCCS to store the latest input data for CCS.
2	Binary input/output file either read or written from subroutine INLDS to store the latest input data for LDS.
3	Binary input/output file either read or written from subroutine INPRS to store the latest input data for PRS.
4	Binary input/output file either read or written from subroutine INSCS to store the latest input data for SCS.
5	Connected file for the interactive output of information to the CLAP program from a terminal keyboard.
6	Connected file for the interactive input of information from the CLAP program to a CRT display.
20	Formatted output file written from subroutines DUTCCS, DUTLDS, DUTPRS, and DUTSCS to print the results of the CLAP program in SI units on 132 character line printers.
30	Formatted output file written from subroutine DUTENG to print the results of the CLAP program in mixed engineering units on 132 character line printers.

to define the input/output variables, and to describe each step of the calculations. Furthermore, a system of failure flags and error messages have been set up to assist in the location of failures.

B. MAIN

The root overlay, MAIN, calls the primary overlays in sequence and stores the output of the primary overlays.

Subroutine DUTENG contained in the MAIN overlay converts the output of the CLAP program to a mixed system of engineering units and is the only subroutine which does not use the SI system. The converted variables are stored in separate core locations to eliminate the need of converting back to SI units, thus avoiding any mixed unit errors.

C. COMBUSTION CHEMISTRY SECTION (CCS)

The primary overlay CCS performs all the combustion chemistry calculations for the laser primary combustor and laser cavity for either DF or HF laser chemistry. Any primary combustor fuel of the form $C_{N1}H_{N2}$ or $C_{N1}D_{N2}$ and any primary combustor oxidizer of the form $N_{N3}F_{N4}$ may be used. Both helium and nitrogen are allowed as diluents; however, the cavity mirror purge gas is assumed to be nitrogen.

Because of differences in definitions existant in the laser community, some of the variables listed in the nomenclature for CCS require further definition. These are:

ALPHA = Fluorine dissociation fraction

$$\alpha = \frac{\text{moles F}}{\text{moles F} + 2 \text{ moles F}_2}$$

PSIC = Molar combustor diluent ratio

$$\psi_C = \frac{\text{moles diluent} + \text{moles other}}{\text{moles F}_2 + 1/2 \text{ mole F}}$$

PSIL = Molar cavity diluent ratio

$$\psi_L = \frac{\text{moles diluent} + \text{moles other}}{\text{moles F}_2 + 1/2 \text{ mole F}}$$

PSILTRW = Molar cavity diluent ratio (TRW definition)

$$\psi_{L-TRW} = \frac{\text{moles diluent}}{\text{moles F}_2 + 1/2 \text{ mole F}}$$

OMEGA = Total laser molar diluent ratio

$$\Omega = \psi_C + \psi_L$$

OMEGTRW = Total laser molar diluent ratio (TRW definition)

$$\psi_{TRW} = \psi_C + \psi_{I-TRW}$$

RC = Molar combustor mixture ratio

$$R_C = \frac{\text{moles oxidizer}}{\text{moles of fuel required to react stoichiometrically with all the oxidizer}}$$

RL = Molar cavity mixture ratio

$$R_L = \frac{\text{moles of cavity fuel}}{\text{moles } F_2 + 1/2 \text{ mole } F}$$

RLF = Total laser cavity mixture ratio

$$R_{LF} = \frac{\text{moles of cavity fuel} + \text{moles of cavity diluent}}{\text{moles } F_2 + 1/2 \text{ mole } F}$$

D. LASER DEVICE SECTION (LDS)

The primary overlay LDS performs the gas dynamic calculations for the laser device including the primary and secondary nozzles and the laser cavity. All calculations are based on 1 kmole/s of laser primary nozzle flow; hence, the units on flow area, for example, are (s-m²)/kmole.

No attempt was made to predict heat loss in the laser nozzles, nor was any rigorous boundary layer analysis applied to a given nozzle profile. Instead, the nozzle stagnation temperature is either estimated or taken from experimental data and the nozzle boundary layer thickness is computed using a simple correlation equation from the throat to exit plane. All the nozzle flow is assumed to pass through the core or "effective" flow area as shown in Figure 1. Finally, a simple correction is applied, namely adjusting the number of nozzles for 1 kmole/s of primary flow, to correct for the change in specific heat ratio due to temperature change from the nozzle throat to exit.

Totally viscous, subsonic nozzle flow, i.e. all boundary layer flow in converging-diverging nozzles, is not allowed and has been the most common failure encountered with the CLAP program in subroutines LPNCS and LSNCS1. Constant-area, sonic secondary laser nozzles are treated separately as Fanno flow devices in subroutine LSNCS2.

Two nozzle calculational procedures are followed. For the primary nozzles, either the nozzle stagnation temperature is specified and the stagnation pressure is computed or vice versa. For the laser secondary nozzles, however, the stagnation pressure is always computed for a given

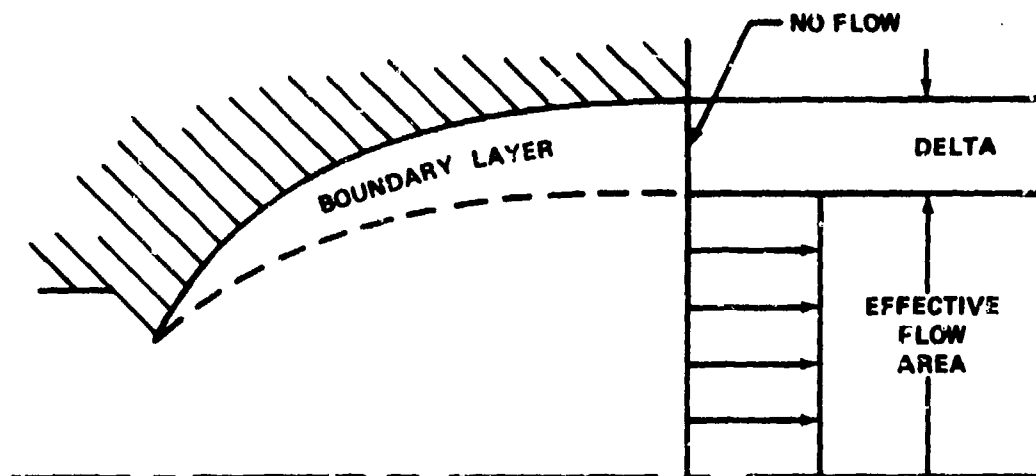


Figure 1. Laser nozzle boundary layer.

stagnation temperature. When both the primary nozzle stagnation temperature and pressure are known, as when scaling up from an experimental device, the usual procedure is to match both experimental values by adjusting the primary nozzle throat diameter, D_{1S} , which will ordinarily vary from the design value due to thermal expansion or throat erosion.

The complex mixing and reacting cavity flow is broken down into three simple processes separated by station numbers as designated in the nomenclature of Appendix F and illustrated in Figure 2. First, the effective primary and secondary nozzle flows are assumed to mix at constant-area to a uniform stream and then expand isentropically to the full cavity flow area at the nozzle face. Next, the mass addition, chemical reaction, and accompanying heat release calculations are carried out step-wise to the cavity exit similar to the cavity analysis given by Addy and Mikkelsen [2] and outlined in Shapiro [3]. Included in the cavity analysis is an empirical flow separation test after Zukoski [4] which has proven to be an important criterion in laser scale-up design operations, especially for devices with low bank relief nozzles [5].

The specific heat at constant pressure and absolute viscosity data included in subroutines CPCALC and VISC were taken largely from two sources, the JANAF [6] and NASA [7] tables, respectively. Subroutine VISC computes the viscosity of gas mixtures using the semi-empirical formula of Wilke [8].

E. PRESSURE RECOVERY SECTION (PRS)

The primary overlay PRS performs the gas dynamic calculations for the laser pressure recovery subsystem. Again, as in LDS, all calculations are based on 1 kmole/s of laser primary nozzle flow. Most of this section is described in and taken from Mikkelsen, Sandberg, and Addy [2, 9, 10].

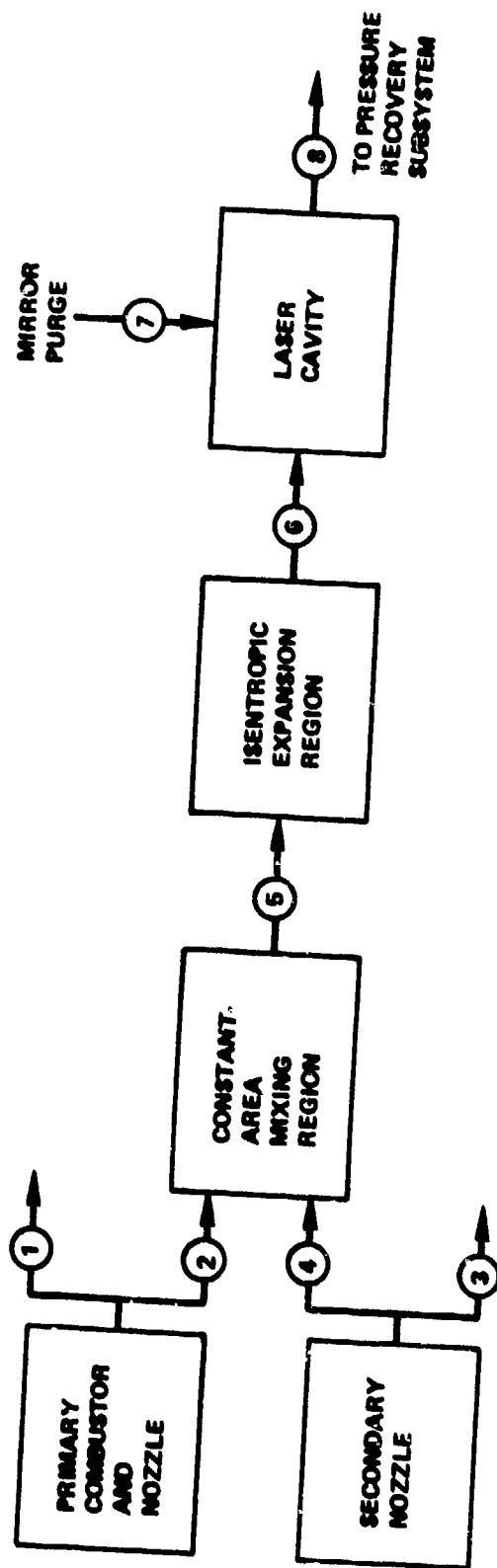


Figure 2. Laser device subsystem schematic.

The PRS overlay calculations are optional; however, the user may select from three pressure recovery subsystems including (1) a supersonic-subsonic diffuser; (2) a supersonic-subsonic diffuser and constant-area, subsonic-supersonic ejector; and (3) a constant-area, supersonic-supersonic ejector. The constant-area, supersonic-supersonic ejector analysis differs only slightly from that of Mikkelsen, et al., in that a Zukoski [4] type of separation criteria has been added to the options for limiting ejector operation. A flow schematic for the pressure recovery options with station numbers corresponding to the nomenclature of Appendix F is given in Figure 3.

To give the best ejector system possible as well as minimize user inputs, each of the ejector systems are optimized to give the minimum driver-to-driven stream mass flow ratio for a specified driver stagnation pressure. Care, however, is required since impossible pressure recovery requirements, either too high or too low, have been the most common cause of failures in the optimization routines. Since the ejector optimization routines are somewhat more time consuming, usual practice with proposed chemical laser designs is to select the supersonic-subsonic diffuser option and to vary the laser device flow conditions until a desired pressure recovery at the subsonic diffuser exit is achieved.

F. SYSTEM CALCULATION SECTION (SCS)

The primary overlay SCS, using output from the other primary overlays and system scale-up information, estimates the mass and volume of a chemical laser system including reactants, storage tanks, lines, supports, regulators, optics, etc. Unfortunately, the systems analysis leading to the computer algorithms is too extensive to include in this volume but will be published later. This is particularly unfortunate since the analysis is not readily apparent from the computer code, especially for the tank factor subroutines. The majority of the work is original with much of the data compiled from Department of Defense technology programs.

Since specific power calculations have been avoided in CLAP, the hypothetical laser system is scaled to size by specifying the mass flow rate of free fluorine and the laser run time. The principal dimensions are then readily determined since the mole fraction and mole flux of free fluorine are known from the CCS and the flow area in LDS and PRS were based on 1 kmole/s of laser primary flow.

An example of a single-ejector, a single-bank chemical laser configuration is shown in Figure 4, with the principal dimensions of the transition piece and subsonic-supersonic ejector given in Figures 5 and 6. The subsonic-supersonic ejector is of the variable-area type which should just meet the theoretical constant-area ejector performance calculated in PRS. A supersonic-supersonic ejector option (Figure 7) is included in SCS; however, this particular configuration is an untested design

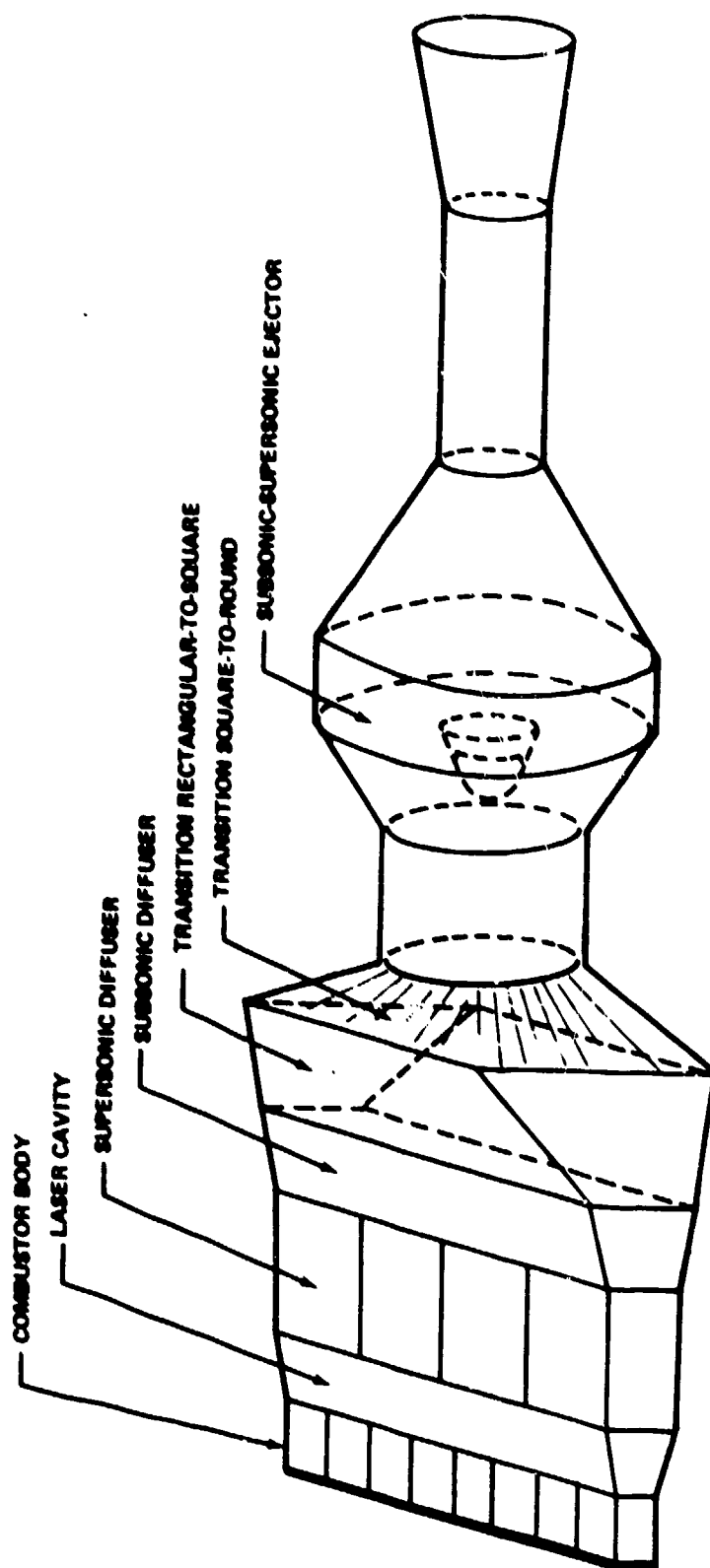


Figure 4. Single-ejector, single-bank laser configuration.

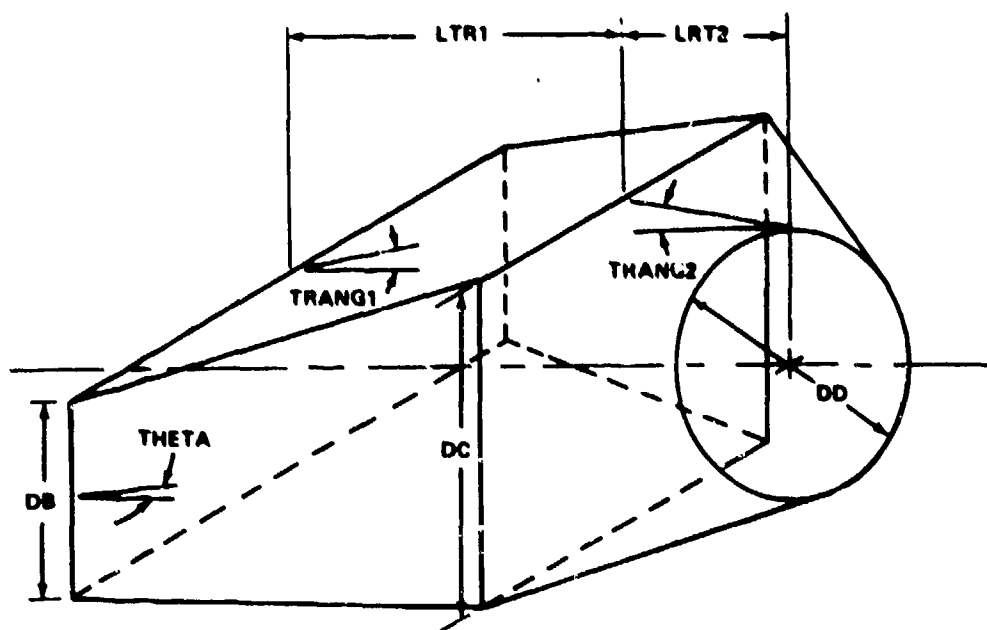


Figure 5. Subsonic-supersonic ejector transition piece.

and strictly proposed for comparison with subsonic-supersonic ejector systems. More than one laser bank and more than one ejector per bank may be specified, but the total number of ejectors per bank is limited such that the height-to-width ratio at the transition section entrance is no greater than unity.

Storage tank volume/mass subroutines are included in SCS for laser fuels C_2H_4 , H_2 , and D_2 ; for laser oxidizers F_2 and NF_3 ; and for laser diluents He and H_2 . Helium is stored as a mixture with the fluorine oxidizer when used only as a primary diluent. N_2H_4 is included as a monopropellant ejector driver fluid and IRFNA/MMH for a biopropellant system. Similar volume/mass subroutines were written for the laser cooling system and nitrogen-driven aero-window.

The laser reactants may be stored in a number of ways given in the listing for each volume/mass subroutine and summarized in the reactant storage mode nomenclature of Appendix F. Cryogenic storage options utilizing a triple vacuum jacket and liquid nitrogen boil-off for thermal protection are included for most of the reactants. Gases are always delivered with a blow-down system whereas liquids are delivered via pressurized gas, pump feed, or heater pressurization systems as illustrated in Figures 8, 9, and 10. Water is delivered to the cooling system by the same schemes used for other liquid reactants with the addition of a radiator-fan-pump recirculation system shown schematically in Figure 11.

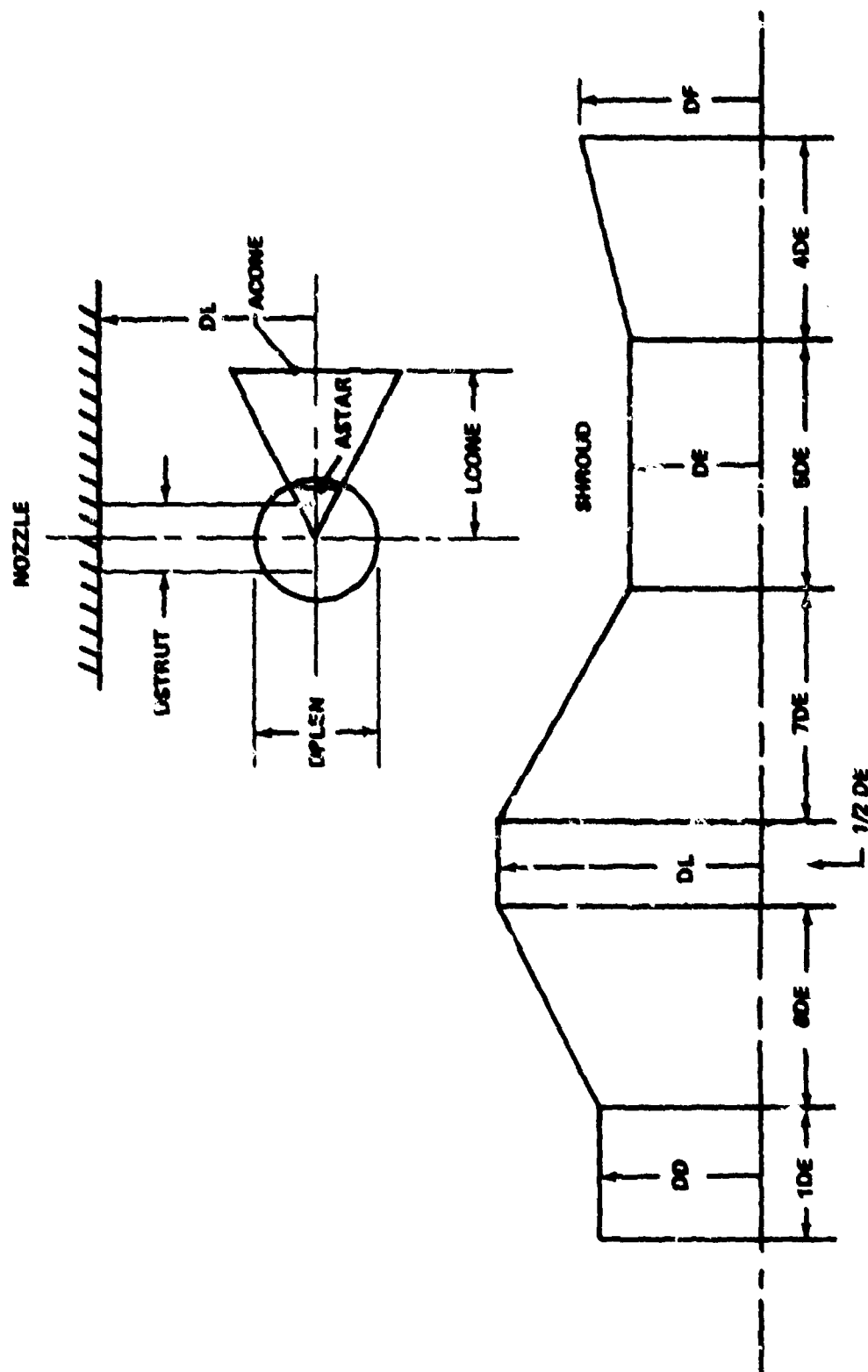


Figure 6. Subsonic-supersonic ejector nozzle and shroud.

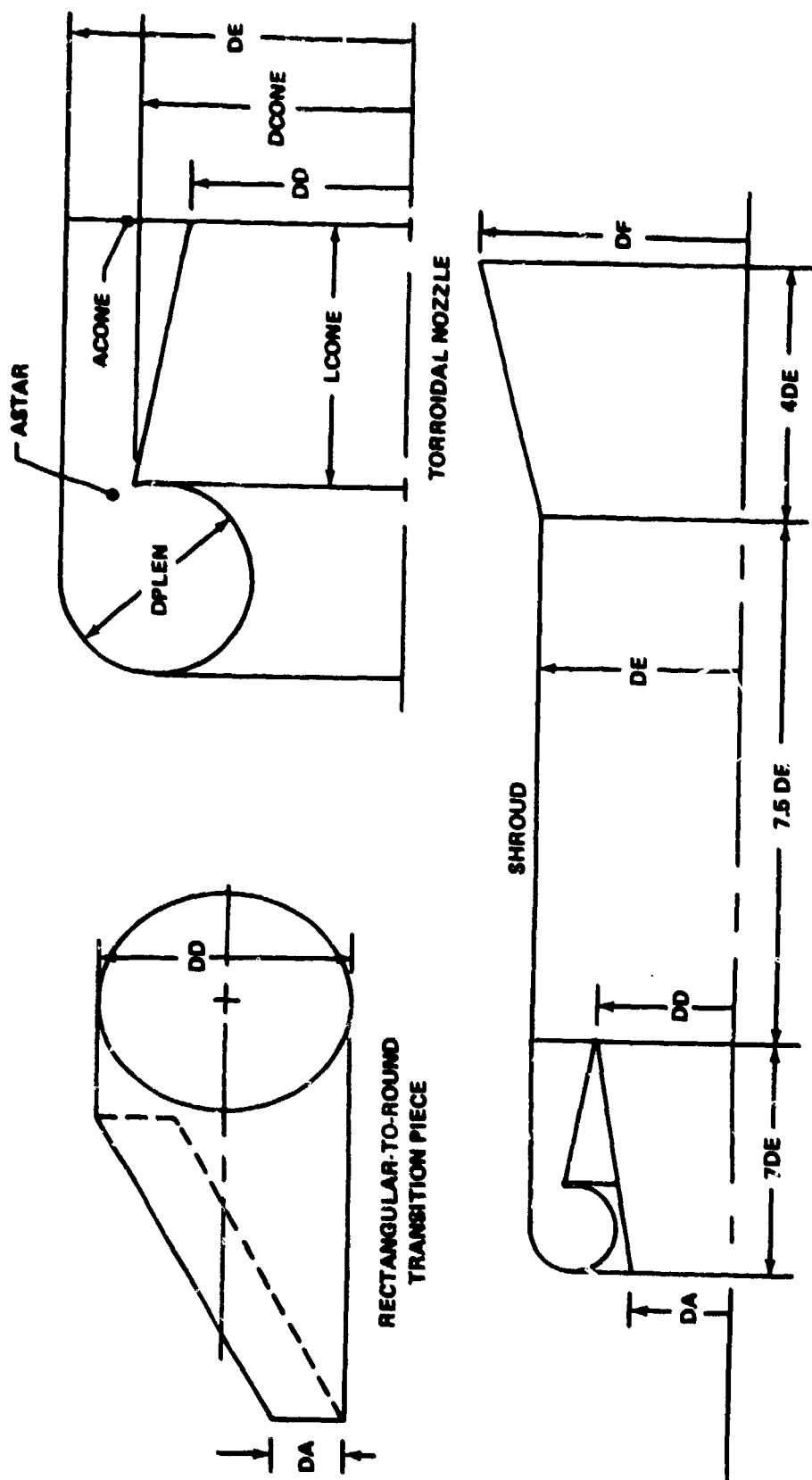


Figure 7. Supersonic-supersonic ejector transition piece, nozzle, and shroud.

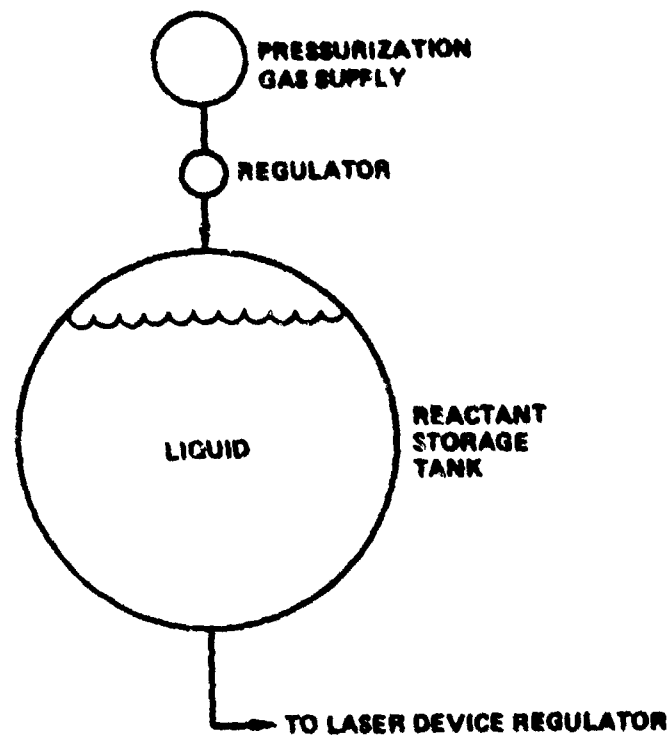


Figure 8. Pressurized gas system.

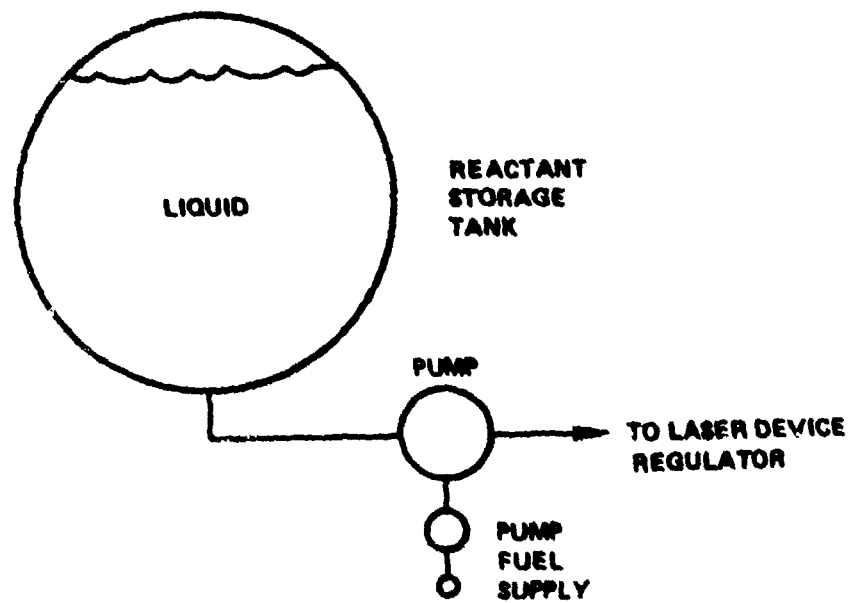


Figure 9. Pump feed system.

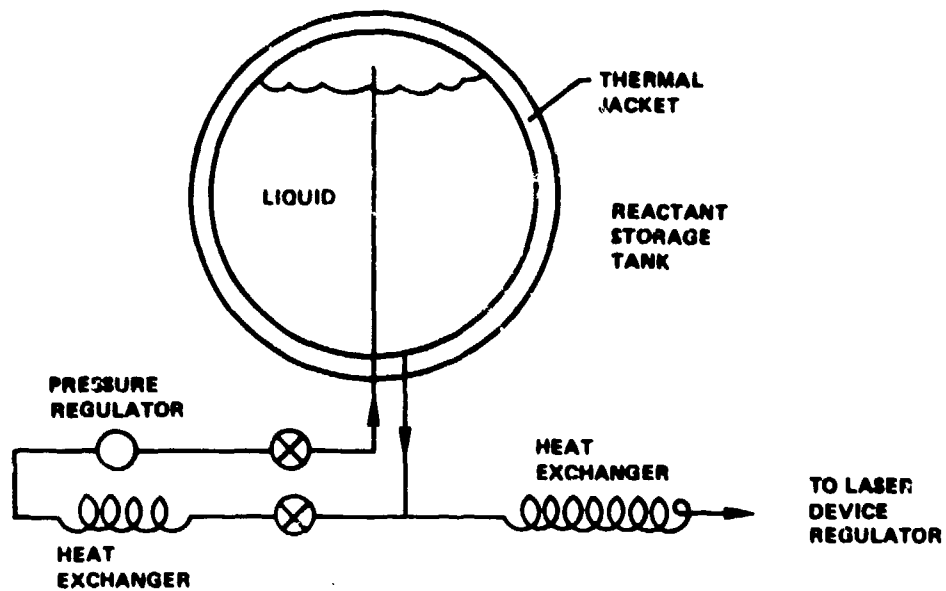


Figure 10. Heater pressurization system.

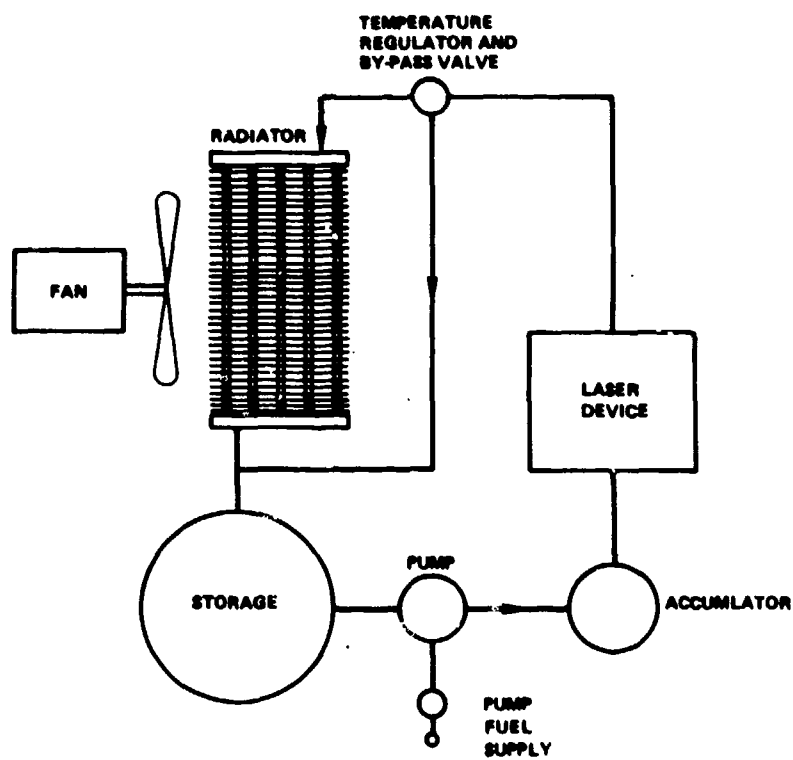


Figure 11. Radiator-fan-pump cooling system.

III. PROGRAM INPUT DATA

Inputs to CLAP are either by namelist or by alphanumeric symbols, usually "YES" or "NO" unless otherwise specified. Two example cases are given in Appendix G, one using only the built-in default values and the second demonstrating most of the input options.

A. COMBUSTION CHEMISTRY SECTION (CCS)

Inputs to CCS are fairly straightforward. The reactant mass flow rates must correspond with the area of the experimental device, AEXP, but need not be scaled for any particular laser system since only the mole fluxes are important. The area of the experimental device, AEXP, refers only to the nozzle bank area as defined in the input section for the LDS overlay.

The input variables for CCS are:

- AEXP = Nozzle bank area of the experimental device [m^2].
- ALPHA = Fluorine dissociation fraction.
- DFORHF = Control variable such that:
 - = "DF" for a DF chemical laser.
 - = "HF" for a HF chemical laser.
- N1 = Number of carbon atoms in primary combustor fuel WPR1.
- N2 = Number of hydrogen (deuterium)* atoms in primary combustor fuel WPR1.
- N3 = Number of nitrogen atoms in primary combustor oxidizer WPR4.
- N4 = Number of fluorine atoms in primary combustor oxidizer WPR4.
- WPG = Mass flow rate of mirror purge N_2 (kg/s).
- WPR1 = Mass flow rate of primary combustor fuel $\text{C}_{\text{N1}}\text{H}_{\text{N2}}$ ($\text{C}_{\text{N1}}\text{D}_{\text{N2}}$) (kg/s).
- WPR2 = Mass flow rate of primary combustor diluent He (kg/s).
- WPR3 = Mass flow rate of primary combustor diluent N_2 (kg/s).
- WPR4 = Mass flow rate of primary combustor oxidizer $\text{N}_{\text{N3}}\text{F}_{\text{N4}}$ (kg/s).
- WSR1 = Mass flow rate of secondary reactant D_2 (H_2) (kg/s).
- WSR2 = Mass flow rate of secondary diluent He (kg/s).
- WSR3 = Mass flow rate of secondary diluent N_2 (kg/s).

B. LASER DEVICE SECTION (LDS)

The inputs to LDS consist primarily of the principal device dimensions illustrated in Figures 12, 13, and 14 for the laser nozzles, nozzle bank/base, and laser cavity.

*Compounds in parenthesis refer to HF laser chemistry.

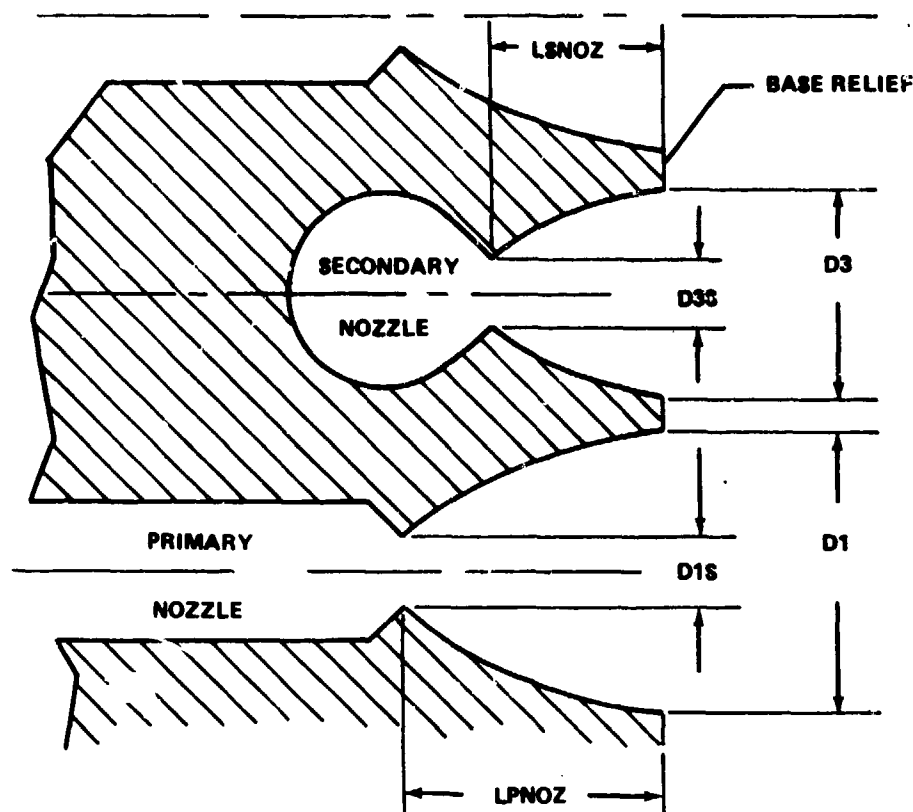


Figure 12. Laser nozzle detail.

The greatest confusion involves the difference between nozzle bank and nozzle base, and packing fraction versus bank relief fraction. Early laser demonstration devices had a nozzle array built as a single unit and termed a nozzle bank with individual nozzles separated at the face by no-flow areas termed base relief. With the advent of modular devices, several of these nozzle banks were inserted into a larger unit and separated by no-flow areas termed bank relief to form a nozzle "base." Therefore, nozzle bank area refers to the nozzle array inserts while the nozzle base area includes both nozzle banks and surrounding bank relief areas. Considering only a nozzle bank, the packing fraction is defined as:

$$PKFRAC = \frac{\text{total flow (void) area}}{\text{total area}} = \frac{\text{nozzle bank area} - \text{base relief area}}{\text{nozzle bank area}}$$

Considering the entire nozzle base, the bank relief fraction is defined as:

$$BRFRAC = \frac{\text{total area} - \text{bank relief area}}{\text{total area}} = \frac{\text{nozzle bank area}}{\text{total area}}$$

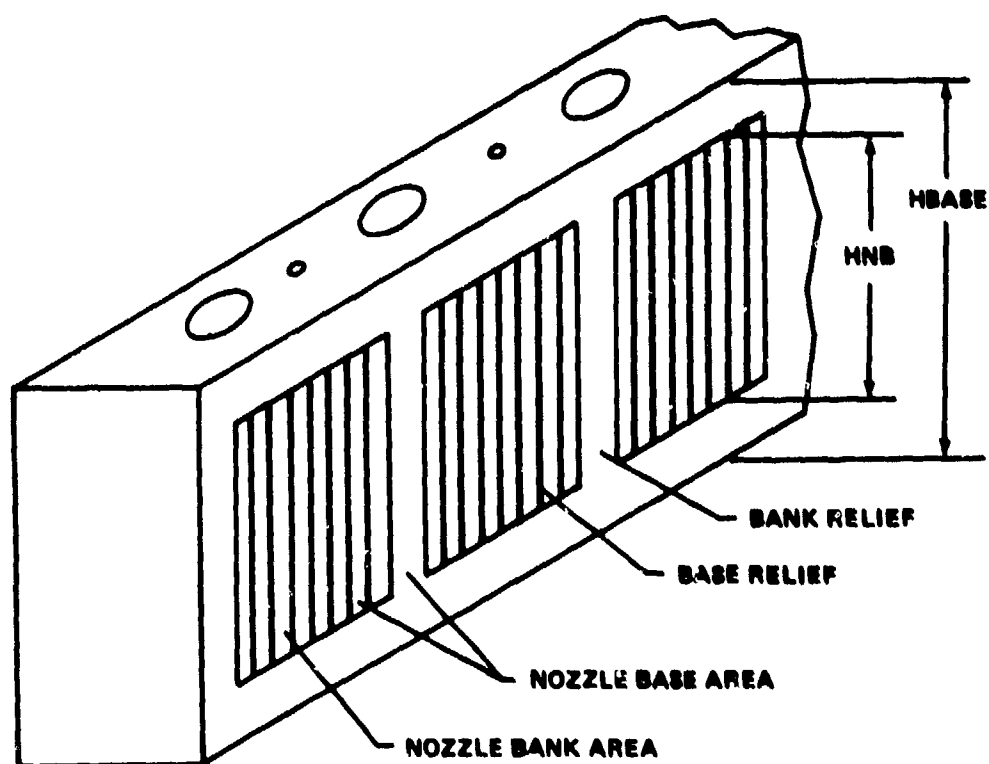


Figure 13. Laser nozzle bank/base detail.

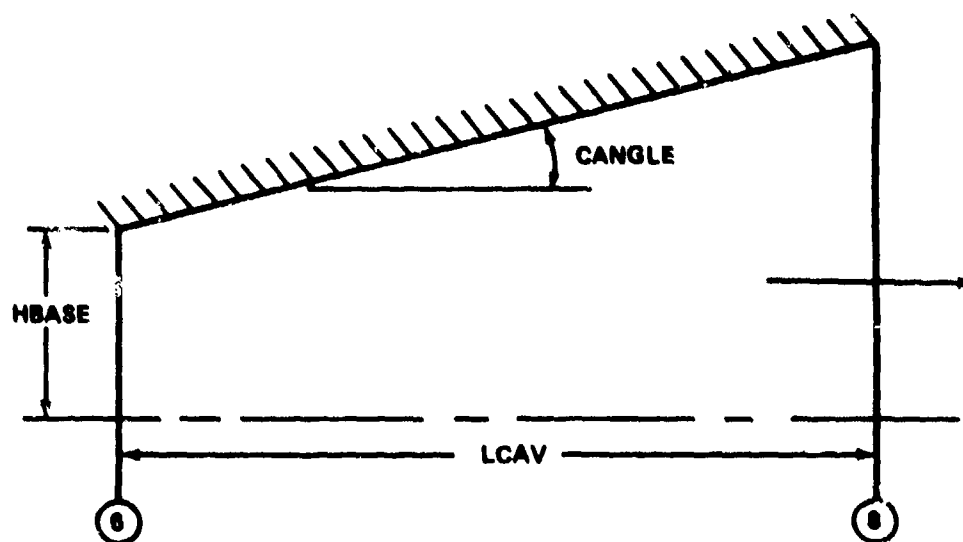


Figure 14. Laser cavity detail.

where the nozzle bank area as also used in CCS inputs includes both voids and base relief.

The input variables for the LDS overlay are:

- BRFRAC = Bank relief fraction.
- CANGLE = Laser cavity half-angle (rad).
 - D1 = Primary nozzle exit diameter (m).
 - D1S = Primary nozzle throat diameter (m).
 - D3 = Secondary nozzle exit diameter (m).
 - D3S = Secondary nozzle throat diameter (m)*.
- GEOMPN = Primary nozzle control variable such that:
 - = "AX" for axisymmetric nozzles.
 - = "2D" for slit nozzles.
- GEOMSN = Primary nozzle control variable such that:
 - = "AX" for axisymmetric nozzles.
 - = "2D" for slit nozzles.
- HBASE = Height of nozzle base (m).
- HNB = Height of nozzle bank (m).
- LCAV = Laser cavity centerline length (m).
- LDSS2 = Control variable such that:
 - = "P10" to specify P10 and solve for T10.
 - = "T10" to specify T10 and solve for P10.
- LPNOZ = Centerline length of a primary nozzle from throat to exit plane (m).
- LSNOZ = Centerline length of a secondary nozzle from throat to exit plane (m).
- NSPNOZ = Number of secondary-to-primary nozzles.
- PKFRAC = Nozzle packing fraction.
 - P10 = Primary combustor or nozzle stagnation pressure (Pa).
 - T10 = Primary combustor or nozzle stagnation temperature (°K).
 - T30 = Secondary nozzle stagnation temperature (°K).
 - T70 = Mirror purge stagnation temperature (°K).

C. PRESSURE RECOVERY SECTION (PRS)

The number of inputs to PRS depends on the particular pressure recovery system chosen but are fairly obvious from the station numbers of Figures 3, 15, 16, and 17. A full discussion of the variables ETA12 and LIMIT is given in References 2 and 9.

The input variables for the PRS overlay are:

- A3A2 = Subsonic diffuser exit-to-entrance area ratio.
- A7A6 = Subsonic diffuser exit-to-entrance area ratio.
- EJECT = Control variable such that:
 - = "NO" for no pressure recovery subsystem.

*NOTE: D3 = D3S for constant-area, sonic nozzles.

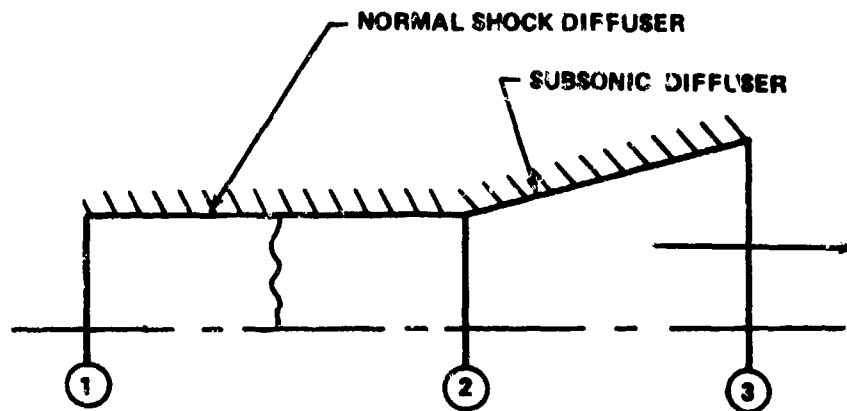


Figure 15. Supersonic-subsonic diffuser detail.

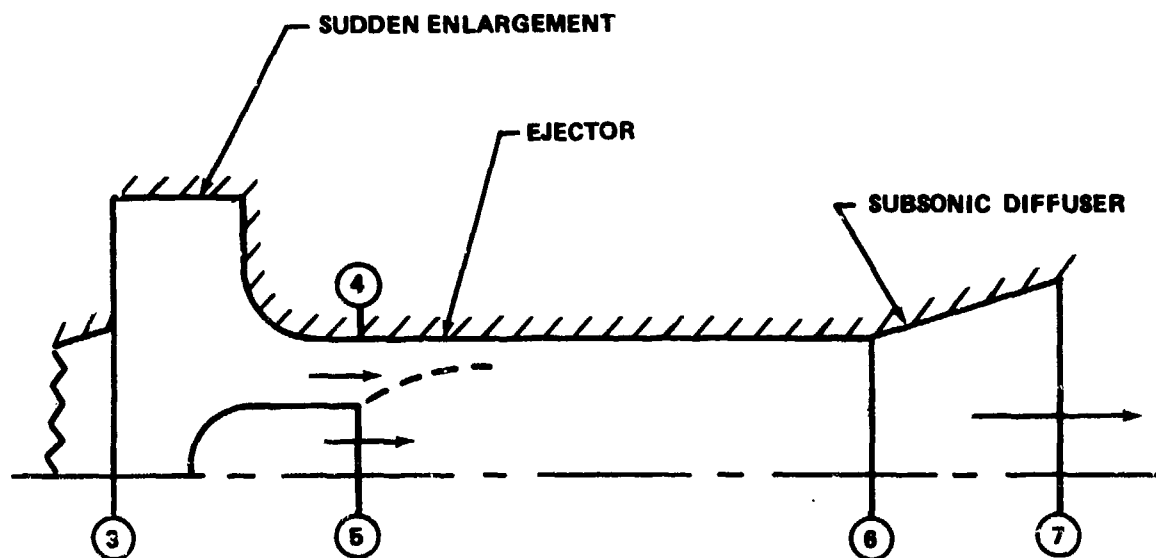


Figure 16. Constant-area, subsonic-supersonic ejector detail.

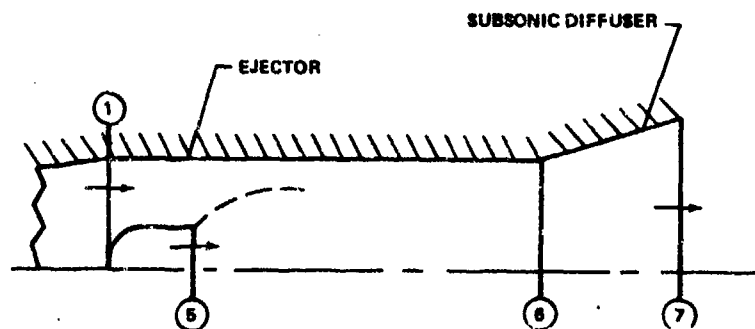


Figure 17. Constant-area, supersonic-supersonic ejector detail.

- "DIF" for a supersonic-subsonic diffuser subsystem.
- "CAE" for a constant-area, subsonic-supersonic ejector subsystem.
- "SSE" for a constant-area, supersonic-supersonic ejector subsystem.
- ETA12 - Normal shock diffuser coefficient.
- G5 - Specific heat ratio for the ejector primary or driver stream.
- LIMIT - Control variable to set the limiting condition on constant-area, supersonic-supersonic ejector operation such that:
 - "MPP" for the matched pressure point.
 - "ZSP" for the Zukoski separation point.
 - "ULP" for the upper limit point.
- MW5 - Molecular weight of the ejector primary or driver stream (kg/kmole).
- P50 - Ejector primary or driver stagnation pressure (Pa).
- P7 - Ambient pressure (Pa).

D. SYSTEM CALCULATION SECTION (SCS)

Inputs to SCS provide scaling and configuration information, select an ejector driver fluid if required, and determine the storage mode for each laser reactant.

The various storage mode inputs are too numerous to list but consist entirely of simple integer inputs as illustrated in Appendix G. The storage mode selection display for each reactant is output by the computer code and requires no user action.

The input variables for the SCS overlay are:

- EREACTION - Alphanumeric symbol for the ejector primary or driver reactant.
 - "N2H4" for a monopropellant driver.
 - "IRFNA/MMH" for a bipropellant driver.
- NBANK - Number of laser banks.
- NEJECT - Number of ejectors per laser bank.
 - 0, for the maximum allowable.
- RTIME - Laser run time (s).
- WPP3 - Free fluorine mass flow rate (kg/s).

IV. CONCLUSIONS AND RECOMMENDATIONS

Due to the complexity of high energy, chemical laser systems, a thorough understanding of the component interactions is required before a practical weapons system can be designed and fielded. Attempts to optimize any given component without regard to the total laser system

are likely fruitless. CLAP provides a quick, convenient, and effective means for conducting parametric studies of a total, integrated chemical laser system, thus allowing for innovation from a component standpoint while measuring total system implications.

CLAP was not meant to be an ultimate means of chemical laser system design, nor will the one-dimensional methods and empirical volume/mass relations allow it to be. Nonetheless, experience has shown that if properly used, the program will give surprisingly good quantitative as well as qualitative results; furthermore, if used with ingenuity, the program can simulate most laser device configurations including axisymmetric and slit nozzles, plane and cylindrical laser cavities, and high or low bank relief geometries.

To further develop and expand the usefulness of this computer code, a detailed description of the individual programs and subroutines will be published together with the background analysis.

REFERENCES

1. Mechtly, E. A., The International System of Units: Physical Constants and Conversion Factors, Revised, NASA SP-7012, 1969.
2. Addy, A. L., and Mikkelsen, C. D., An Investigation of Gas-Dynamic Flow Problems in Chemical Laser Systems, Department of Mechanical and Industrial Engineering, University of Illinois at Urbana-Champaign, Report No. UILU-ENG-74-4009, 1974.
3. Shapiro, A. H., Generalized One-Dimensional Flow, The Dynamics and Thermodynamics of Compressible Fluid Flow, New York, The Ronald Press Company, Vol. 1, 1953, pp. 219-262.
4. Zukoski, E. E., "Turbulent Boundary-Layer Separation in Front of a Forward-Facing Step," AIAA Journal, Vol. 5, No. 10, 1967, pp. 1746-1753.
5. Mikkelsen, C. D., Walker, H. J., and Oglukian, R. L., Scalability of a Combustion Driven Chemical Laser Device (U), Proceedings of the 14th JANNAF Combustion Meeting, U.S. Air Force Academy, Colorado Springs, Colorado, August 15-19, 1977, CPIA Publication 292, Vol. III, pp. 131-137 (Classified Confidential).
6. JANAF Thermochemical Tables, Second Edition, National Bureau of Standards Publication NSRDS-NBS 37, 1971.
7. Svehla, R. A., Estimated Viscosities and Thermal Conductivities of Gases at High Temperatures, NASA TR-132, 1962.
8. Bird, R. B., Stewart, W. E., and Lightfoot, E. N., Transport Phenomena, New York: John Wiley & Sons, Inc., 1960, p. 24.
9. Sandberg, M. R., Mikkelsen, C. D., and Addy, A. L., Theoretical and Experimental Analysis of the Constant-Area, Supersonic-Supersonic Ejector, Department of Mechanical and Industrial Engineering, University of Illinois at Urbana-Champaign, Report No. UILU-ENG-76-4003, 1976.
10. Mikkelsen, C. D., Theoretical and Experimental Analysis of the Constant-Area, Supersonic-Supersonic Ejector, Ph.D. Thesis, University of Illinois at Urbana-Champaign, 1976.

Appendix A. CHEMICAL LASER ANALYSIS PROGRAM (CLAP)-OVERLAY MAIN

REMOVED FROM BLANK

```

C*****MAIN 0100
C*
C*          CHEMICAL LASER ANALYSIS PROGRAM (CLAP)      MAIN 0110
C*
C*          WRITTEN BY: C.L. ADAMS                      MAIN 0120
C*                      A.L. ADDY                      MAIN 0130
C*                      R.D. MASSEY                   MAIN 0140
C*                      C.D. NIKKELSEN                MAIN 0150
C*                      G.F. MORR                     MAIN 0160
C*                      R.L. OOLUKIAN                 MAIN 0170
C*                      B.J. WALKER                   MAIN 0180
C*
C*          1 JANUARY 77 - 1 JANUARY 79                MAIN 0190
C*
C*          AERODYNAMICS GROUP (ORDNI-TOK)             MAIN 0200
C*          SYSTEM SIMULATION DIRECTORATE             MAIN 0210
C*          U.S. ARMY MISSILE RESEARCH & DEVELOPMENT COMMAND MAIN 0220
C*          REDSTONE ARSENAL, ALABAMA 35899           MAIN 0230
C*
C*****MAIN 0240
C*          MAIN 0250
C*          MAIN 0260
C*          MAIN 0270
C*          MAIN 0280
C*          MAIN 0290
C*          MAIN 0300
C*          MAIN 0310
C*          MAIN 0320
C*          PROGRAM CLAP REQUIRES THE FOLLOWING OVERLAYS: MAIN 0330
C*
C*          MAIN      CCS      LDS      PRS      SCS      MAIN 0340
C*
C*          OVERLAY MAIN REQUIRES THE FOLLOWING SUBROUTINES: MAIN 0350
C*
C*          OUTENG      MAIN 0360
C*
C*          OVERLAY CCS REQUIRES THE FOLLOWING SUBROUTINES: MAIN 0370
C*
C*          INCCS      OUTCCS      MAIN 0380
C*
C*          OVERLAY LDS REQUIRES THE FOLLOWING SUBROUTINES: MAIN 0390
C*
C*          CAMS      CPCALC      EXPAN      INLDS      ITER      MAIN 0400
C*          LPLAYR      LCAS      LCFS      LPNCS      LSNCS1     MAIN 0410
C*          LSNCS2      MAAS      OUTLOS      VISC      MAIN 0420
C*
C*          OVERLAY PRS REQUIRES THE FOLLOWING SUBROUTINES: MAIN 0430
C*
C*          CAEFC      CAEOCV      CAEOS      INPRS      ITER      MAIN 0440
C*          MAAS      MIN      NSDS      OUTPRS      SDS      MAIN 0450
C*          SSFOS      SSES      MAIN 0460
C*
C*          OVERLAY SCS REQUIRES THE FOLLOWING SUBROUTINES: MAIN 0470
C*
C*          INSCS      OUTSCS      VMAW      VMCS      VMC2H4     MAIN 0480
C*          VMD2      VMF2      VMHE      VMH2      VMIRFNA     MAIN 0490
C*          VMMH      VMNF3      VMN2      VMN2H4     MAIN 0500
C*
C*****MAIN 0510
C*          MAIN 0520
C*          MAIN 0530
C*          MAIN 0540
C*          MAIN 0550
C*          MAIN 0560
C*          MAIN 0570
C*          MAIN 0580
C*          MAIN 0590
C*          MAIN 0600
C*          MAIN 0610
C*          MAIN 0620
C*          MAIN 0630
C*****MAIN 0640

```

APPENDIX A
PROGRAM MAIN

CHEMICAL LASER ANALYSIS PROGRAM (CLAP)
OVERLAY MAIN

PAGE A- 2

C		MAIN	0650
C		MAIN	0660
	OVERLAY(MAIN,0.0)	MAIN	0670
	PROGRAM MAIN(TAPE1=512,TAPE2=512,TAPE3=512,TAPE4=512,TAPE5,TAPE6,	MAIN	0680
	TAPE20,TAPE30)	MAIN	0690
C		MAIN	0700
	IMPLICIT REAL(L,N)	MAIN	0710
	INTEGER SC54	MAIN	0720
C		MAIN	0730
	COMMON/CCS1/CCS1	MAIN	0740
	COMMON/CCS9/CCS9(4)	MAIN	0750
	COMMON/CCS10/CCS10(4)	MAIN	0760
	COMMON/CCS13/CCS13(4)	MAIN	0770
	COMMON/CCS14/CCS14	MAIN	0780
	COMMON/CCS15/CCS15	MAIN	0790
	COMMON/CCS16/CCS16(3)	MAIN	0800
C		MAIN	0810
	COMMON/LDS1/LDS1	MAIN	0820
C		MAIN	0830
	COMMON/MAIN1/FAIL	MAIN	0840
	COMMON/MAIN2/FLOW	MAIN	0850
	COMMON/MAIN3/SETCCS	MAIN	0860
	COMMON/MAIN4/SETLDS	MAIN	0870
	COMMON/MAIN5/SETPRS	MAIN	0880
	COMMON/MAIN6/SETSCS	MAIN	0890
C		MAIN	0900
	COMMON/PRS1/PRS1	MAIN	0910
C		MAIN	0920
	COMMON/SC54/SC54(10)	MAIN	0930
C		MAIN	0940
	DATA CCS/3HCCS/,LDS/3HLD5/,PRS/3HPRS/,SCS/3HSCS/	MAIN	0950
	DATA SETCCS/3HYES/,SETLDS/3HYES/,SETPRS/3HYES/,SETSCS/3HYES/	MAIN	0960
	DATA CHOKE/3HCHOKE/,NO/2HNO/,RECALL/4HRECALL/,YES/3HYES/	MAIN	0970
C		MAIN	0980
	NAMLIST/NLCCS/AEXP,ALPHA,N1,N2,N3,N4,WPR1,WPR2,WPR3,WPR4,	MAIN	0990
	-USR1,USR2,USR3	MAIN	1000
	NAMLIST/NLDS/BRFRAC,CANGLE,D1,D1S,D3,D3S,HNB,LCAV,LPNOZ,LSNOZ,	MAIN	1010
	-NSPNOZ,PKFRAC,P10,T10,T30,T70	MAIN	1020
	NAMLIST/NLPRS/A3A2,A7A6,ETA12,GS,MWS,P50,P7,T50	MAIN	1030
	NAMLIST/NLSCS/NRANK,NEJECT,RTIME,WPP3	MAIN	1040
C		MAIN	1050
C		MAIN	1060
C	*****	MAIN	1070
C*		MAIN	1080
C*	COMBUSTION CHEMISTRY SECTION	MAIN	1090
C*		MAIN	1100
C	*****	MAIN	1110
C		MAIN	1120
C		MAIN	1130
	CALL CONNED(5)	MAIN	1140
	CALL CONNED(6)	MAIN	1150
101	FAIL=NO	MAIN	1160
	CALL OVERLAY(CCS,1.0,RECALL)	MAIN	1170
C		MAIN	1180
C		MAIN	1190

C.....	MAIN	1200
C.....	MAIN	1210
C.....	MAIN	1220
C.....	MAIN	1230
C.....	MAIN	1240
C.....	MAIN	1250
C.....	MAIN	1260
C.....	MAIN	1270
CALL OVERLAY(LDS,2.0,RECALL)	MAIN	1280
IF(FAIL,EQ,YES) GO TO 103	MAIN	1290
IF(FLOW,EQ,CHOKE) GO TO 102	MAIN	1300
C.....	MAIN	1310
C.....	MAIN	1320
C.....	MAIN	1330
C.....	MAIN	1340
C.....	MAIN	1350
C.....	MAIN	1360
C.....	MAIN	1370
C.....	MAIN	1380
CALL OVERLAY(PRS,3.0,RECALL)	MAIN	1390
IF(FAIL,EQ,YES) GO TO 103	MAIN	1400
C.....	MAIN	1410
C.....	MAIN	1420
C.....	MAIN	1430
C.....	MAIN	1440
C.....	MAIN	1450
C.....	MAIN	1460
C.....	MAIN	1470
C.....	MAIN	1480
C.....	MAIN	1490
CALL OVERLAY(SCS,4.0,RECALL)	MAIN	1500
IF(FAIL,EQ,YES) GO TO 103	MAIN	1510
C.....	MAIN	1520
C.....	MAIN	1530
C.....	MAIN	1540
C.....	MAIN	1550
C.....	MAIN	1560
C.....	MAIN	1570
C.....	MAIN	1580
C.....	MAIN	1590
C.....	MAIN	1600
102 CALL OUTENG	MAIN	1610
C.....	MAIN	1620
C.....	MAIN	1630
C.....	MAIN	1640
C.....	MAIN	1650
C.....	MAIN	1660
C.....	MAIN	1670
C.....	MAIN	1680
C.....	MAIN	1690
103 WRITE(6,104)	MAIN	1700
READ(5,105)RUN	MAIN	1710
IF(RUN,EQ,YES) GO TO 101	MAIN	1720
104 FORMAT('1.12.1 TO RESTART PROGRAM ENTER "YES",/1.2.1 TO STOP PROGRAM	MAIN	1730
-AM ENTER "NO")	MAIN	1740

APPENDIX A
PROGRAM MAIN

CHEMICAL LASER ANALYSIS PROGRAM (CLAP)
OVERLAY MAIN

PAGE A- 4

105	FORMAT(A3)	MAIN	1750
C		MAIN	1760
C		MAIN	1770
C	.....	MAIN	1780
C*		MAIN	1790
C*	DUMMY READ/WRITE STATEMENTS	MAIN	1800
C*		MAIN	1810
C	.....	MAIN	1820
C		MAIN	1830
C		MAIN	1840
	STOP	MAIN	1850
106	READ(1)	MAIN	1860
	WRITE(1)	MAIN	1870
	READ(5,NLCCS)	MAIN	1880
	READ(5,NLDS)	MAIN	1890
	READ(5,NLPRS)	MAIN	1900
	READ(5,NLSCS)	MAIN	1910
	END	MAIN	1920

SUBROUTINE OUTENG	OUTENG 0100
C	OUTENG 0110
C	OUTENG 0120
C.....	OUTENG 0130
C*	OUTENG 0140
C*	OUTENG 0150
C*	OUTENG 0160
C.....	OUTENG 0170
C	OUTENG 0180
C.....	OUTENG 0190
C*	OUTENG 0200
C* SUBROUTINE OUTENG PRINTS THE RESULTS OF PROGRAM CLAP IN MIXED	OUTENG 0210
C* ENGINEERING UNITS ON TERMINALS WITH A MINIMUM OF 132 CHARACTERS	OUTENG 0220
C* PER LINE.	OUTENG 0230
C*	OUTENG 0240
C.....	OUTENG 0250
C	OUTENG 0260
C	OUTENG 0270
IMPLICIT REAL(L,M,N)	OUTENG 0280
C	OUTENG 0290
INTEGER NRANK,NEJECT,N1,N2,N3,N4	OUTENG 0300
C	OUTENG 0310
COMMON/CCS2/CCS1,ALPHA,CCS2(8)	OUTENG 0320
C	OUTENG 0330
COMMON/CCS3/DFORMF	OUTENG 0340
C	OUTENG 0350
COMMON/CCS4/CCS3	OUTENG 0360
C	OUTENG 0370
COMMON/CCS5/N1,N2,N3,N4	OUTENG 0380
C	OUTENG 0390
COMMON/CCS6/OMEGA,OMENTRW,PSIC,PSIL,PSILTRW,RC,RLF,WFCP1,WFCP2,	OUTENG 0400
-WFCP3,WFCP4,WFCP5,WFCP6	OUTENG 0410
C	OUTENG 0420
COMMON/CCS7/CCS4	OUTENG 0430
C	OUTENG 0440
COMMON/CCS8/RL	OUTENG 0450
C	OUTENG 0460
COMMON/CCS11/W7W2	OUTENG 0470
C	OUTENG 0480
COMMON/CCS12/XFCP1(2),XFCP2(2),XFCP3(2),XFCP4(2),XFCP5(2),XFCP6(2)	OUTENG 0490
C	OUTENG 0500
COMMON/LDS2/LDS1(4),GEOMPN,GEOMSN,LDS2(2),NSPNOZ,PKFRAC,	OUTENG 0510
-LDS3(4)	OUTENG 0520
C	OUTENG 0530
COMMON/LDS3/LDS4,A1A1SE,A1A1SE,LDS5(2),A3A3SE,A3A3SE,LDS6(35),RE1,	OUTENG 0540
-RE3,RE8,LDS7(23),W5W2,W6W2,W8W2,LDS8,X4X2,X5X2,X6X2,X7X2,X8X2	OUTENG 0550
C	OUTENG 0560
COMMON/LDS4/LDS9(10)	OUTENG 0570
C	OUTENG 0580
COMMON/LDS5/BRFRAC,LDS10(4)	OUTENG 0590
C	OUTENG 0600
COMMON/LDS6/LDS11(2),W4W2	OUTENG 0610
C	OUTENG 0620
COMMON/MAIN2/FLOW	OUTENG 0630
C	OUTENG 0640

```
COMMON/PRS2/PRS1(4),ETA23,ETA67,PRS2(48),W2W1,PRS3,W4W1,W6W1,W7W1,OUTENG 0650
-X2X1,PRS4,X4X1,X4X1,X6X1,X7X1 OUTENG 0660
C OUTENG 0670
COMMON/PRS3/A3A2,ATA6,ETA12,LIMIT,PRS5(3) OUTENG 0680
C OUTENG 0690
COMMON/PRS4/PRS6(3),W5W1 OUTENG 0700
C OUTENG 0710
COMMON/PRS5/EJECT OUTENG 0720
C OUTENG 0730
COMMON/PRS6/PRS7(2) OUTENG 0740
C OUTENG 0750
COMMON/SCS1/SCSS2 OUTENG 0760
C OUTENG 0770
COMMON/SCS2/EREACT,WRANK,WEJECT,RTIME,SCS1 OUTENG 0780
C OUTENG 0790
COMMON/SCS3/SCS2(47) OUTENG 0800
C OUTENG 0810
COMMON/SCS3/STMODE(10,10) OUTENG 0820
C OUTENG 0830
DATA CAE/3HCAE/,CHOKE/5HCHOKE/,DF/2HDF/,HF/2HHF/,WPD/3HWP/,
-NO/2HNO/,SEP/3HSEP/,SSE/3HSSE/,ULP/3HULP/,ZSP/3HZSP/ OUTENG 0840
C OUTENG 0850
C OUTENG 0860
C OUTENG 0870
C..... OUTENG 0880
C..... OUTENG 0890
C..... OUTENG 0900
C..... OUTENG 0910
C..... OUTENG 0920
C..... OUTENG 0930
C..... OUTENG 0940
C..... OUTENG 0950
C..... OUTENG 0960
C..... OUTENG 0970
C..... OUTENG 0980
C..... OUTENG 0990
C..... OUTENG 1000
C..... OUTENG 1010
C..... OUTENG 1020
C..... OUTENG 1030
C..... OUTENG 1040
C..... OUTENG 1050
C..... OUTENG 1060
C..... OUTENG 1070
C..... OUTENG 1080
C..... OUTENG 1090
CALL DATE(RDATE) OUTENG 1100
WRITE(30,201)RDATE OUTENG 1110
IF(DFORMF.EQ.DF) WRITE(30,202)AEXP,ALPHA,DFORMF,N1,N2,N3,N4,WPG, OUTENG 1120
-WPR1,N1,N2,WPR2,WPR3,WPR4,N3,N4,WSR1,WSR2,WSR3 OUTENG 1130
IF(DFORMF.EQ.HF) WRITE(30,203)AEXP,ALPHA,DFORMF,N1,N2,N3,N4,WPG, OUTENG 1140
-WPR1,N1,N2,WPR2,WPR3,WPR4,N3,N4,WSR1,WSR2,WSR3 OUTENG 1150
WRITE(30,204)FDAA,OMEGA,OMEGATW,PSIC,PSIL,PSILTRW,G,RC,RL,RLF OUTENG 1160
IF(DFORMF.EQ.DF) WRITE(30,205)WFCP1,XFCP1(2),WFCP2,XFCP2(2),WFCP3, OUTENG 1170
-XFCP3(2),WFCP4,XFCP4(2),WFCP5,XFCP5(2),WFCP6,XFCP6(2) OUTENG 1180
IF(DFORMF.EQ.HF) WRITE(30,206)WFCP1,XFCP1(2),WFCP2,XFCP2(2),WFCP3, OUTENG 1190
-XFCP3(2),WFCP4,XFCP4(2),WFCP5,XFCP5(2),WFCP6,XFCP6(2) OUTENG 1190
C
```

C	OUTENG 1200
C.....	OUTENG 1210
C*	OUTENG 1220
C*	OUTENG 1230
C*	OUTENG 1240
C.....	OUTENG 1250
C	OUTENG 1260
C	OUTENG 1270
	OUTENG 1280
A1=LDS4*7.03066E+02	OUTENG 1290
A2=LDS5(1)*7.03066E+02	OUTENG 1300
A3=LDS5(2)*7.03066E+02	OUTENG 1310
A4=LDS6(1)*7.03066E+02	OUTENG 1320
A5=LDS6(2)*7.03066E+02	OUTENG 1330
A6=LDS6(3)*7.03066E+02	OUTENG 1340
A8=LDS9(1)*7.03066E+02	OUTENG 1350
CANOLE=LDS10(1)/1.7453292519943E-02	OUTENG 1360
D1=LDS1(1)/2.54E-02	OUTENG 1370
D1S=LDS1(2)/2.54E-02	OUTENG 1380
D3=LDS1(3)/2.54E-02	OUTENG 1390
D3S=LDS1(4)/2.54E-02	OUTENG 1400
G1=LDS6(4)	OUTENG 1410
G2=LDS6(5)	OUTENG 1420
G3=LDS6(6)	OUTENG 1430
G4=LDS6(7)	OUTENG 1440
G5=LDS6(8)	OUTENG 1450
G6=LDS6(9)	OUTENG 1460
G7=LDS6(10)	OUTENG 1470
G8=LDS9(2)	OUTENG 1480
H04SE=LDS10(2)/2.54E-02	OUTENG 1490
HNR=LDS10(3)/2.54E-02	OUTENG 1500
LCAV=LDS10(4)/2.54E-02	OUTENG 1510
LPNOZ=LDS2(1)/2.54E-02	OUTENG 1520
LSNOZ=LDS2(2)/2.54E-02	OUTENG 1530
LSEP=LDS6(11)/2.54E-02	OUTENG 1540
MW1=LDS6(12)	OUTENG 1550
MW2=LDS6(13)	OUTENG 1560
MW3=LDS6(14)	OUTENG 1570
MW4=LDS6(15)	OUTENG 1580
MW5=LDS6(16)	OUTENG 1590
MW6=LDS6(17)	OUTENG 1600
MW7=LDS6(18)	OUTENG 1610
MW8=LDS9(3)	OUTENG 1620
M1=LDS6(19)	OUTENG 1630
M2=LDS6(20)	OUTENG 1640
M3=LDS6(21)	OUTENG 1650
M4=LDS6(22)	OUTENG 1660
M5=LDS6(23)	OUTENG 1670
M6=LDS6(24)	OUTENG 1680
M8=LDS9(4)	OUTENG 1690
NPNOZ=LDS6(25)*0.45359	OUTENG 1700
NSNOZ=LDS6(26)*0.45359	OUTENG 1710
P1=LDS6(27)/1.333224E+02	OUTENG 1720
P10=LDS3(1)/6.8947572E+03	OUTENG 1730
P2=LDS6(28)/1.333224E+02	OUTENG 1740
P20=LDS11(1)/6.8947572E+03	

APPENDIX A
SUBROUTINE OUTENG

CHEMICAL LASER ANALYSIS PROGRAM (CLAP)
OVERLAY MAIN

PAGE A- 8

```

P3=LDS6(29)/1.333224E+02
P30=LDS6(30)/6.8947572E+03
P4=LDS6(31)/1.333224E+02
P40=LDS6(32)/6.8947572E+03
P5=LDS6(32)/1.333224E+02
P50=LDS6(33)/1.333224E+02
P6=LDS6(34)/1.333224E+02
P60=LDS6(35)/1.333224E+02
P8=LDS9(5)/1.333224E+02
P80=LDS9(6)/1.333224E+02
R1=LDS7(1)/1.0E+03
R10=LDS7(2)/1.0E+03
R2=LDS7(3)/1.0E+03
R20=LDS7(4)/1.0E+03
R3=LDS7(5)/1.0E+03
R30=LDS7(6)/1.0E+03
R4=LDS7(7)/1.0E+03
R40=LDS7(8)/1.0E+03
R5=LDS7(9)/1.0E+03
R50=LDS7(10)/1.0E+03
R6=LDS7(11)/1.0E+03
R60=LDS7(12)/1.0E+03
R8=LDS9(7)/1.0E+03
R80=LDS9(8)/1.0E+03
T1=LDS7(13)
T10=LDS7(2)
T2=LDS7(14)
T20=LDS7(15)
T3=LDS7(16)
T30=LDS7(13)
T4=LDS7(17)
T40=LDS7(18)
T5=LDS7(19)
T50=LDS7(20)
T6=LDS7(21)
T60=LDS7(22)
T7=LDS7(4)
T8=LDS9(9)
T80=LDS9(10)
W3W=LDS7(23)
X3X=LDS6

OUTENG 1750
OUTENG 1760
OUTENG 1770
OUTENG 1780
OUTENG 1790
OUTENG 1800
OUTENG 1810
OUTENG 1820
OUTENG 1830
OUTENG 1840
OUTENG 1850
OUTENG 1860
OUTENG 1870
OUTENG 1880
OUTENG 1890
OUTENG 1900
OUTENG 1910
OUTENG 1920
OUTENG 1930
OUTENG 1940
OUTENG 1950
OUTENG 1960
OUTENG 1970
OUTENG 1980
OUTENG 1990
OUTENG 2000
OUTENG 2010
OUTENG 2020
OUTENG 2030
OUTENG 2040
OUTENG 2050
OUTENG 2060
OUTENG 2070
OUTENG 2080
OUTENG 2090
OUTENG 2100
OUTENG 2110
OUTENG 2120
OUTENG 2130
OUTENG 2140
OUTENG 2150
OUTENG 2160
OUTENG 2170
OUTENG 2180
OUTENG 2190
OUTENG 2200
OUTENG 2210
OUTENG 2220
OUTENG 2230
OUTENG 2240
OUTENG 2250
OUTENG 2260
OUTENG 2270
OUTENG 2280
OUTENG 2290

C
C
WRITE(30,301)
IF(LDSS2.EQ.3HT10) WRITE(30,302)BRFRAC,CANGLF,D1,D1R,D3,D3S,
-GEOMPN,GEOMSN,HBASE,HNB,LCAV,LPNOZ,LSNOZ,NSPNOZ,PKFRAC,P10,T30,T70
IF(LDSS2.EQ.3HT10) WRITE(30,303)BRFRAC,CANGLF,D1,D1R,D3,D3S,
-GEOMPN,GEOMSN,HBASE,HNB,LCAV,LPNOZ,LSNOZ,NSPNOZ,PKFRAC,T10,T30,T70
WRITE(30,304)A1,A1A1SE,A1A1SE,0,MW1,M1,NPNOZ,P1,P10,RE1,R1,R10,
-T1,T10
WRITE(30,305)A2,G2,MW2,M2,P2,P20,R2,R20,T2,T20
WRITE(30,306)A3,A3A3SE,A3A3SE,0,MW3,M3,NSNOZ,P3,P30,RE3,R3,R30,
-T3,T30,W3W1,X3X1
WRITE(30,307)A4,G4,MW4,M4,P4,P40,R4,R40,T4,T40,W4W2,X4X2
WRITE(30,308)A5,G5,MW5,M5,P5,P50,R5,R50,T5,T50,W5W2,X5X2

```

WRITE (30,309)AB,GB,MW6,M6,PA,P60,R6,RA0,T6,T60,WSWP,X6X2	OUTENS 2300
WRITE (30,310)BT,MW7,T70,WTW2,X7X2	OUTENS 2310
IF (FLOW,EQ,SEP) GO TO 101	OUTENS 2320
IF (FLOW,EQ,CHOKE) GO TO 102	OUTENS 2330
WRITE (30,311)AB,GB,MW8,MA,PA,P80,REA,R8,RA0,T8,T80,WSW2,X8X2	OUTENS 2340
GO TO 103	OUTENS 2350
101 WRITE (30,312)	OUTENS 2360
WRITE (30,313)AB,GB,LSEP,MW8,M8,PA,P80,REA,RP,R80,TA,T80,WSW2,X8X2	OUTENS 2370
GO TO 103	OUTENS 2380
102 WRITE (30,314)	OUTENS 2390
RETURN	OUTENS 2400
C	OUTENS 2410
C	OUTENS 2420
C.....	OUTENS 2430
C*	OUTENS 2440
C*	OUTENS 2450
C*	OUTENS 2460
C.....	OUTENS 2470
C	OUTENS 2480
C	OUTENS 2490
103 IF (EJECT,EQ,NO) GO TO 109	OUTENS 2500
A1=LDS9(1)*7.03066E+02	OUTENS 2510
A2=PRS1(1)*7.03066E+02	OUTENS 2520
A3=PRS1(2)*7.03066E+02	OUTENS 2530
A4=PRS1(3)*7.03066E+02	OUTENS 2540
A5=PRS6(1)*7.03066E+02	OUTENS 2550
A6=PRS6(2)*7.03066E+02	OUTENS 2560
A7=PRS1(4)*7.03066E+02	OUTENS 2570
G1=LDS9(2)	OUTENS 2580
G2=PRS2(1)	OUTENS 2590
G3=PRS2(2)	OUTENS 2600
G4=PRS2(3)	OUTENS 2610
G5=PRS7(1)	OUTENS 2620
G6=PRS2(4)	OUTENS 2630
G7=PRS2(5)	OUTENS 2640
MW1=LDS9(3)	OUTENS 2650
MW2=PRS2(6)	OUTENS 2660
MW3=PRS2(7)	OUTENS 2670
MW4=PRS2(8)	OUTENS 2680
MW5=PRS5(1)	OUTENS 2690
MW6=PRS2(9)	OUTENS 2700
MW7=PRS2(10)	OUTENS 2710
M1=LDS9(4)	OUTENS 2720
M2=PRS2(11)	OUTENS 2730
M3=PRS2(12)	OUTENS 2740
M4=PRS2(13)	OUTENS 2750
M5=PRS6(3)	OUTENS 2760
M6=PRS2(14)	OUTENS 2770
M7=PRS2(15)	OUTENS 2780
P1=LDS9(5)/1.333224E+02	OUTENS 2790
P10=LDS9(6)/1.333224E+02	OUTENS 2800
P2=PRS2(16)/1.333224E+02	OUTENS 2810
P20=PRS2(17)/1.333224E+02	OUTENS 2820
P3=PRS2(18)/1.333224E+02	OUTENS 2830
P30=PRS2(19)/1.333224E+02	OUTENS 2840

APPENDIX A
SUBROUTINE OUTENG

CHEMICAL LASER ANALYSIS PROGRAM (CLAP)
OVERLAY MAIN

PAGE A-10

P4=PRS2(P0)/1.333224E+02	OUTENG 2859
P40=PRS2(P1)/1.333224E+02	OUTENG 2860
P5=PRS2(P2)/1.333224E+02	OUTENG 2870
P50=PRS2(P3)/6.694797E+03	OUTENG 2880
P6=PRS2(P4)/1.333224E+02	OUTENG 2890
P60=PRS2(P5)/1.333224E+02	OUTENG 2900
P7=PRS2(P6)/1.333224E+02	OUTENG 2910
P70=PRS2(P7)/1.333224E+02	OUTENG 2920
R1=LOS9(7)/1.0E+03	OUTENG 2930
R10=LOS9(8)/1.0E+03	OUTENG 2940
R2=PRS2(P8)/1.0E+03	OUTENG 2950
R20=PRS2(P9)/1.0E+03	OUTENG 2960
R3=PRS2(P10)/1.0E+03	OUTENG 2970
R30=PRS2(P11)/1.0E+03	OUTENG 2980
R4=PRS2(P12)/1.0E+03	OUTENG 2990
R40=PRS2(P13)/1.0E+03	OUTENG 3000
R5=PRS2(P14)/1.0E+03	OUTENG 3010
R50=PRS2(P15)/1.0E+03	OUTENG 3020
R6=PRS2(P16)/1.0E+03	OUTENG 3030
R60=PRS2(P17)/1.0E+03	OUTENG 3040
R7=PRS2(P18)/1.0E+03	OUTENG 3050
R70=PRS2(P19)/1.0E+03	OUTENG 3060
T1=LOS9(9)	OUTENG 3070
T10=LOS9(10)	OUTENG 3080
T2=PRS2(P20)	OUTENG 3090
T20=PRS2(P21)	OUTENG 3100
T3=PRS2(P22)	OUTENG 3110
T30=PRS2(P23)	OUTENG 3120
T4=PRS2(P24)	OUTENG 3130
T40=PRS2(P25)	OUTENG 3140
T5=PRS2(P26)	OUTENG 3150
T50=PRS2(P27)	OUTENG 3160
T6=PRS2(P28)	OUTENG 3170
T60=PRS2(P29)	OUTENG 3180
T7=PRS2(P30)	OUTENG 3190
T70=PRS2(P31)	OUTENG 3200
M3W1=PRS3	OUTENG 3210
M3X1=PRS4	OUTENG 3220
	OUTENG 3230
	OUTENG 3240
	OUTENG 3250
	OUTENG 3260
	OUTENG 3270
	OUTENG 3280
	OUTENG 3290
	OUTENG 3300
104 WRITE(30,403)A3A2,ATA6,EJECT,ETA12,OS,MW5,P50,P7,T50	OUTENG 3310
WRITE(30,405)	OUTENG 3320
GO TO 106	OUTENG 3330
105 WRITE(30,404)ATA6,EJECT,OS,LIMIT,MW5,P50,P7,T50	OUTENG 3340
WRITE(30,406)	OUTENG 3350
106 WRITE(30,407)A1,01,MW1,M1,P1,P10,R1,R10,T1,T10	OUTENG 3360
IF(EJECT,EQ,SSE) GO TO 107	OUTENG 3370
WRITE(30,408)A2,ETA12,02,MW2,M2,P2,P20,M2,M20,T2,T20,MW1,X2X1	OUTENG 3380
WRITE(30,409)	OUTENG 3390


```

      IF(EJECT.EQ.CAE) WRITE(30,410)
      WRITE(30,411)A3,ETA23,G3,MW3,M3,P3,P30,R3,R30,T3,T30,W3W1,X3X1
      IF(EJECT.NE.CAE) RETURN
      WRITE(30,412)A4,G4,MW4,M4,P4,P40,R4,R40,T4,T40,W4W1,X4X1
      WRITE(30,413)
      GO TO 108
107  IF(LIMIT.EQ.ULP) WRITE(30,414)
      IF(LIMIT.EQ.ZSP) WRITE(30,415)
      IF(LIMIT.EQ.MPP) WRITE(30,416)
      WRITE(30,417)
108  WRITE(30,418)A5,G5,MW5,M5,P5,P50,R5,R50,T5,T50,W5W1,X5X1
      IF(EJECT.EQ.CAE) WRITE(30,419)
      IF(EJECT.EQ.SSE) WRITE(30,420)
      WRITE(30,421)A6,G6,MW6,M6,P6,P60,R6,R60,T6,T60,W6W1,X6X1
      WRITE(30,422)A7,ETA67,G7,MW7,M7,P7,P70,R7,R70,T7,T70,W7W1,X7X1
C
C
C.....OUTENG 3400
C*
C*
C*
C*
C.....OUTENG 3570
C*
C*
C*
C.....OUTENG 3580
C*
C*
C*
C.....OUTENG 3590
C*
C*
C*
C.....OUTENG 3600
C*
C*
C*
C.....OUTENG 3610
C*
C*
C*
C.....OUTENG 3620
C*
C*
C*
C.....OUTENG 3630
C*
C*
C*
C.....OUTENG 3640
C*
C*
C*
C.....OUTENG 3650
C*
C*
C*
C.....OUTENG 3660
C*
C*
C*
C.....OUTENG 3670
C*
C*
C*
C.....OUTENG 3680
C*
C*
C*
C.....OUTENG 3690
C*
C*
C*
C.....OUTENG 3700
C*
C*
C*
C.....OUTENG 3710
C*
C*
C*
C.....OUTENG 3720
C*
C*
C*
C.....OUTENG 3730
C*
C*
C*
C.....OUTENG 3740
C*
C*
C*
C.....OUTENG 3750
C*
C*
C*
C.....OUTENG 3760
C*
C*
C*
C.....OUTENG 3770
C*
C*
C*
C.....OUTENG 3780
C*
C*
C*
C.....OUTENG 3790
C*
C*
C*
C.....OUTENG 3800
C*
C*
C*
C.....OUTENG 3810
C*
C*
C*
C.....OUTENG 3820
C*
C*
C*
C.....OUTENG 3830
C*
C*
C*
C.....OUTENG 3840
C*
C*
C*
C.....OUTENG 3850
C*
C*
C*
C.....OUTENG 3860
C*
C*
C*
C.....OUTENG 3870
C*
C*
C*
C.....OUTENG 3880
C*
C*
C*
C.....OUTENG 3890
C*
C*
C*
C.....OUTENG 3900
C*
C*
C*
C.....OUTENG 3910
C*
C*
C*
C.....OUTENG 3920
C*
C*
C*
C.....OUTENG 3930
C*
C*
C*
C.....OUTENG 3940
      IF(SCS2.EQ.NO) RETURN
      MBXDEV=SCS2(1)/2.54E-02
      LBXDEV=SCS2(2)/2.54E-02
      LLDS=SCS2(3)/2.54E-02
      LPRS=SCS2(4)/2.54E-02
      MAW=SCS2(5)/0.45359237
      MBASE=SCS2(6)/0.45359237
      MCAV=SCS2(7)/0.45359237
      MCB=SCS2(8)/0.45359237
      MCS=SCS2(9)/0.45359237
      MDS=SCS2(10)/0.45359237
      MEJECT=SCS2(11)/0.45359237
      MELINE=SCS2(12)/0.45359237
      MERREG=SCS2(13)/0.45359237
      MERT=SCS2(14)/0.45359237
      MINJ=SCS2(15)/0.45359237
      MLDMDW=SCS2(16)/0.45359237
      MLDS=SCS2(17)/0.45359237
      MLLINE=SCS2(18)/0.45359237
      MLRREG=SCS2(19)/0.45359237
      MLRT=SCS2(20)/0.45359237
      MMISC=SCS2(21)/0.45359237
      MOPT=SCS2(22)/0.45359237
      MPRMDW=SCS2(23)/0.45359237
      MPRS=SCS2(24)/0.45359237
      MSUBD=SCS2(25)/0.45359237
      MSUPD=SCS2(26)/0.45359237
      MTOTAL=SCS2(27)/0.45359237
      VAW=SCS2(28)/2.8316846592E-02
      VBXDEV=SCS2(29)/2.8316846592E-02
      VCAV=SCS2(30)/2.8316846592E-02

```

```
VCOMB=SCS2(31)/2.8316846592E-02      OUTENG 3950
VCS=SCS2(32)/2.8316846592E-02        OUTENG 3960
V7JECT=SCS2(33)/2.8316846592E-02     OUTENG 3970
VERT=SCS2(34)/2.8316846592E-02       OUTENG 3980
VLDMOW=SCS2(35)/2.8316846592E-02     OUTENG 3990
VLDS=SCS2(36)/2.8316846592E-02       OUTENG 4000
VLRT=SCS2(37)/2.8316846592E-02       OUTENG 4010
VOPT=SCS2(38)/2.8316846592E-02       OUTENG 4020
VPRMDW=SCS2(39)/2.8316846592E-02     OUTENG 4030
VPRS=SCS2(40)/2.8316846592E-02       OUTENG 4040
VSUBD=SCS2(41)/2.8316846592E-02     OUTENG 4050
VSUPD=SCS2(42)/2.8316846592E-02     OUTENG 4060
VSYSTM=SCS2(43)/2.8316846592E-02     OUTENG 4070
VTOTAL=SCS2(44)/2.8316846592E-02    OUTENG 4080
WBASE=SCS2(45)/2.54E-02              OUTENG 4090
WBXDEV=SCS2(46)/2.54E-02             OUTENG 4100
WPP3=SCS1*1.0E+03                    OUTENG 4110
XLP=SCS2(47)/1.0E+03                 OUTENG 4120
C                                     OUTENG 4130
C                                     OUTENG 4140
C                                     OUTENG 4150
WRITE(30,501)                          OUTENG 4160
IF(EJECT.NE.CAE.AND.EJECT.NE.SSE) WRITE(30,502)NBANK,RTIME,WPP3 OUTENG 4170
IF(EJECT.EQ.CAE.OR.EJECT.EQ.SSE) WRITE(30,503)EREACT,NBANK,NEJECT, OUTENG 4180
-RTIME,WPP3                             OUTENG 4190
WRITE(30,504)((STMODE(I,J),J=1,6),I=1,10),(STMODE(I,1), OUTENG 4200
-(STMODE(I,J),J=7,10),I=1,10)          OUTENG 4210
WRITE(30,505)XLP                        OUTENG 4220
WRITE(30,506)MINJ,MCB,WBASE,VCOMB,MCAV,VCAV,MAW,VAW,VCS,VCS,MOPT, OUTENG 4230
-VOPT,MDS,MLRREG,MLLINE,MLDMOW,VLDMOW,MLRT,VLRT,MLDS,VLDS OUTENG 4240
IF(EJECT.EQ.NO) GO TO 113               OUTENG 4250
IF(EJECT.EQ.CAE) GO TO 110              OUTENG 4260
IF(EJECT.EQ.SSE) GO TO 111              OUTENG 4270
WRITE(30,507)MSUPD,VSUPD,MSUBD,VSUBD,MPRS,VPRS OUTENG 4280
GO TO 112                               OUTENG 4290
110 WRITE(30,508)MSUPD,VSUPD,MSUBD,VSUBD,MEJECT,VEJECT,MERREG,MELINE, OUTENG 4300
-MPRMDW,VPRMDW,MERT,VERT,MPRS,VPRS     OUTENG 4310
GO TO 112                               OUTENG 4320
111 WRITE(30,509)MEJECT,VEJECT,MERREG,MELINE,MPRMDW,MERT,VERT,MPRS, OUTENG 4330
-VPRS                                   OUTENG 4340
112 WRITE(30,510)MLDS,VLDS,MPRS,VPRS,MMISC,MTOTAL,VTOTAL,VSYSTM,WBASE, OUTENG 4350
-LLDS,LPRS,LBXDEV,WBXDEV,MBXDEV,VBXDEV OUTENG 4360
RETURN                                  OUTENG 4370
113 WRITE(30,511)MLDS,VLDS,MMISC,MTOTAL,VTOTAL,VSYSTM,WBASE,LLDS, OUTENG 4380
-LBXDEV,WBXDEV,MBXDEV,VBXDEV           OUTENG 4390
C                                     OUTENG 4400
C                                     OUTENG 4410
C*****OUTENG 4420
C*                                     OUTENG 4430
C*                                     OUTENG 4440
C*                                     OUTENG 4450
C*****OUTENG 4460
C                                     OUTENG 4470
C                                     OUTENG 4480
201 FORMAT(*1*////////,T47,*CHEMICAL LASER ANALYSIS PROGRAM (CLAP)*,//OUTENG 4490
-,T53,*WRITTEN BY: C.L. ADAMS*,//,T65,*A.L. ADDY*,//,T85,*R.D. MASSEYOUTENG 4490
```

```

-.,T65.,C.D. MIKKELSEN.,T65.,O.F. MORR.,T65.,R.L. ORLUKIAN.,OUTENG 4500
-.,T65.,R.J. WALKER.,T60.,1 JANUARY 77.,T51.,AFRODYNAMICS GROUOUTENG 4510
-P (DROMI-TDK),T51.,SYSTEM SIMULATION DIRECTORATF.,T62.,U.S. AOUTENG 4520
-RMY MISSILE RESEARCH & DEVELOPMENT COMMAND.,T51.,REDSTONE ARSENAOUTENG 4530
-L. ALARAMA 35809.,T57.,RUN DATE .,A10) OUTENG 4540
202 FORMAT(0.,T52.,COMBUSTION CHEMISTRY SECTION.,T60. OUTENG 4550
-.,INITIAL DATA.,T60. OUTENG 4560
-T31.,AEXP ==,E13.6.,IN2.,T67.,ALPHA ==,E13.6.,/ OUTENG 4570
-T31.,DFORMF ==,A13.,T67.,N1 ==,I13.,ATOMS C.,/ OUTENG 4580
-T31.,N2 ==,I13.,ATOMS H.,T67.,N3 ==,I13.,ATOMS N.,/ OUTENG 4590
-T31.,N4 ==,I13.,ATOMS F.,T67.,NPG ==,E13.6.,GM/S N2.,/ OUTENG 4600
-T31.,WPR1 ==,E13.6.,GM/S C.,I1.,H.,I1. OUTENG 4610
-T67.,WPR2 ==,E13.6.,GM/S HE.,T31.,WPR3 ==,E13.6., OUTENG 4620
-.,GM/S N2.,T67.,WPR4 ==,E13.6.,GM/S N.,I1.,F.,I1.,T31. OUTENG 4630
-.,WSR1 ==,E13.6.,GM/S D2.,T67.,WSR2 ==,E13.6.,GM/S HE.,/ OUTENG 4640
-T31.,WSR3 ==,E13.6.,GM/S N2.) OUTENG 4650
203 FORMAT(0.,T52.,COMBUSTION CHEMISTRY SECTION.,T60. OUTENG 4660
-.,INITIAL DATA.,T60. OUTENG 4670
-T31.,AEXP ==,E13.6.,IN2.,T67.,ALPHA ==,E13.6.,/ OUTENG 4680
-T31.,DFORMF ==,A13.,T67.,N1 ==,I13.,ATOMS C.,/ OUTENG 4690
-T31.,N2 ==,I13.,ATOMS D.,T67.,N3 ==,I13.,ATOMS N.,/ OUTENG 4700
-T31.,N4 ==,I13.,ATOMS F.,T67.,NPG ==,E13.6.,GM/S N2.,/ OUTENG 4710
-T31.,WPR1 ==,E13.6.,GM/S C.,I1.,D.,I1. OUTENG 4720
-T67.,WPR2 ==,E13.6.,GM/S HE.,T31.,WPR3 ==,E13.6., OUTENG 4730
-.,GM/S N2.,T67.,WPR4 ==,E13.6.,GM/S N.,I1.,F.,I1.,T31. OUTENG 4740
-.,WSR1 ==,E13.6.,GM/S N2.,T67.,WSR2 ==,E13.6.,GM/S HE.,/ OUTENG 4750
-T31.,WSR3 ==,E13.6.,GM/S N2.) OUTENG 4760
204 FORMAT(0.,T50.,RESULTANT DATA.,T60. OUTENG 4770
-T31.,FDAA ==,E13.6.,GMOLE/S-IN2.,T67.,OMEGA ==,E13.6.,/ OUTENG 4780
-T31.,OMEGTRW ==,E13.6.,T67.,PSIC ==,E13.6.,/ OUTENG 4790
-T31.,PSIL ==,E13.6.,T67.,PSILTRW ==,E13.6.,/ OUTENG 4800
-T31.,Q ==,E13.6.,CAL/GMOLE.,T67.,RC ==,E13.6.,/ OUTENG 4810
-T31.,RL ==,E13.6.,T67.,RLF ==,E13.6.,/ OUTENG 4820
205 FORMAT(0.,T60. OUTENG 4830
-T31.,WFCP1 ==,E13.6.,CF4.,T67.,XFCP1 ==,E13.6.,CF4.,/ OUTENG 4840
-T31.,WFCP2 ==,E13.6.,HF.,T67.,XFCP2 ==,E13.6.,HF.,/ OUTENG 4850
-T31.,WFCP3 ==,E13.6.,DF.,T67.,XFCP3 ==,E13.6.,DF.,/ OUTENG 4860
-T31.,WFCP4 ==,E13.6.,HE.,T67.,XFCP4 ==,E13.6.,HE.,/ OUTENG 4870
-T31.,WFCP5 ==,E13.6.,N2.,T67.,XFCP5 ==,E13.6.,N2.,/ OUTENG 4880
-T31.,WFCP6 ==,E13.6.,D.,T67.,XFCP6 ==,E13.6.,D.,/ OUTENG 4890
206 FORMAT(0.,T60. OUTENG 4900
-T31.,WFCP1 ==,E13.6.,CF4.,T67.,XFCP1 ==,E13.6.,CF4.,/ OUTENG 4910
-T31.,WFCP2 ==,E13.6.,HF.,T67.,XFCP2 ==,E13.6.,HF.,/ OUTENG 4920
-T31.,WFCP3 ==,E13.6.,DF.,T67.,XFCP3 ==,E13.6.,DF.,/ OUTENG 4930
-T31.,WFCP4 ==,E13.6.,HE.,T67.,XFCP4 ==,E13.6.,HE.,/ OUTENG 4940
-T31.,WFCP5 ==,E13.6.,N2.,T67.,XFCP5 ==,E13.6.,N2.,/ OUTENG 4950
-T31.,WFCP6 ==,E13.6.,H.,T67.,XFCP6 ==,E13.6.,H.,/ OUTENG 4960
301 FORMAT(0.,T56.,LASER DEVICE SECTION.,T60.,INITIAL DATA.,/ OUTENG 4970
302 FORMAT(0.,T31.,RRFRAC ==,E13.6.,T67.,CANGLE ==,E13.6.,DEG.,/ OUTENG 4980
-T31.,D1 ==,E13.6.,IN.,T67.,D1S ==,E13.6.,IN.,/ OUTENG 4990
-T31.,D3 ==,E13.6.,IN.,T67.,D3S ==,E13.6.,IN.,/ OUTENG 5000
-T31.,GEOMPN ==,A13.,T67.,GEOMSN ==,A13.,/ OUTENG 5010
-T31.,HRSF ==,E13.6.,IN.,T67.,HNB ==,E13.6.,IN.,/ OUTENG 5020
-T31.,LCAV ==,E13.6.,IN.,T67.,LPNOZ ==,E13.6.,IN.,/ OUTENG 5030
-T31.,LSNOZ ==,E13.6.,IN.,T67.,NSPNOZ ==,E13.6.,/ OUTENG 5040
```

APPENDIX A
SUBROUTINE OUTENS

CHEMICAL LASER ANALYSIS PROGRAM (CLAP)
OVERLAY MAIN

PAGE A-14

```

-T31,PKFRAC ==,E13.6,T67,P10 ==,E13.6,PSIA,/, OUTENS 5050
-T31,T30 ==,E13.6,K,T67,T70 ==,E13.6,K, OUTENS 5060
303 FORMAT(=,T31,PKFRAC ==,E13.6,T67,CANOLF ==,E13.6,DEG,/, OUTENS 5070
-T31,D1 ==,E13.6,IN,T67,D1S ==,E13.6,IN,/, OUTENS 5080
-T31,D3 ==,E13.6,IN,T67,D3S ==,E13.6,IN,/, OUTENS 5090
-T31,GEOMPH ==,A13,T67,GEOMSN ==,A13,/, OUTENS 5100
-T31,HBASE ==,E13.6,IN,T67,HNR ==,E13.6,IN,/, OUTENS 5110
-T31,LCAV ==,E13.6,IN,T67,LPHNOZ ==,E13.6,IN,/, OUTENS 5120
-T31,LSNOZ ==,E13.6,IN,T67,NSPNOZ ==,E13.6,/, OUTENS 5130
-T31,PKFRAC ==,E13.6,T67,T10 ==,E13.6,K,/, OUTENS 5140
-T31,T30 ==,E13.6,K,T67,T70 ==,E13.6,K, OUTENS 5150
304 FORMAT(=,T59,RESULTANT DATA,/,T22,POINT 1 PRIMARY NOZZLE EXIT, OUTENS 5160
-KIT - CONDITIONS BASED ON THE NOZZLE STAGNATION,/,T31,(COMBUSTOR, OUTENS 5170
-1) TEMPERATURE,/, OUTENS 5180
-T31,A1 ==,E13.6,S-IN2/LBMOLE,T67,A1AISE ==,E13.6,/, OUTENS 5190
-T31,A1A150 ==,E13.6,T67,A1 ==,E13.6,/, OUTENS 5200
-T31,MW1 ==,E13.6,LBM/LBMOLE,T67,MW1 ==,E13.6,/, OUTENS 5210
-T31,MPNOZ ==,E13.6,S/LBMOLE,T67,P1 ==,E13.6,TORR,/, OUTENS 5220
-T31,P10 ==,E13.6,PSIA,T67,RE1 ==,E13.6,/, OUTENS 5230
-T31,R1 ==,E13.6,GM/CM3,T67,R10 ==,E13.6,GM/CM3,/, OUTENS 5240
-T31,T1 ==,E13.6,K,T67,T10 ==,E13.6,K, OUTENS 5250
305 FORMAT(=,T22,POINT 2 PRIMARY NOZZLE EXIT - CONDITIONS BASED ON, OUTENS 5260
- THE NOZZLE EXIT,/,T31,TEMPERATURE,/, OUTENS 5270
-T31,A2 ==,E13.6,S-IN2/LBMOLE,T67,A2 ==,E13.6,/, OUTENS 5280
-T31,MW2 ==,E13.6,LBM/LBMOLE,T67,MW2 ==,E13.6,/, OUTENS 5290
-T31,P2 ==,E13.6,TORR,T67,P20 ==,E13.6,PSIA,/, OUTENS 5300
-T31,R2 ==,E13.6,GM/CM3,T67,R2 ==,E13.6,GM/CM3,/, OUTENS 5310
-T31,T2 ==,E13.6,K,T67,T20 ==,E13.6,K, OUTENS 5320
306 FORMAT(=,T22,POINT 3 SECONDARY NOZZLE EXIT - CONDITIONS BASED, OUTENS 5330
-ON THE NOZZLE STAGNATION,/,T31,(COMBUSTOR) TEMPERATURE,/, OUTENS 5340
-T31,A3 ==,E13.6,S-IN2/LBMOLE,T67,A3A3SE ==,E13.6,/, OUTENS 5350
-T31,A3A3SE ==,E13.6,T67,A3 ==,E13.6,/, OUTENS 5360
-T31,MW3 ==,E13.6,LBM/LBMOLE,T67,MW3 ==,E13.6,/, OUTENS 5370
-T31,MSNOZ3 ==,E13.6,S/LBMOLE,T67,P3 ==,E13.6,TORR,/, OUTENS 5380
-T31,P30 ==,E13.6,PSIA,T67,RE3 ==,E13.6,/, OUTENS 5390
-T31,R3 ==,E13.6,GM/CM3,T67,R30 ==,E13.6,GM/CM3,/, OUTENS 5400
-T31,T3 ==,E13.6,K,T67,T30 ==,E13.6,K,/, OUTENS 5410
-T31,MW3W1 ==,E13.6,T67,MW3 ==,E13.6,/, OUTENS 5420
307 FORMAT(=,T22,POINT 4 SECONDARY NOZZLE EXIT - CONDITIONS BASED, OUTENS 5430
-ON THE NOZZLE EXIT,/,T31,TEMPERATURE,/, OUTENS 5440
-T31,A4 ==,E13.6,S-IN2/LBMOLE,T67,A4 ==,E13.6,/, OUTENS 5450
-T31,MW4 ==,E13.6,LBM/LBMOLE,T67,MW4 ==,E13.6,/, OUTENS 5460
-T31,P4 ==,E13.6,TORR,T67,P40 ==,E13.6,PSIA,/, OUTENS 5470
-T31,R4 ==,E13.6,GM/CM3,T67,R40 ==,E13.6,GM/CM3,/, OUTENS 5480
-T31,T4 ==,E13.6,K,T67,T40 ==,E13.6,K,/, OUTENS 5490
308 FORMAT(=,T22,POINT 5 CONSTANT-AREA MIXING REGION EXIT,/, OUTENS 5500
-T31,A5 ==,E13.6,S-IN2/LBMOLE,T67,A5 ==,E13.6,/, OUTENS 5510
-T31,MW5 ==,E13.6,LBM/LBMOLE,T67,MW5 ==,E13.6,/, OUTENS 5520
-T31,P5 ==,E13.6,TORR,T67,P50 ==,E13.6,TORR,/, OUTENS 5530
-T31,R5 ==,E13.6,GM/CM3,T67,R50 ==,E13.6,GM/CM3,/, OUTENS 5540
-T31,T5 ==,E13.6,K,T67,T50 ==,E13.6,K,/, OUTENS 5550
309 FORMAT(=,T22,POINT 6 ISENTROPIC EXPANSION REGION EXIT,/, OUTENS 5560
-T31,A6 ==,E13.6,S-IN2/LBMOLE,T67,A6 ==,E13.6,/, OUTENS 5570

```

```
-T31,0MWA      ==.E13.6.* LBM/LBMOLE*.T67,0MA      ==.E13.6./,      OUTENS 5600
-T31,0P6       ==.E13.6.* TORR*.T67,0PAN      ==.E13.6.* TORR./,      OUTENS 5610
-T31,0RA       ==.E13.6.* GM/CM3*.T67,0R60      ==.E13.6.* GM/CM3./,      OUTENS 5620
-T31,0T6       ==.E13.6.* K*.T67,0TA0      ==.E13.6.* K./,      OUTENS 5630
-T31,0M6W2     ==.E13.6.*T67,0X6X2      ==.E13.6./,      OUTENS 5640
310  FORMAT(00, T22, POINT 7 MIRROR PURGE CONDITIONS, //,      OUTENS 5650
      -T31,067      ==.E13.6.*T67,0MW7      ==.E13.6.* LBM/LBMOLE./,      OUTENS 5660
      -T31,0T70     ==.E13.6.* K*.T67,0M7W2     ==.E13.6./,      OUTENS 5670
      -T31,0X7X2     ==.E13.6./,      OUTENS 5680
311  FORMAT(00, T22, POINT A LASER CAVITY EXIT, //,      OUTENS 5690
      -T31,0AA      ==.E13.6.* S-IN2/LBMOLE*.T67,068      ==.E13.6./,      OUTENS 5700
      -T31,0MWA     ==.E13.6.* LBM/LBMOLE*.T67,0MA     ==.E13.6./,      OUTENS 5710
      -T31,0PA      ==.E13.6.* TORR*.T67,0P80      ==.E13.6.* TORR./,      OUTENS 5720
      -T31,0REA     ==.E13.6.*T67,0R8      ==.E13.6.* GM/CM3./,      OUTENS 5730
      -T31,0RA0     ==.E13.6.* GM/CM3*.T67,0T8      ==.E13.6.* K./,      OUTENS 5740
      -T31,0T80     ==.E13.6.* K*.T67,0M8W2     ==.E13.6./,      OUTENS 5750
      -T31,0X8X2     ==.E13.6./,      OUTENS 5760
312  FORMAT(00, T22, WARNING: THE CAVITY FLOW HAS SEPARATED. ALL FURTHER      OUTENS 5770
      -ER RESULTS SHOULD BE USED, //, T31, WITH CAUTION, //,      OUTENS 5780
313  FORMAT(00, T22, POINT A LASER CAVITY EXIT, //,      OUTENS 5790
      -T31,0A8      ==.E13.6.* S-IN2/LBMOLE*.T67,068      ==.E13.6./,      OUTENS 5800
      -T31,0LSEP     ==.E13.6.* IN*.T67,0MWA     ==.E13.6.* LBM/LBMOLE./,      OUTENS 5810
      -T31,0MA      ==.E13.6.*T67,0P8      ==.E13.6.* TORR./,      OUTENS 5820
      -T31,0PA0     ==.E13.6.* TORR*.T67,0R8      ==.E13.6./,      OUTENS 5830
      -T31,0RA      ==.E13.6.* GM/CM3*.T67,0R80      ==.E13.6.* GM/CM3./,      OUTENS 5840
      -T31,0TA      ==.E13.6.* K*.T67,0T80      ==.E13.6.* K./,      OUTENS 5850
      -T31,0M8W2     ==.E13.6.*T67,0X8X2     ==.E13.6./,      OUTENS 5860
314  FORMAT(00, T22, WARNING: THE CAVITY FLOW HAS CHOKED. ALL FURTHER      OUTENS 5870
      -CALCULATIONS HAVE, //, T31, BEEN DISCONTINUED, //,      OUTENS 5880
401  FORMAT(01, T54, PRESSURE RECOVERY SECTION, //, T60, INITIAL DATA, //,      OUTENS 5890
402  FORMAT(00, T31, A7A2      ==.E13.6.*T67,0EJECT      ==.A1, //,      OUTENS 5900
      -T31,0ETA12     ==.E13.6./,      OUTENS 5910
403  FORMAT(00, T31, A7A2      ==.E13.6.*T67,0A7A6      ==.E13.6./,      OUTENS 5920
      -T31,0EJECT     ==.A13.*T67,0ETA12     ==.E13.6./,      OUTENS 5930
      -T31,065      ==.E13.6.*T67,0MWS      ==.E13.6.* LBM/LBMOLE./,      OUTENS 5940
      -T31,0P50      ==.E13.6.* PSIA*.T67,0P7      ==.E13.6.* TORR./,      OUTENS 5950
      -T31,0T50      ==.E13.6.* K/,      OUTENS 5960
404  FORMAT(00, T31, A7A6      ==.E13.6.*T67,0EJECT      ==.A13./,      OUTENS 5970
      -T31,065      ==.E13.6.*T67,0LIMIT      ==.A13./,      OUTENS 5980
      -T31,0MWS      ==.E13.6.* LBM/LBMOLE*.T67,0P50      ==.E13.6.* PSIA/,      OUTENS 5990
      -/T31,0P7      ==.E13.6.* TORR*.T67,0T50      ==.E13.6.* K/,      OUTENS 6000
405  FORMAT(00, T59, RESULTANT DATA, //, T22, POINT 1 LASER CAVITY EXIT,      OUTENS 6010
      -T AND NORMAL SHOCK DIFFUSER ENTRANCE, //,      OUTENS 6020
406  FORMAT(00, T59, RESULTANT DATA, //, T22, POINT 1 LASER CAVITY EXIT,      OUTENS 6030
      -T AND CONSTANT-AREA, SUPERSONIC-SUPERSONIC EJECTOR, //, T31, SECONDARY,      OUTENS 6040
      -RY ENTRANCE, //,      OUTENS 6050
407  FORMAT(00, //,      OUTENS 6060
      -T31,0A1      ==.E13.6.* S-IN2/LBMOLE*.T67,061      ==.E13.6./,      OUTENS 6070
      -T31,0MW1      ==.E13.6.* LBM/LBMOLE*.T67,0M1      ==.E13.6./,      OUTENS 6080
      -T31,0P1      ==.E13.6.* TORR*.T67,0P10      ==.E13.6.* TORR./,      OUTENS 6090
      -T31,0R1      ==.E13.6.* GM/CM3*.T67,0R10      ==.E13.6.* GM/CM3./,      OUTENS 6100
      -T31,0T1      ==.E13.6.* K*.T67,0T10      ==.E13.6.* K/,      OUTENS 6110
408  FORMAT(00, T22, POINT 2 NORMAL SHOCK DIFFUSER EXIT AND SUBSONIC DOUTENS 6120
      -IFFUSER ENTRANCE, //,      OUTENS 6130
      -T31,0AP      ==.E13.6.* S-IN2/LBMOLE*.T67,0ETA12      ==.E13.6./,      OUTENS 6140
```

```
-T31,007      **E13.6,T67,0MW2      **E13.6, LBM/LBMOLE,/,      OUTENG 6150
-T31,002      **E13.6,T67,0P2       **E13.6, TORR,/,      OUTENG 6160
-T31,0P20     **E13.6, TORR,T67,0P2   **E13.6, GM/CM3,/,      OUTENG 6170
-T31,0R20     **E13.6, GM/CM3,T67,0T2  **E13.6, K,/,      OUTENG 6180
-T31,0T20     **E13.6, K,T67,0W2W1    **E13.6,/,      OUTENG 6190
-T31,0X2X1    **E13.6)              OUTENG 6200
400  FORMAT(00,T22,POINT 3 SUBSONIC DIFFUSER EXIT *)      OUTENG 6210
410  FORMAT(00,T55,AND SUDDEN ENLARGEMENT ENTRANCE*)      OUTENG 6220
411  FORMAT(00,      OUTENG 6230
-T31,0A3      **E13.6, S-IN2/LBMOLE,T67,0TA23 **E13.6,/,      OUTENG 6240
-T31,003      **E13.6,T67,0MW3      **E13.6, LBM/LBMOLE,/,      OUTENG 6250
-T31,0M3      **E13.6,T67,0P3       **E13.6, TORR,/,      OUTENG 6260
-T31,0P30     **E13.6, TORR,T67,0P3   **E13.6, GM/CM3,/,      OUTENG 6270
-T31,0R30     **E13.6, GM/CM3,T67,0T3  **E13.6, K,/,      OUTENG 6280
-T31,0T30     **E13.6, K,T67,0W3W1    **E13.6,/,      OUTENG 6290
-T31,0X3X1    **E13.6)              OUTENG 6300
412  FORMAT(00,T22,POINT 4 CONSTANT-AREA, SUBSONIC-SUPERSONIC EJECTO      OUTENG 6310
-R SECONDARY NOZZLE EXIT,/,      OUTENG 6320
-T31,0A4      **E13.6, S-IN2/LBMOLE,T67,004      **E13.6,/,      OUTENG 6330
-T31,0MW4     **E13.6, LBM/LBMOLE,T67,0M4      **E13.6,/,      OUTENG 6340
-T31,0P4      **E13.6, TORR,T67,0P40    **E13.6, TORR,/,      OUTENG 6350
-T31,0R4      **E13.6, GM/CM3,T67,0R40    **E13.6, GM/CM3,/,      OUTENG 6360
-T31,0T4      **E13.6, K,T67,0T40    **E13.6, K,/,      OUTENG 6370
-T31,0W4W1    **E13.6,T67,0X4X1    **E13.6)              OUTENG 6380
413  FORMAT(00,T22,POINT 5 CONSTANT-AREA, SUBSONIC-SUPERSONIC EJECTO      OUTENG 6390
-R PRIMARY NOZZLE EXIT*)      OUTENG 6400
414  FORMAT(00,T22,NOTE: THE UPPER LIMIT POINT WAS USED AS THE LIM      OUTENG 6410
-ITING CONDITION FOR,/,T31,THE CONSTANT-AREA, SUPERSONIC-SUPERSON      OUTENG 6420
-IC EJECTOR*)      OUTENG 6430
415  FORMAT(00,T22,NOTE: THE ZUKOSKI SEPARATION POINT WAS USED AS      OUTENG 6440
-THE LIMITING CONDITION FOR,/,T31,THE CONSTANT-AREA, SUPERSONIC-S      OUTENG 6450
-SUPERSONIC EJECTOR*)      OUTENG 6460
416  FORMAT(00,T22,NOTE: THE MATCHED PRESSURE POINT WAS USED AS TH      OUTENG 6470
-E LIMITING CONDITION FOR,/,T31,THE CONSTANT-AREA, SUPERSONIC-S      OUTENG 6480
-ERSONIC EJECTOR*)      OUTENG 6490
417  FORMAT(00,T22,POINT 5 CONSTANT-AREA, SUPERSONIC-SUPERSONIC EJE      OUTENG 6500
-TOR PRIMARY NOZZLE EXIT*)      OUTENG 6510
418  FORMAT(00,      OUTENG 6520
-T31,0A5      **E13.6, S-IN2/LBMOLE,T67,005      **E13.6,/,      OUTENG 6530
-T31,0MW5     **E13.6, LBM/LBMOLE,T67,0M5      **E13.6,/,      OUTENG 6540
-T31,0P5      **E13.6, TORR,T67,0P50    **E13.6, PSIA,/,      OUTENG 6550
-T31,0R5      **E13.6, GM/CM3,T67,0R50    **E13.6, GM/CM3,/,      OUTENG 6560
-T31,0T5      **E13.6, K,T67,0T50    **E13.6, K,/,      OUTENG 6570
-T31,0W5W1    **E13.6,T67,0X5X1    **E13.6)              OUTENG 6580
419  FORMAT(01,T22,POINT 6 CONSTANT-AREA, SUBSONIC-SUPERSONIC EJECTO      OUTENG 6590
-R EXIT AND SUBSONIC,/,T31,DIFFUSER ENTRANCE*)      OUTENG 6600
420  FORMAT(00,T22,POINT 6 CONSTANT-AREA, SUPERSONIC-SUPERSONIC EJE      OUTENG 6610
-TOR EXIT AND SUBSONIC,/,T31,DIFFUSER ENTRANCE*)      OUTENG 6620
421  FORMAT(00,      OUTENG 6630
-T31,0A6      **E13.6, S-IN2/LBMOLE,T67,006      **E13.6,/,      OUTENG 6640
-T31,0MW6     **E13.6, LBM/LBMOLE,T67,0M6      **E13.6,/,      OUTENG 6650
-T31,0P6      **E13.6, TORR,T67,0P60    **E13.6, TORR,/,      OUTENG 6660
-T31,0R6      **E13.6, GM/CM3,T67,0R60    **E13.6, GM/CM3,/,      OUTENG 6670
-T31,0T6      **E13.6, K,T67,0T60    **E13.6, K,/,      OUTENG 6680
-T31,0W6W1    **E13.6,T67,0X6X1    **E13.6)              OUTENG 6690
```

```

422  FORMAT(00,T22,POINT 7 SUBSONIC DIFFUSER EXIT,/,/,
      -T31,0A7    =,E13.6, S-IN2/LAHOLE,T67,0TA67    =,E13.6,/,
      -T31,0B7    =,E13.6,T67,0H7    =,E13.6, LBM/LAHOLE,/,
      -T31,0M7    =,E13.6,T67,0P7    =,E13.6, TORR,/,
      -T31,0P70   =,E13.6, TORR,T67,0R7    =,E13.6, GM/CM3,/,
      -T31,0R70   =,E13.6, GM/CM3,T67,0T7    =,E13.6, K,/,
      -T31,0T70   =,E13.6, K,T67,0TW1    =,E13.6,/,
      -T31,0X7X1   =,E13.6)
501  FORMAT(01,T53,SYSTEM CALCULATION SECTION,/,T60,INITIAL DATA:
      -)
502  FORMAT(00,T31,0NRANK    =,I13,T67,0RTIME    =,E13.6, S,/,
      -T31,0VPP3    =,E13.6, K/S)
503  FORMAT(00,T31,0FREACT    =,A13,T67,0NBANK    =,I13,/,
      -T31,0NEJECT    =,I13,T67,0RTIME    =,E13.6, S,/,
      -T31,0VPP3    =,E13.6, GM/S)
504  FORMAT(00,T55,0REACTANT STORAGE METHOD,/,10(T31,0A11,/)
      -10(/,T31,0A11))
505  FORMAT(00,T59,0RESULTANT DATA,/,T55,0SYSTEM SCALE-UP FACTOR,
      -/,T31,0XLP    =,E13.6, 0MOLE/S)
506  FORMAT(00,T51,0LASER DEVICE SYSTEM VOLUME/MASS,/,/,
      -T31,0MINJ    =,E13.6, LBM,/,T31,0MCS    =,E13.6, LBM,/,
      -T31,0MBASE    =,E13.6, LBM,T67,0VCOMB    =,E13.6, FT3,/,
      -T31,0MCAV    =,E13.6, LBM,T67,0VCAV    =,E13.6, FT3,/,
      -T31,0MAW    =,E13.6, LBM,T67,0VAW    =,E13.6, FT3,/,
      -T31,0MCS    =,E13.6, LBM,T67,0VCS    =,E13.6, FT3,/,
      -T31,0MOPT    =,E13.6, LBM,T67,0VOPT    =,E13.6, FT3,/,
      -T31,0MDS    =,E13.6, LBM,/,T31,0MLRFB    =,E13.6, LBM,/,
      -T31,0MLINE    =,E13.6, LBM,/,T42,0,/,
      -T78,0,/,T31,0MLDHDW    =,E13.6, LBM,/,
      -T67,0VLHDW    =,E13.6, FT3,/,T31,0MLRT    =,E13.6, LBM,/,
      -T67,0VLRT    =,E13.6, FT3,/,T42,0,/,
      -T78,0,/,T31,0MLDS    =,E13.6, LBM,/,
      -T67,0VLDS    =,E13.6, FT3)
507  FORMAT(01,T48,0PRESSURE RECOVERY SYSTEM VOLUME/MASS,/,/,
      -T31,0MSUPD    =,E13.6, LBM,T67,0VSUPD    =,E13.6, FT3,/,
      -T31,0MSURD    =,E13.6, LBM,T67,0VSURD    =,E13.6, FT3,/,
      -T42,0,/,T78,0,/,
      -T31,0MPRS    =,E13.6, LBM,T67,0VPRS    =,E13.6, FT3)
508  FORMAT(01,T48,0PRESSURE RECOVERY SYSTEM VOLUME/MASS,/,/,
      -T31,0MSUPD    =,E13.6, LBM,T67,0VSUPD    =,E13.6, FT3,/,
      -T31,0MSURD    =,E13.6, LBM,T67,0VSURD    =,E13.6, FT3,/,
      -T31,0MEJECT    =,E13.6, LBM,T67,0VEJECT    =,E13.6, FT3,/,
      -T31,0MERREG    =,E13.6, LBM,/,T31,0MLINE    =,E13.6, LBM,/,
      -T42,0,/,T78,0,/,
      -T31,0MPRHDW    =,E13.6, LBM,T67,0VPRHDW    =,E13.6, FT3,/,
      -T31,0MERT    =,E13.6, LBM,T67,0VERT    =,E13.6, FT3,/,
      -T42,0,/,T78,0,/,
      -T31,0MPRS    =,E13.6, LBM,T67,0VPRS    =,E13.6, FT3)
509  FORMAT(01,T48,0PRESSURE RECOVERY SYSTEM VOLUME/MASS,/,/,
      -T31,0MEJECT    =,E13.6, LBM,T67,0VEJECT    =,E13.6, FT3,/,
      -T31,0MERREG    =,E13.6, LBM,/,T31,0MLINE    =,E13.6, LBM,/,
      -T42,0,/,T31,0MPRHDW    =,E13.6, LBM,/,
      -T31,0MERT    =,E13.6, LBM,T67,0VERT    =,E13.6, FT3,/,
      -T42,0,/,T78,0,/,
      -T31,0MPRS    =,E13.6, LBM,T67,0VPRS    =,E13.6, FT3)

```

OUTENS 6700
 OUTENS 6710
 OUTENS 6720
 OUTENS 6730
 OUTENS 6740
 OUTENS 6750
 OUTENS 6760
 OUTENS 6770
 OUTENS 6780
 OUTENS 6790
 OUTENS 6800
 OUTENS 6810
 OUTENS 6820
 OUTENS 6830
 OUTENS 6840
 OUTENS 6850
 OUTENS 6860
 OUTENS 6870
 OUTENS 6880
 OUTENS 6890
 OUTENS 6900
 OUTENS 6910
 OUTENS 6920
 OUTENS 6930
 OUTENS 6940
 OUTENS 6950
 OUTENS 6960
 OUTENS 6970
 OUTENS 6980
 OUTENS 6990
 OUTENS 7000
 OUTENS 7010
 OUTENS 7020
 OUTENS 7030
 OUTENS 7040
 OUTENS 7050
 OUTENS 7060
 OUTENS 7070
 OUTENS 7080
 OUTENS 7090
 OUTENS 7100
 OUTENS 7110
 OUTENS 7120
 OUTENS 7130
 OUTENS 7140
 OUTENS 7150
 OUTENS 7160
 OUTENS 7170
 OUTENS 7180
 OUTENS 7190
 OUTENS 7200
 OUTENS 7210
 OUTENS 7220
 OUTENS 7230
 OUTENS 7240

APPENDIX A
SUBROUTINE OUTENS

CHEMICAL LASER ANALYSIS PROGRAM (CLAP)
OVERLAY MAIN

PAGE A-18

910	FORMAT(000,T53,0SYSTEM VOLUME/MASS SUMMARY,/,	OUTENS 7250
	-T31,0MLDS 00,E13.6,0 LBM,0T67,0VLDS 00,E13.6,0 FT30,/,	OUTENS 7260
	-T31,0MPRS 00,E13.6,0 LBM,0T67,0VPRS 00,E13.6,0 FT30,/,	OUTENS 7270
	-T31,0MMISC 00,E13.6,0 LBM,/,042,0-----0	OUTENS 7280
	-T70,0-----0,/,T31,0MTOTAL 00,E13.6,0 LBM,	OUTENS 7290
	-T67,0VTOTAL 00,E13.6,0 FT30,/,T67,0VSYSTEM 00,E13.6,0 FT30,/,	OUTENS 7300
	-T31,0WBASF 00,E13.6,0 IN,0T67,0LLDS 00,E13.6,0 IN,/,	OUTENS 7310
	-T31,0LPRS 00,E13.6,0 IN,/,T31,0LBXDEV 00,E13.6,0 IN,	OUTENS 7320
	-T67,0WBXDEV 00,E13.6,0 IN,/,T31,0MBXDEV 00,E13.6,0 IN,	OUTENS 7330
	-T67,0VBXDEV 00,E13.6,0 FT30)	OUTENS 7340
911	FORMAT(010,T53,0SYSTEM VOLUME/MASS SUMMARY,/,	OUTENS 7350
	-T31,0MLDS 00,E13.6,0 LBM,0T67,0VLDS 00,E13.6,0 FT30,/,	OUTENS 7360
	-T31,0MPRS 00,E13.6,0 LBM,/,042,0-----0	OUTENS 7370
	-T70,0-----0,/,T31,0MTOTAL 00,E13.6,0 LBM,	OUTENS 7380
	-T67,0VTOTAL 00,E13.6,0 FT30,/,T67,0VSYSTEM 00,E13.6,0 FT30,/,	OUTENS 7390
	-T31,0WBASF 00,E13.6,0 IN,0T67,0LLDS 00,E13.6,0 IN,/,	OUTENS 7400
	-T31,0LBXDEV 00,E13.6,0 IN,0T67,0WBXDEV 00,E13.6,0 IN,/,	OUTENS 7410
	-T31,0MBXDEV 00,E13.6,0 IN,0T67,0VBXDEV 00,E13.6,0 FT30)	OUTENS 7420
	END	OUTENS 7430

Appendix B. CHEMICAL LASER ANALYSIS PROGRAM (CLAP)-OVERLAY CCS

```

OVERLAY(CCS.1.0)
PROGRAM CCS

C
C
C.....
C0
C0      COMBUSTION CHEMISTRY OVERLAY (CCS)
C0
C0.....
C
C.....
C0      OVERLAY CCS PERFORMS THE COMBUSTION CHEMISTRY CALCULATIONS FOR
C0      PROGRAM CLAP.
C0
C0 INPUT VARIABLES:
C0
C0 AFXP      = NOZZLE BANK AREA OF THE EXPERIMENTAL DEVICE (M2)
C0 ALPHA     = FLUORINE DISSOCIATION FRACTION
C0 CCSS1     = CONTROL VARIABLE
C0 DFORMF    = CONTROL VARIABLE SUCH THAT:
C0           = "DF" FOR A DF CHEMICAL LASER
C0           = "MF" FOR A MF CHEMICAL LASER
C0 N1        = NUMBER OF CARBON ATOMS IN PRIMARY REACTANT 1
C0 N2        = NUMBER OF HYDROGEN ATOMS IN PRIMARY REACTANT 1
C0 N3        = NUMBER OF NITROGEN ATOMS IN PRIMARY REACTANT 4
C0 N4        = NUMBER OF FLUORINE ATOMS IN PRIMARY REACTANT 4
C0 WPR1      = MASS FLOW RATE OF C-H1 H-MP (KG/S)
C0 WPR2      = MASS FLOW RATE OF H2 (KG/S)
C0 WPR3      = MASS FLOW RATE OF N2 (KG/S)
C0 WPR4      = MASS FLOW RATE OF N-H3 F-H4 (KG/S)
C0 WSR1      = MASS FLOW RATE OF O2 (KG/S)
C0 WSR2      = MASS FLOW RATE OF HE (KG/S)
C0 WSR3      = MASS FLOW RATE OF N2 (KG/S)
C0
C0 OUTPUT VARIABLES:
C0
C0 FQAA      = FREE FLUORINE FLUX (MMOLE/S-M2)
C0 QHEBA     = TOTAL LASER MOLAR DILUENT RATIO
C0 QHEBTA    = TOTAL LASER MOLAR DILUENT RATIO (THE DEFINITION)
C0 PSIC      = MOLAR COMBUSTION DILUENT RATIO
C0 PSIL      = MOLAR CAVITY DILUENT RATIO
C0 PSILTA    = MOLAR CAVITY DILUENT RATIO (THE DEFINITION)
C0 Q         = HEAT RELEASED PER MMOLE OF PRIMARY FLOW BY THE CHEMICAL
C0           = REACTION OF FLUORINE IN THE LASER CAVITY (J/MMOLE)
C0 QC        = MOLAR COMBUSTION MIXTURE RATIO
C0 QF        = MOLAR CAVITY MIXTURE RATIO
C0 QF        = TOTAL LASER CAVITY MIXTURE RATIO
C0 QFC1      = MASS FRACTION OF C1
C0 QFC2      = MASS FRACTION OF H2
C0 QFC3      = MASS FRACTION OF N2
C0 QFC4      = MASS FRACTION OF HE
C0 QFC5      = MASS FRACTION OF O2
C0 QFC6      = MASS FRACTION OF I

```

```

CCS  0100
CCS  0110
CCS  0120
CCS  0130
CCS  0140
CCS  0150
CCS  0160
CCS  0170
CCS  0180
CCS  0190
CCS  0200
CCS  0210
CCS  0220
CCS  0230
CCS  0240
CCS  0250
CCS  0260
CCS  0270
CCS  0280
CCS  0290
CCS  0300
CCS  0310
CCS  0320
CCS  0330
CCS  0340
CCS  0350
CCS  0360
CCS  0370
CCS  0380
CCS  0390
CCS  0400
CCS  0410
CCS  0420
CCS  0430
CCS  0440
CCS  0450
CCS  0460
CCS  0470
CCS  0480
CCS  0490
CCS  0500
CCS  0510
CCS  0520
CCS  0530
CCS  0540
CCS  0550
CCS  0560
CCS  0570
CCS  0580
CCS  0590
CCS  0600
CCS  0610
CCS  0620
CCS  0630
CCS  0640
CCS  0650
CCS  0660
CCS  0670
CCS  0680
CCS  0690
CCS  0700
CCS  0710
CCS  0720
CCS  0730
CCS  0740
CCS  0750
CCS  0760
CCS  0770
CCS  0780
CCS  0790
CCS  0800
CCS  0810
CCS  0820
CCS  0830
CCS  0840
CCS  0850
CCS  0860
CCS  0870
CCS  0880
CCS  0890
CCS  0900
CCS  0910
CCS  0920
CCS  0930
CCS  0940
CCS  0950
CCS  0960
CCS  0970
CCS  0980
CCS  0990
CCS  1000

```

C* WFPF3	= MASS FRACTION OF F	*CCS	0650
C* WFPF1	= MASS FRACTION OF C-N1 H-NP (C-N1 D-N2)	*CCS	0660
C* WFPF2	= MASS FRACTION OF HE	*CCS	0670
C* WFPF3	= MASS FRACTION OF NP	*CCS	0680
C* WFPF4	= MASS FRACTION OF N-N1 F-N4	*CCS	0690
C* WFSR1	= MASS FRACTION OF D2 (H2)	*CCS	0700
C* WFSR2	= MASS FRACTION OF HE	*CCS	0710
C* WFSR3	= MASS FRACTION OF NP	*CCS	0720
C* WPSWPP	= MIRROR PURGE-TO-PRIMARY COMBUSTOR PRODUCT MASS FLOW RATIO	*CCS	0730
C* XFCP1	= MOLE FRACTION OF CF4	*CCS	0740
C* XFCP2	= MOLE FRACTION OF HF	*CCS	0750
C* XFCP3	= MOLE FRACTION OF DF	*CCS	0760
C* XFCP4	= MOLE FRACTION OF HE	*CCS	0770
C* XFCP5	= MOLE FRACTION OF NP	*CCS	0780
C* XFCP6	= MOLE FRACTION OF D (H)	*CCS	0790
C* XFPP1	= MOLE FRACTION OF CF4	*CCS	0800
C* XFPP2	= MOLE FRACTION OF F2	*CCS	0810
C* XFPP3	= MOLE FRACTION OF F	*CCS	0820
C* XFPP4	= MOLE FRACTION OF HF (DF)	*CCS	0830
C* XFPP5	= MOLE FRACTION OF HE	*CCS	0840
C* XFPP6	= MOLE FRACTION OF N2	*CCS	0850
C* XFSR1	= MOLE FRACTION OF D2 (H2)	*CCS	0860
C* XFSR2	= MOLE FRACTION OF HE	*CCS	0870
C* XFSR3	= MOLE FRACTION OF N2	*CCS	0880
C*		*CCS	0890
C* NOTE: ALL CALCULATIONS ARE PERFORMED IN SI UNITS.		*CCS	0900
C*		*CCS	0910
C*****		*CCS	0920
C		*CCS	0930
C*****		*CCS	0940
C*		*CCS	0950
C*		*CCS	0960
C*		*CCS	0970
C* VARIABLES ARE DEFINED AS FOLLOWS :		*CCS	0980
C*		*CCS	0990
C* PREFIX:		*CCS	1000
C*		*CCS	1010
C* W	= MASS FLOW RATE	*CCS	1020
C* WF	= MASS FRACTION	*CCS	1030
C* X	= MOLAR FLOW RATE	*CCS	1040
C* XF	= MOLE FRACTION	*CCS	1050
C*		*CCS	1060
C* SUFFIX:		*CCS	1070
C*		*CCS	1080
C* CP	= CAVITY PRODUCT	*CCS	1090
C* PG	= MIRROR PURGE	*CCS	1100
C* PP	= PRIMARY COMBUSTOR PRODUCT	*CCS	1110
C* PR	= PRIMARY COMBUSTOR REACTANT	*CCS	1120
C* SR	= SECONDARY REACTANT	*CCS	1130
C*		*CCS	1140
C* EXAMPLE: XFPP1 = MOLE FRACTION OF PRIMARY COMBUSTOR PRODUCT 1		*CCS	1150
C*		*CCS	1160
C* LASER PRIMARY COMBUSTOR REACTANTS:		*CCS	1170
C*		*CCS	1180
C* PR1	= C-N1 H-N2 (C-N1 D-N2)	*CCS	1190

APPENDIX A
PROGRAM CCS

CHEMICAL LASER ANALYSIS PROGRAM (CLAP)
OVERLAY CCS

PAGE 8- 3

C* PR2	= HF	*CCS	1200
C* PR3	= N2	*CCS	1210
C* PR4	= N-N3 F-N4	*CCS	1220
C*		*CCS	1230
C* LASER SECONDARY REACTANTS:		*CCS	1240
C*		*CCS	1250
C* SR1	= O2 (H2)	*CCS	1260
C* SR2	= HE	*CCS	1270
C* SR3	= N2	*CCS	1280
C*		*CCS	1290
C* LASER PRIMARY COMBUSTOR PRODUCTS:		*CCS	1300
C*		*CCS	1310
C* PP1	= CF4	*CCS	1320
C* PP2	= F2	*CCS	1330
C* PP3	= F	*CCS	1340
C* PP4	= HF (DF)	*CCS	1350
C* PP5	= HF	*CCS	1360
C* PP6	= N2	*CCS	1370
C*		*CCS	1380
C* LASER CAVITY PRODUCTS:		*CCS	1390
C*		*CCS	1400
C* CP1	= CF4	*CCS	1410
C* CP2	= HF	*CCS	1420
C* CP3	= DF	*CCS	1430
C* CP4	= HF	*CCS	1440
C* CP5	= N2	*CCS	1450
C* CP6	= D (H)	*CCS	1460
C*		*CCS	1470
C*		*CCS	1480
C*		*CCS	1490
C*		*CCS	1500
C	REAL NO	*CCS	1510
C	COMMON/CCS1/CCS1	*CCS	1520
C	COMMON/CCS2/AEXP,ALPHA,WPG,WPR1,WPR2,WPR3,WPR4,WSR1,WSR2,WSR3	*CCS	1530
C	COMMON/CCS3/DFORHF	*CCS	1540
C	COMMON/CCS4/FDAA	*CCS	1550
C	COMMON/CCS5/N1,N2,N3,N4	*CCS	1560
C	COMMON/CCS6/OMEGA,OMENTRW,PSIC,PSIL,PSILTRW,RC,RLF,WFCP1,WFCP2, -WFCP3,WFCP4,WFCP5,WFCP6	*CCS	1570
C	COMMON/CCS7/0	*CCS	1580
C	COMMON/CCS8/RL	*CCS	1590
C	COMMON/CCS9/WFPP3,WFPRI,WFPR4,WFSR1	*CCS	1600
C	COMMON/CCS10/WFPR2,WFPR3,WFSRP,WFSR3	*CCS	1610
C	COMMON/CCS11/WP8WPP	*CCS	1620
		*CCS	1630
		*CCS	1640
		*CCS	1650
		*CCS	1660
		*CCS	1670
		*CCS	1680
		*CCS	1690
		*CCS	1700
		*CCS	1710
		*CCS	1720
		*CCS	1730
		*CCS	1740

APPENDIX B
PROGRAM CCS

CHEMICAL LASER ANALYSIS PROGRAM (CLAP)
OVERLAY CCS

PAGE B- 4

C	COMMON/CCS12/XFCP1(2),XFCP2(2),XFCP3(2),XFCP4(2),XFCP5(2),XFCP6(2)	CCS	1750
C	COMMON/CCS13/XFPP1,XFPP4,XFPP5,XFPP6	CCS	1760
C	COMMON/CCS14/XFPP2	CCS	1770
C	COMMON/CCS15/XFPP3	CCS	1780
C	COMMON/CCS16/XFSR1,XFSR2,XFSR3	CCS	1790
C	DATA D2F/1.29662E+08/,D2F2/5.51033E+08/,H2F/1.31294F+08/,	CCS	1800
C	-H2F2/5.45092E+08/	CCS	1810
C	DATA DF/2HDF/,HF/2MHF/,NO/2MNO/	CCS	1820
C		CCS	1830
C		CCS	1840
C		CCS	1850
C		CCS	1860
C		CCS	1870
C		CCS	1880
C		CCS	1890
C		CCS	1900
C		CCS	1910
C	*****	CCS	1920
C*		*CCS	1930
C*	READ INPUT DATA	*CCS	1940
C*		*CCS	1950
C	*****	CCS	1960
C		CCS	1970
C		CCS	1980
C	CALL INCCS	CCS	1990
C	IF (CCSS1.EQ.NO) 80 TO 103	CCS	2000
C		CCS	2010
C		CCS	2020
C	*****	CCS	2030
C*		*CCS	2040
C*	COMPUTE PRIMARY COMBUSTOR REACTANT MOLAR FLOW RATES (KMOLE/S)	*CCS	2050
C*		*CCS	2060
C	*****	CCS	2070
C		CCS	2080
C		CCS	2090
C	IF (DFORMF.EQ.DF) XPR1=WPR1/(N1*12.0111+N2*1.00797)	CCS	2100
C	IF (DFORMF.EQ.HF) XPR1=WPR1/(N1*12.0111+N2*2.01410)	CCS	2110
C	XPR2=WPR2/4.00260	CCS	2120
C	XPR3=WPR3/28.0134	CCS	2130
C	XPR4=WPR4/(N3*14.0067+N4*18.9984)	CCS	2140
C		CCS	2150
C		CCS	2160
C	*****	CCS	2170
C*		*CCS	2180
C*	COMPUTE MOLE FRACTIONS OF THE PRIMARY COMBUSTOR REACTANTS	*CCS	2190
C*		*CCS	2200
C	*****	CCS	2210
C		CCS	2220
C		CCS	2230
C	XPRTOT=XPR1+XPR2+XPR3+XPR4	CCS	2240
C	XFPR1=XPR1/XPRTOT	CCS	2250
C	XFPR2=XPR2/XPRTOT	CCS	2260
C	XFPR3=XPR3/XPRTOT	CCS	2270
C	XFPR4=XPR4/XPRTOT	CCS	2280
C		CCS	2290

C	CCS	2300
C*****	CCS	2310
C*	*CCS	2320
C* COMPUTE MASS FRACTIONS OF THE PRIMARY COMBUSTOR REACTANTS	*CCS	2330
C*	*CCS	2340
C*****	*CCS	2350
C	CCS	2360
C	CCS	2370
WPRTOT=WPR1+WPR2+WPR3+WPR4	CCS	2380
WFR1=WPR1/WPRTOT	CCS	2390
WFR2=WPR2/WPRTOT	CCS	2400
WFR3=WPR3/WPRTOT	CCS	2410
WFR4=WPR4/WPRTOT	CCS	2420
C	CCS	2430
C	CCS	2440
C*****	*CCS	2450
C*	*CCS	2460
C* COMPUTE PRIMARY COMBUSTOR PRODUCT MOLAR FLOW RATES (KMOLE/S)	*CCS	2470
C*	*CCS	2480
C*****	*CCS	2490
C	CCS	2500
C	CCS	2510
XPP1=XPR1*N1	CCS	2520
XPP4=XPR1*N2	CCS	2530
XPP5=XPR2	CCS	2540
XPP6=XPR3+0.5*XPR4*N3	CCS	2550
XPP3TM=XPR4*N4-XPP4-4.0*XPP1	CCS	2560
XPP3=ALPHA*XPP3TM	CCS	2570
XPP2=0.5*(1.0-ALPHA)*XPP3TM	CCS	2580
C	CCS	2590
C	CCS	2600
C*****	*CCS	2610
C*	*CCS	2620
C* COMPUTE PRIMARY COMBUSTOR PRODUCT MASS FLOW RATES (KG/S)	*CCS	2630
C*	*CCS	2640
C*****	*CCS	2650
C	CCS	2660
C	CCS	2670
WPP1=XPP1*(12.0111+4.0*18.9984)	CCS	2680
WPP2=XPP2*37.9968	CCS	2690
WPP3=XPP3*18.9984	CCS	2700
IF (DFORMF.EQ.DF) WPP4=XPP4*(1.00797*18.9984)	CCS	2710
IF (DFORMF.EQ.HF) WPP4=XPP4*(2.01410*18.9984)	CCS	2720
WPP5=XPP5*4.00260	CCS	2730
WPP6=XPP6*28.0134	CCS	2740
C	CCS	2750
C	CCS	2760
C*****	*CCS	2770
C*	*CCS	2780
C* COMPUTE MOLE FRACTIONS OF THE PRIMARY COMBUSTOR PRODUCTS	*CCS	2790
C*	*CCS	2800
C*****	*CCS	2810
C	CCS	2820
C	CCS	2830
XPPTOT=XPP1+XPP2+XPP3+XPP4+XPP5+XPP6	CCS	2840

XFP1=XPP1/XPPTOT	CCS	2850
XFP2=XPP2/XPPTOT	CCS	2860
XFP3=XPP3/XPPTOT	CCS	2870
XFP4=XPP4/XPPTOT	CCS	2880
XFP5=XPP5/XPPTOT	CCS	2890
XFP6=XPP6/XPPTOT	CCS	2900
C	CCS	2910
C	CCS	2920
C*****	CCS	2930
C*	*CCS	2940
C* COMPUTE MASS FRACTIONS OF THE PRIMARY COMBUSTOR PRODUCTS	*CCS	2950
C*	*CCS	2960
C*****	CCS	2970
C	CCS	2980
C	CCS	2990
WPPTOT=WP1+WP2+WP3+WP4+WP5+WP6	CCS	3000
WFP1=WP1/WPPTOT	CCS	3010
WFP2=WP2/WPPTOT	CCS	3020
WFP3=WP3/WPPTOT	CCS	3030
WFP4=WP4/WPPTOT	CCS	3040
WFP5=WP5/WPPTOT	CCS	3050
WFP6=WP6/WPPTOT	CCS	3060
W6WFP=WP6/WPPTOT	CCS	3070
C	CCS	3080
C	CCS	3090
C*****	CCS	3100
C*	*CCS	3110
C* COMPUTE SECONDARY REACTANT MOLAR FLOW RATES (KMOLE/S)	*CCS	3120
C*	*CCS	3130
C*****	CCS	3140
C	CCS	3150
C	CCS	3160
IF (DFORMF,EQ,DF) XSR1=WSR1/4.02620	CCS	3170
IF (DFORMF,EQ,WF) XSR1=WSR1/2.01594	CCS	3180
XSR2=WSR2/4.00260	CCS	3190
XSR3=WSR3/28.0134	CCS	3200
C	CCS	3210
C	CCS	3220
C*****	CCS	3230
C*	*CCS	3240
C* COMPUTE MOLE FRACTIONS OF THE SECONDARY REACTANTS	*CCS	3250
C*	*CCS	3260
C*****	CCS	3270
C	CCS	3280
C	CCS	3290
XSRTOT=XSR1+XSR2+XSR3	CCS	3300
XFSR1=XSR1/XSRTOT	CCS	3310
XFSR2=XSR2/XSRTOT	CCS	3320
XFSR3=XSR3/XSRTOT	CCS	3330
C	CCS	3340
C	CCS	3350
C*****	CCS	3360
C*	*CCS	3370
C* COMPUTE MASS FRACTIONS OF THE SECONDARY REACTANTS	*CCS	3380
C*	*CCS	3390

```

C.....CCS 3400
C                                     CCS 3410
C                                     CCS 3420
      WSRTOT=WSR1+WSR2+WSR3          CCS 3430
      SR1=WSR1/WSRTOT                CCS 3440
      WFSR2=WSR2/WSRTOT              CCS 3450
      WFSR3=WSR3/WSRTOT              CCS 3460
C                                     CCS 3470
C                                     CCS 3480
C.....CCS 3490
C*                                     CCS 3500
C*      COMPUTE CAVITY PRODUCT MOLAR FLOW RATES (KMOLE/S)  CCS 3510
C*                                     CCS 3520
C.....CCS 3530
C                                     CCS 3540
C                                     CCS 3550
      XCP1=XPP1                      CCS 3560
      IF (DFORMF.EQ.HF) GO TO 101    CCS 3570
      XCP2=XPP4                      CCS 3580
      XCP3=2.0*XPP2+XPP3             CCS 3590
      XCP6=2.0*XSRI-XCP3             CCS 3600
      GO TO 102                      CCS 3610
101  XCP2=2.0*XPP2+XPP3             CCS 3620
      XCP3=XPP4                      CCS 3630
      XCP6=2.0*XSRI-XCP2             CCS 3640
102  XCP4=XPP5+XSRI                 CCS 3650
      XCP5=XPP6+XSRI                 CCS 3660
C.....CCS 3670
C*                                     CCS 3680
C*      COMPUTE CAVITY PRODUCT MASS FLOW RATES (KG/S)      CCS 3690
C*                                     CCS 3700
C.....CCS 3710
C                                     CCS 3720
C                                     CCS 3730
      WCP1=XCP1*88.0047              CCS 3740
      WCP2=XCP2*20.0064              CCS 3750
      WCP3=XCP3*21.0125              CCS 3760
      WCP4=XCP4*4.00260              CCS 3770
      WCP5=XCP5*28.0134              CCS 3780
      IF (DFORMF.EQ.DF) WCP6=XCP6*2.01410 CCS 3790
      IF (DFORMF.EQ.HF) WCP6=XCP6*1.00797 CCS 3800
C                                     CCS 3810
C                                     CCS 3820
C.....CCS 3830
C*                                     CCS 3840
C*      COMPUTE MOLE FRACTIONS OF THE CAVITY PRODUCTS      CCS 3850
C*      (1) WITHOUT MIRROR PURGE                             CCS 3860
C*      (2) WITH MIRROR PURGE                                CCS 3870
C*                                     CCS 3880
C.....CCS 3890
C                                     CCS 3900
C                                     CCS 3910
      XCPTOT=XCP1+XCP2+XCP3+XCP4+XCP5+XCP6 CCS 3920
      XFCP1(1)=XCP1/XCPTOT           CCS 3930
      XFCP2(1)=XCP2/XCPTOT           CCS 3940

```


XFCP3(1)=XCP3/XCPTOT	CCS	3950
XFCP4(1)=XCP4/XCPTOT	CCS	3960
XFCP5(1)=XCP5/XCPTOT	CCS	3970
XFCP6(1)=XCP6/XCPTOT	CCS	3980
XCPTOT=XCPTOT*WP6/28.0134	CCS	3990
XFCP1(2)=XCP1/XCPTOT	CCS	4000
XFCP2(2)=XCP2/XCPTOT	CCS	4010
XFCP3(2)=XCP3/XCPTOT	CCS	4020
XFCP4(2)=XCP4/XCPTOT	CCS	4030
XFCP5(2)=(XCP5*WP6/28.0134)/XCPTOT	CCS	4040
XFCP6(2)=XCP6/XCPTOT	CCS	4050
C	CCS	4060
C	CCS	4070
C*****	CCS	4080
C*	*CCS	4090
C* COMPUTE MASS FRACTIONS OF THE CAVITY PRODUCTS	*CCS	4100
C* WITH MIRROR PURGE	*CCS	4110
C*	*CCS	4120
C*****	CCS	4130
C	CCS	4140
C	CCS	4150
WCPTOT=WCP1+WCP2+WCP3+WCP4+WCP5+WCP6+WP6	CCS	4160
WFCP1=WCP1/WCPTOT	CCS	4170
WFCP2=WCP2/WCPTOT	CCS	4180
WFCP3=WCP3/WCPTOT	CCS	4190
WFCP4=WCP4/WCPTOT	CCS	4200
WFCP5=(WCP5+WP6)/WCPTOT	CCS	4210
WFCP6=WCP6/WCPTOT	CCS	4220
C	CCS	4230
C	CCS	4240
C*****	CCS	4250
C*	*CCS	4260
C* COMPUTE THE DILUENT AND MIXTURE RATIOS	*CCS	4270
C*	*CCS	4280
C* NOTE: TRW ASSUMES EXCESS O2 IS NOT USED IN THE PSIL CALCULATION!	*CCS	4290
C* HENCE, OMEGA IS DIFFERENT.	*CCS	4300
C*	*CCS	4310
C*****	CCS	4320
C	CCS	4330
C	CCS	4340
PSIC=(XPP1+XPP4+XPP5+XPP6)/(XPP2+0.5*XPP3)	CCS	4350
PSIL=(XSR1+XSR2+XSR3)/(XPP2+0.5*XPP3)	CCS	4360
PSILTRW=(XSR2+XSR3)/(XPP2+0.5*XPP3)	CCS	4370
RC=(XPR4*N2)/(XPR1*(4.0*N1+N2))	CCS	4380
RL=XSR1/(XPP2+0.5*XPP3)	CCS	4390
RLF=(XSR1+XSR2+XSR3)/(XPP2+0.5*XPP3)	CCS	4400
OMEGA=PSIC*PSIL	CCS	4410
OMEGTRW=PSIC*PSILTRW	CCS	4420
C	CCS	4430
C	CCS	4440
C*****	CCS	4450
C*	*CCS	4460
C* COMPUTE THE AVAILABLE FLUORINE FLUX	*CCS	4470
C*	*CCS	4480
C*****	CCS	4490

APPENDIX B
PROGRAM CCS

CHEMICAL LASER ANALYSIS PROGRAM (CLAP)
OVERLAY CCS

PAGE 11- 9

C		CCS	4500
C		CCS	4510
C	FDAA=XPP3/AEXP	CCS	4520
C		CCS	4530
C		CCS	4540
C	.....	CCS	4550
C		CCS	4560
C	COMPUTE THE HEAT RELEASE WHERE:	CCS	4570
C		CCS	4580
C	D2F = HEAT OF COMBUSTION (J/KMOLE) FOR THE REACTION	CCS	4590
C	D2 + F = DF + D	CCS	4600
C		CCS	4610
C	D2FP = HEAT OF COMBUSTION (J/KMOLE) FOR THE REACTION	CCS	4620
C	D2 + F2 = 2DF	CCS	4630
C		CCS	4640
C	H2F = HEAT OF COMBUSTION (J/KMOLE) FOR THE REACTION	CCS	4650
C	H2 + F = HF + H	CCS	4660
C		CCS	4670
C	H2FP = HEAT OF COMBUSTION (J/KMOLE) FOR THE REACTION	CCS	4680
C	H2 + F2 = 2HF	CCS	4690
C		CCS	4700
C	.....	CCS	4710
C		CCS	4720
C		CCS	4730
C	IF (NFORMF.EQ.DF) Q=D2F*XFP3+D2F2*XFP2	CCS	4740
C	IF (NFORMF.EQ.HF) Q=H2F*XFP3+H2F2*XFP2	CCS	4750
C		CCS	4760
C		CCS	4770
C	.....	CCS	4780
C		CCS	4790
C	OUTPUT. RESULTS	CCS	4800
C		CCS	4810
C	.....	CCS	4820
C		CCS	4830
C		CCS	4840
C		CCS	4850
103	CALL OUTCCS	CCS	4860
	END		

SUBROUTINE INCCS	INCCS 0100
C	INCCS 0110
C	INCCS 0120
C.....	INCCS 0130
C*	INCCS 0140
C* INPUT SUBROUTINE (INCCS)	INCCS 0150
C*	INCCS 0160
C.....	INCCS 0170
C	INCCS 0180
C.....	INCCS 0190
C*	INCCS 0200
C* SUBROUTINE INCCS CONTROLS THE INPUT OF INITIAL DATA FOR THE	INCCS 0210
C* COMBUSTION CHEMISTRY SECTION.	INCCS 0220
C*	INCCS 0230
C* INPUT/OUTPUT VARIABLES:	INCCS 0240
C*	INCCS 0250
C* AEXP = NOZZLE BANK AREA OF THE EXPERIMENTAL DEVICE (M2)	INCCS 0260
C* ALPHA = FLUORINE DISSOCIATION FRACTION	INCCS 0270
C* CCSS1 = CONTROL VARIABLE	INCCS 0280
C* CCSS2 = CONTROL VARIABLE	INCCS 0290
C* DFORMF = CONTROL VARIABLE SUCH THAT:	INCCS 0300
C* = "DF" FOR A DF CHEMICAL LASER	INCCS 0310
C* = "HF" FOR A HF CHEMICAL LASER	INCCS 0320
C* N1 = NUMBER OF CARBON ATOMS IN REACTANT WPR1	INCCS 0330
C* N2 = NUMBER OF HYDROGEN ATOMS IN REACTANT WPR1	INCCS 0340
C* N3 = NUMBER OF NITROGEN ATOMS IN REACTANT WPR4	INCCS 0350
C* N4 = NUMBER OF FLUORINE ATOMS IN REACTANT WPR4	INCCS 0360
C* SETCCS = CONTROL VARIABLE	INCCS 0370
C* WPR0 = MASS FLOW RATE OF MIRROR PURGE N2 (KG/S)	INCCS 0380
C* WPR1 = MASS FLOW RATE OF C-N1 H-N2 (C-N1 D-N2) (KG/S)	INCCS 0390
C* WPR2 = MASS FLOW RATE OF HE (KG/S)	INCCS 0400
C* WPR3 = MASS FLOW RATE OF N2 (KG/S)	INCCS 0410
C* WPR4 = MASS FLOW RATE OF N-N3 F-N4 (KG/S)	INCCS 0420
C* WSR1 = MASS FLOW RATE OF D2 (M2) (KG/S)	INCCS 0430
C* WSR2 = MASS FLOW RATE OF HE (KG/S)	INCCS 0440
C* WSR3 = MASS FLOW RATE OF N2 (KG/S)	INCCS 0450
C*	INCCS 0460
C* NOTE: ALL INPUT IS IN SI UNITS.	INCCS 0470
C*	INCCS 0480
C.....	INCCS 0490
C	INCCS 0500
C	INCCS 0510
C REAL NO	INCCS 0520
C	INCCS 0530
C COMMON/CCS1/CCSS1	INCCS 0540
C	INCCS 0550
C COMMON/CCS2/AEXP,ALPHA,WPR1,WPR2,WPR3,WPR4,WSR1,WSR2,WSR3	INCCS 0560
C	INCCS 0570
C COMMON/CCS3/DFORMF	INCCS 0580
C	INCCS 0590
C COMMON/CCS5/N1,N2,N3,N4	INCCS 0600
C	INCCS 0610
C COMMON/MAIN3/SETCCS	INCCS 0620
C	INCCS 0630
C DATA NO/2HNO/,YES/3HYES/	INCCS 0640

C		INCCS 0650
	NAMELIST/NLCCS/AEXP,ALPHA,N1,N2,N3,N4,WP6,WPR1,WPR2,WPR3,WPR4,	INCCS 0660
	-WSR1,WSR2,WSR3	INCCS 0670
C		INCCS 0680
C		INCCS 0690
C	.....	INCCS 0700
C*		*INCCS 0710
C*	SET DEFAULT VALUES	*INCCS 0720
C*		*INCCS 0730
C	.....	INCCS 0740
C		INCCS 0750
C		INCCS 0760
	WRITE(4,201)	INCCS 0770
	READ(5,202)CCSS1	INCCS 0780
	IF (SETCCS.EQ.NO) GO TO 101	INCCS 0790
	AEXP=3.61935E-03	INCCS 0800
	ALPHA=0.802700	INCCS 0810
	DFORMF=2HMF	INCCS 0820
	N1=2	INCCS 0830
	N2=4	INCCS 0840
	N3=1	INCCS 0850
	N4=3	INCCS 0860
	WP6=0.0	INCCS 0870
	WPR1=3.62160E-03	INCCS 0880
	WPR2=17.2416E-03	INCCS 0890
	WPR3=0.0	INCCS 0900
	WPR4=57.1093E-03	INCCS 0910
	WSR1=4.37250E-03	INCCS 0920
	WSR2=33.8518E-03	INCCS 0930
	WSR3=0.0	INCCS 0940
	SETCCS=NO	INCCS 0950
	IF (CCSS1.EQ.YES) GO TO 102	INCCS 0960
	CCSS1=YES	INCCS 0970
	RETURN	INCCS 0980
C		INCCS 0990
C		INCCS 1000
C	.....	INCCS 1010
C*		*INCCS 1020
C*	CONTROL STATEMENTS	*INCCS 1030
C*		*INCCS 1040
C	.....	INCCS 1050
C		INCCS 1060
C		INCCS 1070
101	IF (CCSS1.EQ.NO) RETURN	INCCS 1080
102	WRITE(6,203)	INCCS 1090
	READ(5,202)CCSS2	INCCS 1100
	IF (CCSS2.EQ.NO) GO TO 103	INCCS 1110
	REWIND 1	INCCS 1120
	READ(1)AEXP,ALPHA,DFORMF,N1,N2,N3,N4,WP6,WPR1,WPR2,WPR3,WPR4,WSR1,	INCCS 1130
	-WSR2,WSR3	INCCS 1140
	RETURN	INCCS 1150
103	WRITE(6,204)	INCCS 1160
	READ(5,205)DFORMF	INCCS 1170
	WRITE(6,206)	INCCS 1180
	WRITE(6,207)AEXP,ALPHA,N1,N2,N3,N4,WP6,WPR1,WPR2,WPR3,WPR4,WSR1,	INCCS 1190

-WSR2,WSR3	INCCS	1200
READ(5,NLCCS)	INCCS	1210
REVIND 1	INCCS	1220
WRITE(1)AEXP,ALPHA,DFORMF,N1,N2,N3,N4,WPS,WPR1,WPR2,WPR3,WPR4,	INCCS	1230
-WSR1,WSR2,WSR3	INCCS	1240
C	INCCS	1250
C	INCCS	1260
C.....	INCCS	1270
C*	*INCCS	1280
C*	*INCCS	1290
C*	*INCCS	1300
C.....	INCCS	1310
C	INCCS	1320
C	INCCS	1330
201 FORMAT(10,T2,'ARE NEW COMBUSTION CHEMISTRY INPUTS REQUIRED?.'/)	INCCS	1340
202 FORMAT(A3)	INCCS	1350
203 FORMAT(10,T2,'SHOULD INPUT DATA BE READ FROM TAPE1?.'/)	INCCS	1360
204 FORMAT(10,T2,'SELECT THE LASER CHEMISTRY FROM THE FOLLOWING LIST:	INCCS	1370
-1,1,T2,'DFM FOR A DF CHEMICAL LASER.'/,T2,'HFM FOR A HF CHEMICAL	INCCS	1380
-LASER.'/)	INCCS	1390
205 FORMAT(A2)	INCCS	1400
206 FORMAT(10,T2,'INPUT DATA FOR THE COMBUSTION CHEMISTRY SECTION BY	INCCS	1410
-NAMELIST,1,1,T2,'CURRENT VALUES ARE:')	INCCS	1420
207 FORMAT(10,T2,'NLCCS',T26,'AZXP ==,E13.6,T50,'ALPHA ==,	INCCS	1430
-E13.6,/,T2,'N1 ==,I13,T26,'N2 ==,I13,T50,'N3 ==,	INCCS	1440
-I13,/,T2,'N4 ==,I13,T26,'WPS ==,E13.6,T50,'WPR1 ==,	INCCS	1450
-E13.6,/,T2,'WPR2 ==,E13.6,T26,'WPR3 ==,E13.6,T50,	INCCS	1460
-WPR4 ==,E13.6,/,T2,'WSR1 ==,E13.6,T26,'WSR2 ==,E13.6,	INCCS	1470
-T50,'WSR3 ==,E13.6,'S'.'/)	INCCS	1480
END	INCCS	1490

```

SUBROUTINE OUTCCS                                OUTCCS 0100
C                                                    OUTCCS 0110
C                                                    OUTCCS 0120
C.....OUTCCS 0130
C*                                                    *OUTCCS 0140
C*                OUTPUT SUBROUTINE (OUTCCS)          *OUTCCS 0150
C*                                                    *OUTCCS 0160
C.....OUTCCS 0170
C                                                    OUTCCS 0180
C.....OUTCCS 0190
C*                                                    *OUTCCS 0200
C* SUBROUTINE OUTCCS PRINTS THE COMBUSTION CHEMISTRY SECTION RESULTS *OUTCCS 0210
C* OF PROGRAM CLAP IN SI UNITS ON TERMINALS WITH A MINIMUM OF 132 *OUTCCS 0220
C* CHARACTERS PER LINE.                                *OUTCCS 0230
C*                                                    *OUTCCS 0240
C.....OUTCCS 0250
C                                                    OUTCCS 0260
C                                                    OUTCCS 0270
C    COMMON/CCS2/AEXP,ALPHA,WP6,WPR1,WPR2,WPR3,WPR4,WSR1,WSR2,WSR3 OUTCCS 0280
C    COMMON/CCS3/DFORMF                                OUTCCS 0290
C                                                    OUTCCS 0300
C    COMMON/CCS4/FDAA                                  OUTCCS 0310
C                                                    OUTCCS 0320
C    COMMON/CCS5/N1,N2,N3,N4                          OUTCCS 0330
C                                                    OUTCCS 0340
C    COMMON/CCS6/OME6A,OME6TRW,PSIC,PSIL,PSILTRW,RC,RLF,WFCP1,WFCP2, OUTCCS 0360
C    -WFCP3,WFCP4,WFCP5,WFCP6                        OUTCCS 0370
C                                                    OUTCCS 0380
C    COMMON/CCS7/Q                                    OUTCCS 0390
C                                                    OUTCCS 0400
C    COMMON/CCS8/RL                                   OUTCCS 0410
C                                                    OUTCCS 0420
C    COMMON/CCS12/XFCP1(2),XFCP2(2),XFCP3(2),XFCP4(2),XFCP5(2),XFCP6(2) OUTCCS 0430
C                                                    OUTCCS 0440
C    DATA DF/2HDF/,HF/2HHF/                        OUTCCS 0450
C                                                    OUTCCS 0460
C                                                    OUTCCS 0470
C.....OUTCCS 0480
C*                                                    *OUTCCS 0490
C*                OUTPUT INITIAL DATA                *OUTCCS 0500
C*                                                    *OUTCCS 0510
C.....OUTCCS 0520
C                                                    OUTCCS 0530
C                                                    OUTCCS 0540
C                                                    OUTCCS 0550
C    CALL DATE(RDATE)                                OUTCCS 0560
C    WRITE(20,201)RDATE                              OUTCCS 0570
C    IF(DFORMF.EQ.DF) WRITE(20,202)AEXP,ALPHA,DFORMF,N1,N2,N3,N4,WP6, OUTCCS 0580
C    -WPR1,N1,N2,WPR2,WPR3,WPR4,N3,N4,WSR1,WSR2,WSR3 OUTCCS 0590
C    IF(DFORMF.EQ.HF) WRITE(20,203)AEXP,ALPHA,DFORMF,N1,N2,N3,N4,WP6, OUTCCS 0600
C    -WPR1,N1,N2,WPR2,WPR3,WPR4,N3,N4,WSR1,WSR2,WSR3 OUTCCS 0610
C                                                    OUTCCS 0620
C.....OUTCCS 0630
C*                                                    *OUTCCS 0640

```

```
C*          OUTPUT RESULTANT DATA                                *OUTCCS 0650
C*          *OUTCCS 0660
C*          *OUTCCS 0670
C*          *OUTCCS 0680
C*          *OUTCCS 0690
C          WRITE(20,204)FDAA,OMEGA,OMEGTRW,PSIC,PSIL,PSILTRW,O,RC,RL,RLF
C          IF(DFORMF,EQ,DF) WRITE(20,205)WFCP1,XFCP1(2),WFCP2,XFCP2(2),WFCP3,OUTCCS 0700
C          -XFCP3(2),WFCP4,XFCP4(2),WFCP5,XFCP5(2),WFCP6,XFCP6(2) OUTCCS 0710
C          IF(DFORMF,EQ,HF) WRITE(20,206)WFCP1,XFCP1(2),WFCP2,XFCP2(2),WFCP3,OUTCCS 0720
C          -XFCP3(2),WFCP4,XFCP4(2),WFCP5,XFCP5(2),WFCP6,XFCP6(2) OUTCCS 0730
C          *OUTCCS 0740
C          *OUTCCS 0750
C          *OUTCCS 0760
C          *OUTCCS 0770
C*          *OUTCCS 0780
C*          *OUTCCS 0790
C*          *OUTCCS 0800
C*          *OUTCCS 0810
C          *OUTCCS 0820
C          *OUTCCS 0830
C          *OUTCCS 0840
201  FORMAT(*1,//////,T47,*CHEMICAL LASER ANALYSIS PROGRAM (CLAP)*,//OUTCCS 0850
C          -.T53,*WRITTEN BY: C.L. ADAMS*,//T65,*A.L. ADDY*,//T65,*R.D. MASSEY*OUTCCS 0860
C          -.T65,*C.D. MIKKELSEN*,//T65,*B.F. MORR*,//T65,*R.L. ORLUKIAN*,//OUTCCS 0870
C          -.T65,*B.J. WALKER*,//T60,*1 JANUARY 77*,//T51,*AFRODYNAMICS GROUP*OUTCCS 0880
C          -P (DDPMI-TDK)*,//T51,*SYSTEM SIMULATION DIRECTORATE*,//T42,*U.S. AOUTCCS 0890
C          -ARMY MISSILE RESEARCH & DEVELOPMENT COMMAND*,//T51,*REDSTONE ARSENAOUTCCS 0900
C          -L ALABAMA 35809*,//T57,*RUN DATE *,A10) OUTCCS 0910
202  FORMAT(*0,//////,T52,*COMBUSTION CHEMISTRY SECTION*,//T60, OUTCCS 0920
C          *INITIAL DATA*,//, OUTCCS 0930
C          -T32,*AEXP ==,E13.6,* N2*,T66,*ALPHA ==,E13.6,/, OUTCCS 0940
C          -T32,*DFORMF ==,A13,T66,*N1 ==,I13,* ATOMS C*,/, OUTCCS 0950
C          -T32,*N2 ==,I13,* ATOMS H*,T66,*N3 ==,I13,* ATOMS N*,/, OUTCCS 0960
C          -T32,*N4 ==,I13,* ATOMS F*,T66,*WP6 ==,E13.6,* K6/S N2*,/, OUTCCS 0970
C          -T32,*WPR1 ==,E13.6,* K6/S C*,I1,*D*,I1, OUTCCS 0980
C          -T66,*WPR2 ==,E13.6,* K6/S HE*,//T32,*WPR3 ==,E13.6, OUTCCS 0990
C          -* K6/S N2*,T66,*WPR4 ==,E13.6,* K6/S N*,I1,*F*,I1,/,T32, OUTCCS 1000
C          -*WSR1 ==,E13.6,* K6/S D2*,T66,*WSR2 ==,E13.6,* K6/S HE*,/, OUTCCS 1010
C          -T32,*WSR3 ==,E13.6,* K6/S N2) OUTCCS 1020
203  FORMAT(*0,//////,T52,*COMBUSTION CHEMISTRY SECTION*,//T60, OUTCCS 1030
C          *INITIAL DATA*,//, OUTCCS 1040
C          -T32,*AEXP ==,E13.6,* N2*,T66,*ALPHA ==,E13.6,/, OUTCCS 1050
C          -T32,*DFORMF ==,A13,T66,*N1 ==,I13,* ATOMS C*,/, OUTCCS 1060
C          -T32,*N2 ==,I13,* ATOMS D*,T66,*N3 ==,I13,* ATOMS N*,/, OUTCCS 1070
C          -T32,*N4 ==,I13,* ATOMS F*,T66,*WP6 ==,E13.6,* K6/S N2*,/, OUTCCS 1080
C          -T32,*WPR1 ==,E13.6,* K6/S C*,I1,*D*,I1, OUTCCS 1090
C          -T66,*WPR2 ==,E13.6,* K6/S HE*,//T32,*WPR3 ==,E13.6, OUTCCS 1100
C          -* K6/S N2*,T66,*WPR4 ==,E13.6,* K6/S N*,I1,*F*,I1,/,T32, OUTCCS 1110
C          -*WSR1 ==,E13.6,* K6/S N2*,//T66,*WSR2 ==,E13.6,* K6/S HE*,/, OUTCCS 1120
C          -T32,*WSR3 ==,E13.6,* K6/S N2) OUTCCS 1130
204  FORMAT(*0,T59,*RESULTANT DATA*,//, OUTCCS 1140
C          -T32,*FDAA ==,E13.6,* KMOLE/S-N2*,T66,*OMEGA ==,E13.6,/, OUTCCS 1150
C          -T32,*OMEGTRW ==,E13.6,T66,*PSIC ==,E13.6,/, OUTCCS 1160
C          -T32,*PSIL ==,E13.6,T66,*PSILTRW ==,E13.6,/, OUTCCS 1170
C          -T32,*O ==,E13.6,* J/KMOLE*,T66,*RC ==,E13.6,/, OUTCCS 1180
C          -T32,*RL ==,E13.6,T66,*RLF ==,E13.6) OUTCCS 1190
205  FORMAT(*0, OUTCCS 1190
```

APPENDIX A
SUBROUTINE OUTCCS

CHEMICAL LASER ANALYSIS PROGRAM (CLAP)
OVERLAY CCS

PAGE 8-15

-T32,WFPC1	==,E13.6, CF4,T66,WFPC1	==,E13.6, CF4,/,	OUTCCS 1200
-T32,WFPC2	==,E13.6, HF,T66,WFPC2	==,E13.6, HF,/,	OUTCCS 1210
-T32,WFPC3	==,E13.6, DF,T66,WFPC3	==,E13.6, DF,/,	OUTCCS 1220
-T32,WFPC4	==,E13.6, HE,T66,WFPC4	==,E13.6, HE,/,	OUTCCS 1230
-T32,WFPC5	==,E13.6, N2,T66,WFPC5	==,E13.6, N2,/,	OUTCCS 1240
-T32,WFPC6	==,E13.6, D,T66,WFPC6	==,E13.6, D,)	OUTCCS 1250
206 FORMAT(=000,			OUTCCS 1260
-T32,WFPC1	==,E13.6, CF4,T66,WFPC1	==,E13.6, CF4,/,	OUTCCS 1270
-T32,WFPC2	==,E13.6, HF,T66,WFPC2	==,E13.6, HF,/,	OUTCCS 1280
-T32,WFPC3	==,E13.6, DF,T66,WFPC3	==,E13.6, DF,/,	OUTCCS 1290
-T32,WFPC4	==,E13.6, HE,T66,WFPC4	==,E13.6, HE,/,	OUTCCS 1300
-T32,WFPC5	==,E13.6, N2,T66,WFPC5	==,E13.6, N2,/,	OUTCCS 1310
-T32,WFPC6	==,E13.6, H,T66,WFPC6	==,E13.6, H,)	OUTCCS 1320
END			OUTCCS 1330

Appendix C. CHEMICAL LASER ANALYSIS PROGRAM (CLAP) - OVERLAY LDS

OVERLAY(LDS,2,0)	LDS	0100
PROGRAM LDS	LDS	0110
C	LDS	0120
C	LDS	0130
C.....	LDS	0140
C*	LDS	0150
C* LASER DEVICE OVERLAY (LDS)	LDS	0160
C*	LDS	0170
C.....	LDS	0180
C	LDS	0190
C.....	LDS	0200
C*	LDS	0210
C* OVERLAY LDS CONTROLS THE LASER DEVICE CALCULATIONS FOR PROGRAM	LDS	0220
C* CLAP.	LDS	0230
C*	LDS	0240
C* GENERAL NOTATION SCHEME	LDS	0250
C*	LDS	0260
C* VARIABLES ARE DEFINED AS FOLLOWS:	LDS	0270
C*	LDS	0280
C* A : AREA PER KMOL/S OF PRIMARY FLOW (S-M ² /KMOL)	LDS	0290
C* D : DIAMETER (M)	LDS	0300
C* G : (GAMMA) SPECIFIC HEAT RATIO	LDS	0310
C* M : MACH NUMBER	LDS	0320
C* MW: MOLECULAR WEIGHT (KG/KMOL)	LDS	0330
C* P : PRESSURE (PA)	LDS	0340
C* R : DENSITY (KG/M ³)	LDS	0350
C* RE: REYNOLDS NUMBER	LDS	0360
C* T : TEMPERATURE (K)	LDS	0370
C* W : MASS FLOW RATE (KG/S)	LDS	0380
C* X : MOLAR FLOW RATE (KMOL/S)	LDS	0390
C*	LDS	0400
C* REPEATED LETTERS INDICATE RATIOS.	LDS	0410
C* EXAMPLE: W6W2=W6/W2	LDS	0420
C*	LDS	0430
C* VARIABLES ARE DESIGNATED AS TO LOCATION BY THE FOLLOWING:	LDS	0440
C*	LDS	0450
C* POINT 1: PRIMARY NOZZLE EXIT - CONDITIONS BASED ON THE NOZZLE	LDS	0460
C* STAGNATION (COMBUSTOR) TEMPERATURE	LDS	0470
C* POINT 2: PRIMARY NOZZLE EXIT - CONDITIONS BASED ON THE NOZZLE	LDS	0480
C* EXIT TEMPERATURE	LDS	0490
C* POINT 3: SECONDARY NOZZLE EXIT - CONDITIONS BASED ON THE NOZZLE	LDS	0500
C* STAGNATION (COMBUSTOR) TEMPERATURE	LDS	0510
C* POINT 4: SECONDARY NOZZLE EXIT - CONDITIONS BASED ON THE NOZZLE	LDS	0520
C* EXIT TEMPERATURE	LDS	0530
C* POINT 5: EXIT OF THE CONSTANT-AREA MIXING REGION	LDS	0540
C* POINT 6: EXIT OF THE ISENTROPIC EXPANSION REGION	LDS	0550
C* POINT 7: MIRROR PURGE CONDITIONS	LDS	0560
C* POINT 8: LASER CAVITY EXIT	LDS	0570
C* EXAMPLE: MW8 = MOLECULAR WEIGHT AT THE CAVITY EXIT	LDS	0580
C*	LDS	0590
C* E: INDICATES "EFFECTIVE" CONDITIONS	LDS	0600
C* G: INDICATES "GEOMETRIC" CONDITIONS	LDS	0610
C* S: INDICATES "S" CONDITIONS	LDS	0620
C* O: INDICATES STAGNATION CONDITIONS	LDS	0630
C* EXAMPLE: A1A1S0 = A/A* AT THE PRIMARY NOZZLE EXIT BASED ON THE	LDS	0640

```

C*      NOZZLE GEOMETRY                                *LDS      0650
C*                                           *LDS      0660
C* VARIABLES NOT FOLLOWING THIS SCHEME ARE DEFINED AS REQUIRED. *LDS      0670
C*                                           *LDS      0680
C*.....*LDS      0690
C                                           LDS      0700
C                                           LDS      0710
C      IMPLICIT REAL(L,M,N)                      LDS      0720
C                                           LDS      0730
C      DIMENSION XF(11)                          LDS      0740
C                                           LDS      0750
C      COMMON/CCS1/CCS51                          LDS      0760
C                                           LDS      0770
C      COMMON/CCS3/DFORHF                          LDS      0780
C                                           LDS      0790
C      COMMON/CCS7/Q                                LDS      0800
C                                           LDS      0810
C      COMMON/CCS11/W7W2                          LDS      0820
C                                           LDS      0830
C      COMMON/CCS12/XFCP1(2),XFCP2(2),XFCP3(2),XFCP4(2),XFCP5(2),XFCP6(2) *LDS      0840
C                                           LDS      0850
C      COMMON/LDS1/LDS51                          LDS      0860
C                                           LDS      0870
C      COMMON/LDS2/D1,D1S,D3,D3S,GEOMPN,GEOMSN,LDS52,LPN07,LSN0Z,NSPN0Z, *LDS      0880
C      -PKFRAC,P10,T10,T30,T70                      LDS      0890
C                                           LDS      0900
C      COMMON/LDS3/A1,A1SE,A1ISO,A2,A3,A3SE,A3ISO,A4,A5,A6,G1,G2, *LDS      0910
C      -G3,G4,G5,G6,G7,LSEP,MW1,MW2,MW3,MW4,MW5,MW6,MW7,M1,M2,M3,M4,M5,M6, *LDS      0920
C      -NPN0Z,NSN0Z,P1,P2,P3,P30,P4,P5,P50,P6,P60,RE1,RE3,RE8,R1,R10,R2, *LDS      0930
C      -R20,R3,R30,R4,R40,R5,R50,R6,R60,T1,T2,T20,T3,T4,T40,T5,T50,T6,T60, *LDS      0940
C      -W3W1,W5W2,W6W2,W8W2,X3X1,X4X2,X5X2,X6X2,X7X2,X8X2 *LDS      0950
C                                           LDS      0960
C      COMMON/LDS4/A8,GR,MW8,M8,P8,P80,R8,R80,TR,T80 *LDS      0970
C                                           LDS      0980
C      COMMON/LDS5/BRFRAC,CANGLE,HBASE,MNB,LCAV *LDS      0990
C                                           LDS      1000
C      COMMON/LDS6/P20,P40,W4W2 *LDS      1010
C                                           LDS      1020
C      COMMON/MAIN1/FAIL *LDS      1030
C                                           LDS      1040
C      COMMON/MAIN2/FLOW *LDS      1050
C                                           LDS      1060
C      DATA RRAR/R.31434E+03/ *LDS      1070
C      DATA CHOKE/5HCHOKE/,HF/2HHF/,NU/2HNO/,SUP/3HSUP/,YFS/3HYES/ *LDS      1080
C                                           LDS      1090
C                                           LDS      1100
C*.....*LDS      1110
C*      GAS DYNAMIC FUNCTIONS *LDS      1120
C*                                           *LDS      1130
C*.....*LDS      1140
C*.....*LDS      1150
C                                           LDS      1160
C                                           LDS      1170
C      TCTH(G,M)=1.0+0.5*(G-1.0)*M*M *LDS      1180
C      POPM(G,M)=TOTH(G,M)**(G/(G-1.0)) *LDS      1190

```

APPENDIX C
PROGRAM LOS

CHEMICAL LASER ANALYSIS PROGRAM (CLAP)
OVERLAY LOS

PAGE C- 3

RORM(G,M)=TOTM(G,M)*((1.0/(G-1.0))	LOS	1200
RHO(P,T,MW)=P*MW/(RBAR*T)	LOS	1210
WM(G,M)=M*SQRT(G*TOTM(G,M))	LOS	1220
	LOS	1230
C	LOS	1240
C	LOS	1250
C.....	*LOS	1260
C* INITIALIZE VARIABLES FOR MULTIPLE RUNS AND READ INPUT DATA	*LOS	1270
C*	*LOS	1280
C*	LOS	1290
C.....	LOS	1300
C	LOS	1310
C	LOS	1320
CALL INLOS	LOS	1330
IF(CCSS1.EQ.YES) LDSS1=YES	LOS	1340
IF(LDSS1.EQ.NO) GO TO 105	LOS	1350
FLOW=5UP	LOS	1360
C	LOS	1370
C	LOS	1380
C.....	*LOS	1390
C*	*LOS	1400
C* LASER PRIMARY NOZZLE CALCULATIONS	*LOS	1410
C*	LOS	1420
C.....	LOS	1430
C	LOS	1440
C	LOS	1450
CALL LPNCS(D1,D1S,D3,GEOMPN,GEOMSN,HNB,LDSS2,LPNOZ,NSPNOZ,PKFRAC,	LOS	1460
-P10,T10,A1A1SE,A1A1S0,A1,A2,A6,FAIL,01,02,M1,MW1,NPNOZ,P1,RE1,T1)	LOS	1470
IF(FAIL.EQ.YES) GO TO 106	LOS	1480
R1=RHO(P1,T1,MW1)	LOS	1490
R10=RHO(P10,T10,MW1)	LOS	1500
M2=M1	LOS	1510
MW2=MW1	LOS	1520
P2=P1	LOS	1530
P20=P10	LOS	1540
T2=T1	LOS	1550
T20=T10	LOS	1560
R2=R1	LOS	1570
R20=R10	LOS	1580
C	LOS	1590
C	LOS	1600
C.....	*LOS	1610
C*	*LOS	1620
C* LASER SECONDARY NOZZLE CALCULATIONS	*LOS	1630
C*	LOS	1640
C.....	LOS	1650
C	LOS	1660
C	LOS	1670
IF(D3.NE.D3S) CALL LSNC1(D3,D3S,GEOMSN,HNB,LSNOZ,NPNOZ,NSPNOZ,	LOS	1680
-T30,A3A3SE,A3A3S0,A3,A4,FAIL,03,04,M3,MW3,NSNOZ,P3,P30,RE3,T3,	LOS	1690
-X3X1)	LOS	1700
IF(FAIL.EQ.YES) GO TO 107	LOS	1710
IF(D3.EQ.D3S) CALL LSNC2(D3,D3S,GEOMSN,HNB,LSNOZ,NPNOZ,NSPNOZ,	LOS	1720
-T30,A3A3SE,A3A3S0,A3,A4,FAIL,03,04,M3,MW3,NSNOZ,P3,P30,RE3,T3,	LOS	1730
-X3X1)	LOS	1740
IF(FAIL.EQ.YES) GO TO 108		

APPENDIX C
PROGRAM LDS

CHEMICAL LASER ANALYSIS PROGRAM (CLAP)
OVERLAY LDS

PAGE C- 4

R3=RH0(P3,T3,MW3)	LDS	1750
R30=RH0(P30,T30,MW3)	LDS	1760
W3W1=X3X1*MW3/MW1	LDS	1770
M4=M3	LDS	1780
MW4=MW3	LDS	1790
P4=P3	LDS	1800
P40=P30	LDS	1810
T4=T3	LDS	1820
T40=T30	LDS	1830
R4=R3	LDS	1840
R40=R30	LDS	1850
W4W2=W3W1	LDS	1860
X4X2=X3X1	LDS	1870
C	LDS	1880
C	LDS	1890
C.....	LDS	1900
C*	*LDS	1910
C* CONSTANT-AREA MIXING CALCULATIONS	*LDS	1920
C*	*LDS	1930
C.....	*LDS	1940
C	LDS	1950
C	LDS	1960
A4A2=A4/A2	LDS	1970
MW4MW2=MW4/MW2	LDS	1980
P4P2=P4/P2	LDS	1990
T40T20=T40/T20	LDS	2000
CALL CAMS(A4A2,FLOW,G2,G4,M2,M4,MW4MW2,P4P2,T40T20,FAIL,G5,M5,	LDS	2010
-MW5MW2,P5P2,T50T20)	LDS	2020
IF (FAIL,EQ,YES) GO TO 109	LDS	2030
A5=A2+A4	LDS	2040
MW5=MW5MW2+MW2	LDS	2050
P5=P5P2+P2	LDS	2060
P51=P50P5(G5,M5)*P5	LDS	2070
T50=T50T20+T20	LDS	2080
T5=T50/T5TM(G5,M5)	LDS	2090
R5=RH0(P5,T5,MW5)	LDS	2100
R50=RH0(P50,T50,MW5)	LDS	2110
X5X2=1.0+X4X2	LDS	2120
W5W2=1.0+W4W2	LDS	2130
C	LDS	2140
C	LDS	2150
C.....	LDS	2160
C*	*LDS	2170
C* ISENTROPIC EXPANSION CALCULATIONS	*LDS	2180
C*	*LDS	2190
C.....	*LDS	2200
C	LDS	2210
C	LDS	2220
A6=A6/BRFHAC	LDS	2230
A6A5=A6/A5	LDS	2240
CALL EXPAN(G5,M5,A6A5,M6,P6P5,P60P50,T6T5,T60T50,FAIL)	LDS	2250
IF (FAIL,EQ,YES) GO TO 110	LDS	2260
G6=G5	LDS	2270
MW6=MW5	LDS	2280
P6=P6P5+P5	LDS	2290

PAGE C- 8

69

XF(1)=XFCP1(2)	LDS	2850
XF(4)=XFCP2(2)	LDS	2860
XF(5)=XFCP3(2)	LDS	2870
XF(6)=XFCP4(2)	LDS	2880
XF(7)=XFCP5(2)	LDS	2890
IF(DFORMF.EQ.MF) GO TO 103	LDS	2900
XF(10)=XFCP6(2)	LDS	2910
GO TO 104	LDS	2920
103 XF(11)=XFCP6(2)	LDS	2930
104 CALL VISC(1,11,XF,A,R)	LDS	2940
REN=R8*MR*SQRT(GB*RRAR*TB/MWB)*(HBASE+2.0*LCAV*TAN(CANGLE))/	LDS	2950
-EXP(A*ALOG(TB)*R)	LDS	2960
C	LDS	2970
C	LDS	2980
C*****	LDS	2990
C*	*LDS	3000
C*	*LDS	3010
C*	*LDS	3020
C*****	LDS	3030
C	LDS	3040
C	LDS	3050
WRITE(6,206)(T10,P10,K=1,10)	LDS	3060
105 CALL OUTLDS	LDS	3070
GO TO 207	LDS	3080
C	LDS	3090
C	LDS	3100
C*****	LDS	3110
C*	*LDS	3120
C*	*LDS	3130
C*	*LDS	3140
C*****	LDS	3150
C	LDS	3160
C	LDS	3170
106 WRITE(6,201)	LDS	3180
GO TO 207	LDS	3190
107 WRITE(6,202)	LDS	3200
108 WRITE(6,203)	LDS	3210
GO TO 207	LDS	3220
109 WRITE(6,204)	LDS	3230
FAIL=YES	LDS	3240
GO TO 207	LDS	3250
110 WRITE(6,205)	LDS	3260
C	LDS	3270
C	LDS	3280
C*****	LDS	3290
C*	*LDS	3300
C*	*LDS	3310
C*	*LDS	3320
C*****	LDS	3330
C	LDS	3340
C	LDS	3350
201 FORMAT(*0*,T2,*SUBROUTINE LPNCS WAS CALLED FROM SUBROUTINE LDS*)	LDS	3360
202 FORMAT(*0*,T2,*SUBROUTINE LSNCS1 WAS CALLED FROM SUBROUTINE LDS*)	LDS	3370
203 FORMAT(*0*,T2,*SUBROUTINE LSNCS2 WAS CALLED FROM SUBROUTINE LDS*)	LDS	3380
204 FORMAT(*0*,T2,*FAILURE IN SUBROUTINE CAMS AS CALLED FROM SUBROUTINE LDS*)	LDS	3390

APPENDIX C
PROGRAM LDS

CHEMICAL LASER ANALYSIS PROGRAM (CLAP)
OVERLAY LDS

PAGE C- 7

	-E LDS*)	LDS	3400
203	FORMAT(*0*,T2,*SUBROUTINE EXPAN WAS CALLED FROM SUBROUTINE LDS*)	LDS	3410
206	FORMAT(*1*,10(T2,*NOTE: T10 =*,F13.6,* K P10 =*,F13.6,* PA*,/))	LDS	3420
207	END	LDS	3430


```

SUBROUTINE CAMS(AS1AP1,FLOW,GP,GS,MP1,MS1,MWSHWP,PS1PP1,TSTPT0,
-FAIL,GM,HM3,MWMHWP,PM3PP1,TNTP0)
C
C
C*****CAMS 0100
C CAMS 0110
C CAMS 0120
C CAMS 0130
C*****CAMS 0140
C+
C+          CONSTANT-AREA MIXING SUBROUTINE (CAMS)
C+
C+
C*****CAMS 0160
C CAMS 0170
C*****CAMS 0180
C CAMS 0190
C*****CAMS 0200
C+
C+ SUBROUTINE CAMS PERFORMS THE CONSTANT-AREA, ADIABATIC, MIXING
C+ CALCULATIONS BY ONE-DIMENSIONAL ANALYSIS FOR TWO UNIFORM STREAMS AT
C+ INLET STATION (1) MIXING TO A UNIFORM STREAM AT MIXED STATION (3).
C+
C+ INPUT VARIABLES:
C+
C+ AS1AP1 = SECONDARY-TO-PRIMARY STREAM AREA RATIO
C+ FLOW   = CONTROL VARIABLE SUCH THAT:
C+        = "SUB" FOR THE SUBSONIC SOLUTION
C+        = "SUP" FOR THE SUPERSONIC SOLUTION
C+ GP     = PRIMARY STREAM GAMMA
C+ GS     = SECONDARY STREAM GAMMA
C+ MP1    = PRIMARY STREAM MACH NO.
C+ MS1    = SECONDARY STREAM MACH NO.
C+ MWSHWP = SECONDARY-TO-PRIMARY STREAM MOLECULAR WEIGHT RATIO
C+ PS1PP1 = SECONDARY-TO-PRIMARY STREAM STATIC PRESSURE RATIO
C+ TSTPT0 = SECONDARY-TO-PRIMARY STREAM STAGNATION TEMPERATURE RATIO
C+
C+ OUTPUT VARIABLES:
C+
C+ FAIL   = ERROR FLAG
C+ GM     = MIXED STREAM GAMMA
C+ HM3    = MIXED STREAM MACH NO.
C+ MWMHWP = MIXED-TO-PRIMARY STREAM MOLECULAR WEIGHT RATIO
C+ PM3PP1 = MIXED-TO-PRIMARY STREAM STATIC PRESSURE RATIO
C+ TNTP0  = MIXED-TO-PRIMARY STREAM STAGNATION TEMPERATURE RATIO
C+
C*****CAMS 0400
C CAMS 0410
C CAMS 0420
C CAMS 0430
C CAMS 0440
C CAMS 0450
C CAMS 0460
C CAMS 0470
C CAMS 0480
C*****CAMS 0490
C CAMS 0500
C CAMS 0510
C IMPLICIT REAL(M)
C DATA SUP/3HSUP/,YES/3HYES/
C
C
C*****CAMS 0520
C CAMS 0530
C CAMS 0540
C CAMS 0550
C*****CAMS 0560
C+
C+ SPECIAL FUNCTIONS
C+
C+
C*****CAMS 0570
C CAMS 0580
C CAMS 0590
C*****CAMS 0600
C CAMS 0610
C CAMS 0620
C CAMS 0630
C CAMS 0640
F(G,M)=1.0+G*M*M
G(R,M)=M*SORT(1.0+0.5*(G-1.0)*M*M)

```

CHEMICAL LASER ANALYSIS PROGRAM (CLAP)
OVERLAY LOG

	H(MM.TT,GG)=SQRT(MM*GR/TT)	CAMS	0690
C		CAMS	0690
C		CAMS	0670
C	.....	CAMS	0680
C*		*CAMS	0690
C*		*CAMS	0700
C*		*CAMS	0710
C	.....	CAMS	0720
C		CAMS	0730
C		CAMS	0740
	GSJ=GS/(GS-1.0)	CAMS	0750
	GPJ=GP/(GP-1.0)	CAMS	0760
	GSP=GS/GP	CAMS	0770
	MWPMWS=.1.0/MWSMWP	CAMS	0780
C		CAMS	0790
C		CAMS	0800
C	.....	CAMS	0810
C*		*CAMS	0820
C*		*CAMS	0830
C*		*CAMS	0840
C	.....	CAMS	0850
C		CAMS	0860
C		CAMS	0870
	WSWP=PSJPP1*ASJAP1*M(MWSMWP,TSOTPO,GSP)*G(GS,MS1)/G(GP,MP1)	CAMS	0880
	C1=WSWP*MWPMWS*GSJ*GPJ	CAMS	0890
	C2=WSWP*MWPMWS*(GSJ-1.0)*(GPJ-1.0)	CAMS	0900
	GM=C1/C2	CAMS	0910
	GMGP=GM/GP	CAMS	0920
	MWMWPA=(WSWP+1.0)/(WSWP*MWPMWS+.1.0)	CAMS	0930
	C1=TSOTPO*WSWP*MWPMWS*GSJ*GPJ	CAMS	0940
	C2=WSWP*MWPMWS*GSJ*GPJ	CAMS	0950
	TN0TP0=C1/C2	CAMS	0960
	FFX=M(MWMWP,TN0TP0,GMGP)*(PSJPP1*ASJAP1)*F(GS,MS1)*F(GP,MP1))/	CAMS	0970
	-((1.0+WSWP)*G(GP,MP1))	CAMS	0980
	C1=0.5*(GM-1.0)*FFX*FFX-GM*GM	CAMS	0990
	C2=FFX*FFX-2.0*GM	CAMS	1000
	C3=(-C2,SQRT(C2*C2+4.0*C1))/(2.0*C1)	CAMS	1010
	C4=(-C2-SQRT(C2*C2+4.0*C1))/(2.0*C1)	CAMS	1020
C		CAMS	1030
C		CAMS	1040
C	.....	CAMS	1050
C*		*CAMS	1060
C*		*CAMS	1070
C*		*CAMS	1080
C	.....	CAMS	1090
C		CAMS	1100
C		CAMS	1110
	IF(FLOW,EQ,SUP) GO TO 101	CAMS	1120
	IF(C3.LT.0.0.OR.C4.LT.0.0) MM3=SQRT(AMAX1(C3,C4))	CAMS	1130
	IF(C3.GF.0.0.AND.C4.GE.0.0) MM3=SQRT(AMIN1(C3,C4))	CAMS	1140
	GO TO 102	CAMS	1150
101	IF(C3.LT.0.0.OR.C4.LT.0.0) GO TO 103	CAMS	1160
	MM3=SQRT(AMAX1(C3,C4))	CAMS	1170
102	PM3PP1=(PSJPP1*ASJAP1)*F(GS,MS1)*F(GP,MP1)/((1.0+ASJAP1)*	CAMS	1180
	-F(GM,MM3))	CAMS	1190

APPENDIX C
SUBROUTINE CAMS

CHEMICAL LASER ANALYSIS PROGRAM (CLAP)
OVERLAY L03

PAGE C-10

RETURN	CAMS	1200
C	CAMS	1210
C	CAMS	1220
C.....	CAMS	1230
C*	*CAMS	1240
C*	*CAMS	1250
C*	*CAMS	1260
C.....	CAMS	1270
C	CAMS	1280
C	CAMS	1290
103 WRITE(6,201)MS1,MP1	CAMS	1300
FAIL=YES	CAMS	1310
201 FORMAT(1*,T2,*NO SUPERSONIC SOLUTION EXISTS FOR*,T2,MS1	*CAMS	1320
-E13.6,2X,MP1 **E13.6)	CAMS	1330
END	CAMS	1340

```

SUBROUTINE CPCALC(NS1,NS2,TDZ,XF,GMIX,MWMIX)
C
C
C.....CPCALC 0100
C.....CPCALC 0110
C.....CPCALC 0120
C.....CPCALC 0130
C*.....CPCALC 0140
C* SPECIFIC HEAT CALCULATION SUBROUTINE (CPCALC)
C*.....CPCALC 0150
C*.....CPCALC 0160
C*.....CPCALC 0170
C.....CPCALC 0180
C.....CPCALC 0190
C*.....CPCALC 0200
C* SUBROUTINE CPCALC CALCULATES THE SPECIFIC HEAT AT CONSTANT PRESSURE
C* OF MIXTURES OF GASES.
C*.....CPCALC 0210
C*.....CPCALC 0220
C*.....CPCALC 0230
C* INPUT VARIABLES:
C*.....CPCALC 0240
C*.....CPCALC 0250
C* NS1 = DO LOOP LIMIT
C* NS2 = DO LOOP LIMIT
C* TDZ = TEMPERATURE OF MIXTURE (K)
C* XF(I) = MOLE FRACTION OF THE I-TH SPECIES
C*.....CPCALC 0260
C*.....CPCALC 0270
C*.....CPCALC 0280
C*.....CPCALC 0290
C*.....CPCALC 0300
C* OUTPUT VARIABLES:
C*.....CPCALC 0310
C*.....CPCALC 0320
C* GMIX = SPECIFIC HEAT RATIO OF THE MIXTURE
C* MWMIX = MOLECULAR WEIGHT OF THE MIXTURE (KG/KMOLE)
C*.....CPCALC 0330
C*.....CPCALC 0340
C*.....CPCALC 0350
C* NOTE: ALL CALCULATIONS ARE PERFORMED IN SI UNITS.
C*.....CPCALC 0360
C*.....CPCALC 0370
C.....CPCALC 0380
C.....CPCALC 0390
C.....CPCALC 0400
C.....CPCALC 0410
C.....CPCALC 0420
C.....CPCALC 0430
C.....CPCALC 0440
C.....CPCALC 0450
C.....CPCALC 0460
C.....CPCALC 0470
C.....CPCALC 0480
C.....CPCALC 0490
C.....CPCALC 0500
C.....CPCALC 0510
C.....CPCALC 0520
C.....CPCALC 0530
C*.....CPCALC 0540
C* CP VALUES ARE STORED IN UNITS OF (1.0E-04 J/KMOLE-K) AND TABULATED
C* BY TEMPERATURE (ROW) FROM 0 K TO 3000 K IN INCREMENTS OF 100 K AND
C* SPECIES (COLUMN).
C*.....CPCALC 0550
C*.....CPCALC 0560
C*.....CPCALC 0570
C*.....CPCALC 0580
C* CP DATA WAS TAKEN FROM: JANAF THERMOCHEMICAL TABLES, 2ND EDITION
C* EXCEPT VALUES FOR DP AND DF WHICH WERE TAKEN FROM LOCKHEED DATA.
C*.....CPCALC 0590
C*.....CPCALC 0600
C*.....CPCALC 0610
C* NOTE: CP VALUES AT 0 K ARE INCLUDED FOR INTERPOLATION PURPOSES
C* ONLY. CP VALUES AT 0 K ARE TAKEN EQUAL TO THOSE AT 100 K SINCE CP
C* IS NEARLY CONSTANT FOR MOST GASES FROM 100 K TO THE SATURATION
C*.....CPCALC 0620
C*.....CPCALC 0630
C*.....CPCALC 0640

IMPLICIT REAL(M)
DIMENSION CP(11,31),MW(11),XF(11)

DATA MW/
C
C      CF4      F2      F      HF      DF
C      -      88.0047, 37.9968, 18.9984, 20.0064, 21.0125,
C      HE      N2      D2      H2      D
C      -      4.00260, 28.0134, 4.02820, 2.01594, 2.01410,
C      H
C      -      1.00797/

```

```

C= POINT,
C=
C.....
C
C
C      DATA ((CP(I,J),I=1,9),J=1,11)/
C      CF4      F2      F      HF      DF      HE      N2      D2      H2
- 3.474, 2.912, 2.120, 2.913, 2.911, 2.079, 2.910, 3.031, 2.256,
- 3.474, 2.912, 2.120, 2.913, 2.911, 2.079, 2.910, 3.031, 2.256,
- 4.737, 2.970, 2.261, 2.913, 2.912, 2.079, 2.911, 2.920, 2.727,
- 6.129, 3.137, 2.274, 2.914, 2.914, 2.079, 2.912, 2.920, 2.884,
- 7.240, 3.305, 2.243, 2.915, 2.915, 2.079, 2.925, 2.924, 2.918,
- 8.071, 3.434, 2.210, 2.917, 2.916, 2.079, 2.958, 2.936, 2.926,
- 8.678, 3.527, 2.183, 2.923, 2.918, 2.079, 3.011, 2.962, 2.933,
- 9.121, 3.594, 2.163, 2.935, 2.920, 2.079, 3.075, 3.001, 2.944,
- 9.447, 3.646, 2.148, 2.955, 2.923, 2.079, 3.143, 3.053, 2.965,
- 9.693, 3.685, 2.136, 2.983, 2.926, 2.079, 3.209, 3.108, 2.991,
- 9.880, 3.717, 2.127, 3.017, 2.930, 2.079, 3.270, 3.164, 3.020/
C      DATA ((CP(I,J),I=1,9),J=12,21)/
-10.025, 3.744, 2.120, 3.056, 2.933, 2.079, 3.324, 3.216, 3.054,
-10.140, 3.767, 2.114, 3.097, 2.937, 2.079, 3.373, 3.269, 3.092,
-10.231, 3.787, 2.109, 3.140, 2.941, 2.079, 3.415, 3.320, 3.134,
-10.306, 3.804, 2.105, 3.182, 2.945, 2.079, 3.453, 3.370, 3.180,
-10.367, 3.820, 2.102, 3.224, 2.949, 2.079, 3.485, 3.417, 3.230,
-10.418, 3.835, 2.100, 3.264, 2.953, 2.079, 3.514, 3.463, 3.273,
-10.460, 3.848, 2.097, 3.302, 2.958, 2.079, 3.539, 3.499, 3.314,
-10.496, 3.861, 2.096, 3.338, 2.962, 2.079, 3.561, 3.535, 3.354,
-10.527, 3.874, 2.094, 3.371, 2.964, 2.079, 3.581, 3.567, 3.392,
-10.554, 3.886, 2.092, 3.403, 2.970, 2.079, 3.599, 3.599, 3.429/
C      DATA ((CP(I,J),I=1,9),J=22,31)/
-10.577, 3.897, 2.092, 3.433, 2.974, 2.079, 3.614, 3.626, 3.464,
-10.597, 3.908, 2.090, 3.460, 2.978, 2.079, 3.628, 3.653, 3.497,
-10.614, 3.919, 2.089, 3.486, 2.982, 2.079, 3.641, 3.678, 3.529,
-10.630, 3.929, 2.089, 3.510, 2.984, 2.079, 3.653, 3.702, 3.559,
-10.644, 3.940, 2.088, 3.532, 2.990, 2.079, 3.664, 3.724, 3.588,
-10.656, 3.950, 2.087, 3.553, 2.994, 2.079, 3.673, 3.745, 3.615,
-10.667, 3.960, 2.087, 3.573, 2.998, 2.079, 3.682, 3.764, 3.640,
-10.677, 3.970, 2.086, 3.592, 3.002, 2.079, 3.690, 3.783, 3.664,
-10.686, 3.979, 2.086, 3.609, 3.005, 2.079, 3.698, 3.799, 3.686,
-10.693, 3.989, 2.085, 3.625, 3.009, 2.079, 3.705, 3.815, 3.707/
C      DATA ((CP(I,J),I=10,11),J=1,31)/62*2.079/
C      DATA RBAR/R,31434E+03/
C
CPMIX=0.0
MMIX=0.0
J=IFIX(TDZ/100.0)+1
TLO=FLOAT(J-1)*100.0
FRAC=(TDZ-TLO)/100.0
DO 101 I=NS1,NS2
CPTDZ=1.0E+04*(FRAC*(CP(I,J+1)-CP(I,J))+CP(I,J))
CPMIX=CPMIX+XF(I)*CPTDZ
101 MMIX=MMIX+XF(I)*MW(I)
GMIX=CPMIX/(CPMIX-RBAR)

```

CPCALC 0650
CPCALC 0660
CPCALC 0670
CPCALC 0680
CPCALC 0690
CPCALC 0700
CPCALC 0710
CPCALC 0720
CPCALC 0730
CPCALC 0740
CPCALC 0750
CPCALC 0760
CPCALC 0770
CPCALC 0780
CPCALC 0790
CPCALC 0800
CPCALC 0810
CPCALC 0820
CPCALC 0830
CPCALC 0840
CPCALC 0850
CPCALC 0860
CPCALC 0870
CPCALC 0880
CPCALC 0890
CPCALC 0900
CPCALC 0910
CPCALC 0920
CPCALC 0930
CPCALC 0940
CPCALC 0950
CPCALC 0960
CPCALC 0970
CPCALC 0980
CPCALC 0990
CPCALC 1000
CPCALC 1010
CPCALC 1020
CPCALC 1030
CPCALC 1040
CPCALC 1050
CPCALC 1060
CPCALC 1070
CPCALC 1080
CPCALC 1090
CPCALC 1100
CPCALC 1110
CPCALC 1120
CPCALC 1130
CPCALC 1140
CPCALC 1150
CPCALC 1160
CPCALC 1170
CPCALC 1180
CPCALC 1190

APPENDIX C
SUBROUTINE CPCALC

CHEMICAL LASER ANALYSIS PROGRAM (CLAP)
OVERLAY LOS

PAGE C-13

END

CPCALC 1200

APPENDIX C
SUBROUTINE EXPAN

CHEMICAL LASER ANALYSIS PROGRAM (CLAP)
OVERLAY LOS

PAGE C-14

```

SUBROUTINE EXPAN(M1,APR1,MP,P2P1,P2P10,T2T1,T2T10,FAIL)
C
C
C.....
C*
C*      ISENTROPIC EXPANSION SUBROUTINE (EXPAN)
C*
C*.....
C
C.....
C*
C*      SUBROUTINE EXPAN CALCULATES THE CONDITIONS ACROSS AN ISENTROPIC
C*      EXPANSION AT SUPERSONIC MACH NUMBERS.
C*
C* INPUT VARIABLES:
C*
C* M1      = GAMMA
C* M1      = ENTRANCE MACH NUMBER
C* APR1    = EXIT-TO-ENTRANCE AREA RATIO
C*
C* OUTPUT VARIABLES:
C*
C* M2      = EXIT MACH NUMBER
C* P2P1    = EXIT-TO-ENTRANCE STATIC PRESSURE RATIO
C* P2P10   = EXIT-TO-ENTRANCE STAGNATION PRESSURE RATIO
C* T2T1    = EXIT-TO-ENTRANCE STATIC TEMPERATURE RATIO
C* T2T10   = EXIT-TO-ENTRANCE STAGNATION TEMPERATURE RATIO
C* FAIL    = ERROR FLAG
C*
C*.....
C
C      IMPLICIT REAL(M)
C      DATA VER/3HYE3,3UP/3H9UP/
C
C.....
C*
C*      GAS DYNAMIC FUNCTIONS
C*
C*.....
C
C      TOTM(MX,MX)=1.0+0.5*(MX-1.0)*MX*MX
C      POPM(MX,MX)=TOTM(MX,MX)*((MX/(MX-1.0))
C
C.....
C*
C*      SOLVE APAPS FOR M2
C*
C*.....
C
C      MP=P.0/(M+1.0)

```

EXPAN 0100
EXPAN 0110
EXPAN 0120
EXPAN 0130
EXPAN 0140
EXPAN 0150
EXPAN 0160
EXPAN 0170
EXPAN 0180
EXPAN 0190
EXPAN 0200
EXPAN 0210
EXPAN 0220
EXPAN 0230
EXPAN 0240
EXPAN 0250
EXPAN 0260
EXPAN 0270
EXPAN 0280
EXPAN 0290
EXPAN 0300
EXPAN 0310
EXPAN 0320
EXPAN 0330
EXPAN 0340
EXPAN 0350
EXPAN 0360
EXPAN 0370
EXPAN 0380
EXPAN 0390
EXPAN 0400
EXPAN 0410
EXPAN 0420
EXPAN 0430
EXPAN 0440
EXPAN 0450
EXPAN 0460
EXPAN 0470
EXPAN 0480
EXPAN 0490
EXPAN 0500
EXPAN 0510
EXPAN 0520
EXPAN 0530
EXPAN 0540
EXPAN 0550
EXPAN 0560
EXPAN 0570
EXPAN 0580
EXPAN 0590
EXPAN 0600
EXPAN 0610
EXPAN 0620
EXPAN 0630
EXPAN 0640

APPENDIX C
SUBROUTINE EXPAN

CHEMICAL LASER ANALYSIS PROGRAM (CLAP)
OVERLAY L05

PAGE C-15

```

      G4=(G+1.0)/(P.0*(G-1.0))
      A1A1S=(1.0/M1)*(G2*TOTM(G,M1))*G4
      APAPS=APA1*A1A1S
      CALL MAAS(G,M1,APAPS,SUP,S.0E-06,MP,FAIL)
      IF(FAIL,EQ,YES) GO TO 1

C
C .....
C* .....
C*          CALCULATE THE PRESSURE AND TEMPERATURE RATIOS
C* .....
C .....
C
      PPOP10=1.0
      TTOP10=1.0
      PDP1=POPM(G,M1)/POPM(G,M2)
      TDT1=TOTM(G,M1)/TOTM(G,M2)
      RETURN

C
C .....
C* .....
C*          ERROR MESSAGE
C* .....
C .....
C
      WRITE(A,Z)
      FORMAT('00,T2,SUBROUTINE MAAS WAS CALLED FROM SUBROUTINE EXPAN')
      STOP
      END

```

EXPAN 0650
EXPAN 0660
EXPAN 0670
EXPAN 0680
EXPAN 0690
EXPAN 0700
EXPAN 0710
EXPAN 0720
EXPAN 0730
EXPAN 0740
EXPAN 0750
EXPAN 0760
EXPAN 0770
EXPAN 0780
EXPAN 0790
EXPAN 0800
EXPAN 0810
EXPAN 0820
EXPAN 0830
EXPAN 0840
EXPAN 0850
EXPAN 0860
EXPAN 0870
EXPAN 0880
EXPAN 0890
EXPAN 0900
EXPAN 0910
EXPAN 0920
EXPAN 0930
EXPAN 0940
EXPAN 0950
EXPAN 0960

APPENDIX C
SUBROUTINE INLOS

CHEMICAL LASER ANALYSIS PROGRAM (CLAP)
OVERLAY LOS

PAGE C-17

COMMON/LDSS/D1,D15,D3,D35,GEOMPN,GEOMSN,LOSS2,LPNOZ,LSNOZ,NSPNOZ,	INLOS	0650
-PKFRAC,P10,T10,T30,T70	INLOS	0660
C	INLOS	0670
COMMON/LDSS/BRFRAC,CANGLE,HBASE,HNB,LCAV	INLOS	0680
C	INLOS	0690
COMMON/MAIN4/SETLOS	INLOS	0700
C	INLOS	0710
DATA NO/PHNO/	INLOS	0720
C	INLOS	0730
NAMLIST/NLLDS/BRFRAC,CANGLE,D1,D15,D3,D35,HBASE,HNB,LCAV,LPNOZ,	INLOS	0740
-LSNOZ,NSPNOZ,PKFRAC,P10,T10,T30,T70	INLOS	0750
C	INLOS	0760
C	INLOS	0770
C.....	INLOS	0780
C	INLOS	0790
C	INLOS	0800
C	INLOS	0810
C	INLOS	0820
C.....	INLOS	0830
C	INLOS	0840
C	INLOS	0850
IF (SETLOS.EQ.NO) GO TO 101	INLOS	0860
BRFRAC=1.0	INLOS	0870
CANGLE=0.174533	INLOS	0880
D1=1.77800E-03	INLOS	0890
D15=6.49534E-05	INLOS	0900
D3=1.37160E-03	INLOS	0910
D35=6.44800E-05	INLOS	0920
GEOMPN=2H2D	INLOS	0930
GEOMSN=2H2D	INLOS	0940
HBASE=3.49250E-02	INLOS	0950
HNB=3.49250E-02	INLOS	0960
LCAV=7.62000E-02	INLOS	0970
LOSS2=3HP10	INLOS	0980
LPNOZ=2.50190E-03	INLOS	0990
LSNOZ=1.85166E-03	INLOS	1000
NSPNOZ=1.03846	INLOS	1010
PKFRAC=0.803431	INLOS	1020
P10=1.92105E+06	INLOS	1030
T10=1.62100E+03	INLOS	1040
T30=600.0	INLOS	1050
T70=300.0	INLOS	1060
SETLOS=NO	INLOS	1070
C	INLOS	1080
C.....	INLOS	1090
C	INLOS	1100
C	INLOS	1110
C	INLOS	1120
C.....	INLOS	1130
C	INLOS	1140
C	INLOS	1150
C	INLOS	1160
101 WRITE (A,201)	INLOS	1170
READ (A,202) LOSS1	INLOS	1180
IF (LOSS1.EQ.NO) RETURN	INLOS	1190
WRITE (A,203)	INLOS	1200

```
      READ(5,202)LDSS3
      IF(LDSS3.EQ.NO) GO TO 102
      REWIND 2
      READ(2)BRFRAC,CANGLE,D1,D1S,D3,D3S,GEOMPN,GEOMSN,HBASE,MNB,LCAV,
-LDSS2,LPNOZ,LSNOZ,NSPNOZ,PKFRAC,P10,T10,T30,T70
      RETURN
102  WRITE(6,204)
      READ(5,205)GEOMPN
      WRITE(6,206)
      READ(5,205)GEOMSN
      WRITE(6,207)
      READ(5,202)LDSS2
      WRITE(6,208)
      IF(LDSS2.EQ.3MT10) WRITE(6,209)BRFRAC,CANGLE,D1,D1S,D3,D3S,HBASE,
-MNB,LCAV,LPNOZ,LSNOZ,NSPNOZ,PKFRAC,P10,T30,T70
      IF(LDSS2.EQ.3MT10) WRITE(6,210)BRFRAC,CANGLE,D1,D1S,D3,D3S,HBASE,
-MNB,LCAV,LPNOZ,LSNOZ,NSPNOZ,PKFRAC,T10,T30,T70
      READ(5,NLLDS)
      REWIND 2
      WRITE(2)BRFRAC,CANGLE,D1,D1S,D3,D3S,GEOMPN,GEOMSN,HBASE,MNB,LCAV,
-LDSS2,LPNOZ,LSNOZ,NSPNOZ,PKFRAC,P10,T10,T30,T70
C
C
C*****
C*
C*
C*
C*
C*****
C
C
201  FORMAT(*1,T2,*ARE NEW LASER DEVICE INPUTS REQUIRED?*/)
202  FORMAT(A3)
203  FORMAT(*0,T2,*SHOULD INPUT DATA BE READ FROM TAPE?*/)
204  FORMAT(*1,T2,*INPUT THE LASER PRIMARY NOZZLE GEOMETRY FROM THE FOLLOINLOS
-LLOWING LIST:*/,T2,*"AX" FOR AXISYMMETRIC NOZZLES*/,T2,*"2D" FORINLOS
-R SLIT NOZZLES*/)
205  FORMAT(A2)
206  FORMAT(*0,T2,*INPUT THE LASER SECONDARY NOZZLE GEOMETRY FROM THE INLOS
-FOLLOWING LIST:*/,T2,*"AX" FOR AXISYMMETRIC NOZZLES*/,T2,*"2D" INLOS
-FOR SLIT NOZZLES*/)
207  FORMAT(*1,T2,*SELECT A LASER DEVICE INPUT VARIABLE FROM THE FOLLOINLOS
-WING LIST:*/,T2,*"P10" FOR THE PRIMARY COMBUSTOR OR NOZZLE STAGNINLOS
-ATION PRESSURE*/,T2,*"T10" FOR THE PRIMARY COMBUSTOR OR NOZZLE STINLOS
-AGNATION TEMPERATURE*/)
208  FORMAT(*1,T2,*INPUT DATA FOR THE LASER DEVICE SECTION BY NAMELISTINLOS
-.,/,T2,*CURRENT VALUES ARE:*)
209  FORMAT(*0,T2,*SNLLDS*,T26,*BRFRAC **E13.6,T50,*CANGLE **, INLOS
-E13.6/,T2,*D1 **E13.6,T26,*D1S **E13.6,T50, INLOS
-*D3 **E13.6/,T2,*D3S **E13.6,T26,*HBASE **,E13.6, INLOS
-T50,*MNB **E13.6/,T2,*LCAV **E13.6,T26,*LPNOZ **, INLOS
-E13.6,T50,*LSNOZ **E13.6/,T2,*NSPNOZ **E13.6,T26, INLOS
-*PKFRAC **E13.6,T50,*P10 **E13.6/,T2,*T30 **E13.6, INLOS
-T26,*T70 **E13.6,*S*,/)
P10  FORMAT(*0,T2,*SNLLDS*,T26,*BRFRAC **E13.6,T50,*CANGLE **, INLOS
-E13.6/,T2,*D1 **E13.6,T26,*D1S **E13.6,T50, INLOS
```

APPENDIX C
SUBROUTINE INLDS

CHEMICAL LASER ANALYSIS PROGRAM (CLAP)
OVERLAY LDS

PAGE C-19

-*D3	==,E13.6,/,T2,*D35	==,E13.6,T26,*MBASF	==,E13.6,	INLDS	1750
-T50,*HNR	==,E13.6,/,T2,*LCAV	==,E13.6,T26,*LPNOZ	==,	INLDS	1760
-E13.6,T50,*LSNOZ	==,E13.6,/,T2,*NSPNOZ	==,E13.6,T26,		INLDS	1770
-*PKFRAC	==,E13.6,T50,*T10	==,E13.6,/,T2,*T30	==,E13.6,	INLDS	1780
-T26,*T70	==,E13.6,*S*,/)			INLDS	1790
END				INLDS	1800

SUBROUTINE ITER(X,DX,ERRORX,SIGN,Y,YGIVEN,ERRORY,NIT, -NTYPE,XNEG,YNEG,XPOS,YPOS,NSIGN1,NSIGN2)	ITER	0100
C	ITER	0110
C	ITER	0120
C	ITER	0130
C*****	ITER	0140
C*	ITER	0150
C* ITERATION SUBROUTINE (ITER)	ITER	0160
C*	ITER	0170
C*****	ITER	0180
C	ITER	0190
C*****	ITER	0200
C*	ITER	0210
C* SUBROUTINE ITER PERFORMS AN ITERATION TO FIND X SUCH THAT THE	ITER	0220
C* PERCENT ERROR IN Y AND YGIVEN IS .LE. TO ERRORY OR THE PERCENT	ITER	0230
C* DEVIATION IN X(I+1) AND X(I) IS .LE. TO ERRORX.	ITER	0240
C* IS .LE. TO ERRORX.	ITER	0250
C*	ITER	0260
C* INPUT VARIABLES:	ITER	0270
C*	ITER	0280
C* DX = INCREMENT IN INDEPENDENT VARIABLE	ITER	0290
C* ERRORX = MAX PERCENT DEVIATION IN X(I+1) AND X(I) FOR SOLUTION	ITER	0300
C* ERRORY = MAX PERCENT ERROR IN Y AND YGIVEN FOR SOLUTION	ITER	0310
C* SIGN = +1.0 OR -1.0, +/- INCREMENTING FROM INITIAL X	ITER	0320
C* Y = DEPENDENT VARIABLE	ITER	0330
C* YGIVEN = GIVEN VALUE OF DEPENDENT VARIABLE	ITER	0340
C*	ITER	0350
C* INPUT/OUTPUT VARIABLES:	ITER	0360
C*	ITER	0370
C* NIT = ITERATION NUMBER	ITER	0380
C* NTYPE = 1--INCREMENT, 2--INTERPOLATION, 3--SOLUTION	ITER	0390
C* X = INDEPENDENT VARIABLE	ITER	0400
C*	ITER	0410
C* NOTE: THE INTERMEDIATE VARIABLES XNEG, YNEG, XPOS, YPOS, NSIGN1,	ITER	0420
C* NSIGN2 MUST BE STORED BETWEEN ITERATIONS.	ITER	0430
C*	ITER	0440
C*****	ITER	0450
C	ITER	0460
C	ITER	0470
ERROR(ACTUAL,GIVEN)=(ACTUAL-GIVEN)*100.0/GIVEN	ITER	0480
C	ITER	0490
IF(ABS(ERROR(Y,YGIVEN))-ERRORY) 90,90,10	ITER	0500
10 IF(Y-YGIVEN) 20,90,30	ITER	0510
20 NSIGN2=-1	ITER	0520
XNEG=X	ITER	0530
YNEG=Y	ITER	0540
GO TO 40	ITER	0550
30 NSIGN2=+1	ITER	0560
XPOS=X	ITER	0570
YPOS=Y	ITER	0580
40 GO TO (50,80), NTYPE	ITER	0590
50 IF(NIT-1) 70,70,60	ITER	0600
60 NSIGN=NSIGN1*NSIGN2	ITER	0610
IF(NSIGN) 80,80,70	ITER	0620
70 NSIGN1=NSIGN2	ITER	0630
NIT=NIT+1	ITER	0640

C	ITER	0650
C	ITER	0660
C.....	ITER	0670
C*	*ITER	0680
C* INCREMENT TO FIND SOLUTION INTERVAL	*ITER	0690
C*	*ITER	0700
C.....	ITER	0710
C	ITER	0720
C	ITER	0730
X=X+SIGN*DX	ITER	0740
GO TO 100	ITER	0750
C	ITER	0760
C	ITER	0770
C.....	ITER	0780
C*	*ITER	0790
C* INTERPOLATION FOR SOLUTION	*ITER	0800
C*	*ITER	0810
C.....	ITER	0820
C	ITER	0830
C	ITER	0840
N0 NTYPE=2	ITER	0850
NIT=NIT+1	ITER	0860
XSAVE=X	ITER	0870
RATIO=(XPOS-XNEG)/(YPOS-YNEG)	ITER	0880
X=XNEG+RATIO*(YCIVEN-YNEG)	ITER	0890
IF (ABS(ERROR(X,XSAVE))-ERRORX) 90,90,100	ITER	0900
90 NTYPE=3	ITER	0910
100 END	ITER	0920

```

      SUBROUTINE LBLAYR(A,R,GEOFAC,LBNOZ,MW,PE,TE,T0,VE,DELTA,RE)
      C
      C
      C.....
      C*
      C*          LAMINAR BOUNDARY LAYER SUBROUTINE (LRLAYR)
      C*
      C*.....
      C          LBLAYR 0100
      C          LBLAYR 0110
      C          LRLAYR 0120
      C          LBLAYR 0130
      C          LBLAYR 0140
      C          LBLAYR 0150
      C          LBLAYR 0160
      C          LBLAYR 0170
      C          LBLAYR 0180
      C          LBLAYR 0190
      C*
      C* SUBROUTINE LBLAYR CALCULATES THE LAMINAR BOUNDARY LAYER THICKNESS
      C* AT THE EXIT OF A CONICAL NOZZLE.
      C          LBLAYR 0200
      C          LBLAYR 0210
      C          LBLAYR 0220
      C          LRLAYR 0230
      C* INPUT VARIABLES:
      C          LRLAYR 0240
      C          LBLAYR 0250
      C* A      = SLOPE OF VISCOSITY-TEMPERATURE RELATION
      C*          [ALOG(N-S/M2)/ALOG(K)]
      C          LBLAYR 0260
      C          LRLAYR 0270
      C* B      = INTERSECT OF VISCOSITY-TEMPERATURE RELATION [ALOG(N-S/M2)]
      C          LBLAYR 0280
      C* GEOFAC = 0.0, FOR 2-D, PLANE NOZZLES
      C          LRLAYR 0290
      C*          = 1.0, FOR AXISYMMETRIC NOZZLES
      C          LBLAYR 0300
      C* LBNOZ  = LENGTH OF NOZZLE BOUNDARY LAYER (M)
      C          LRLAYR 0310
      C* MW     = MOLECULAR WEIGHT (KG/KMOLE)
      C          LBLAYR 0320
      C* PE     = STATIC PRESSURE AT THE NOZZLE EXIT (PA)
      C          LRLAYR 0330
      C* TE     = STATIC TEMPERATURE AT THE NOZZLE EXIT (K)
      C          LBLAYR 0340
      C* T0     = NOZZLE STAGNATION TEMPERATURE
      C          LBLAYR 0350
      C* VE     = VELOCITY AT THE NOZZLE EXIT (M/S)
      C          LBLAYR 0360
      C          LBLAYR 0370
      C* OUTPUT VARIABLES:
      C          LRLAYR 0380
      C          LRLAYR 0390
      C* DELTA  = BOUNDARY LAYER THICKNESS (M)
      C          LBLAYR 0400
      C* RE     = REYNOLDS NUMBER AT THE NOZZLE EXIT
      C          LBLAYR 0410
      C          LRLAYR 0420
      C* NOTE: ALL CALCULATIONS ARE PERFORMED IN SI UNITS.
      C          LBLAYR 0430
      C          LBLAYR 0440
      C.....
      C          LRLAYR 0450
      C          LRLAYR 0460
      C          LRLAYR 0470
      C          LRLAYR 0480
      C          LBLAYR 0490
      C          LRLAYR 0500
      C          LBLAYR 0510
      C          LBLAYR 0520
      C          LBLAYR 0530
      C          LRLAYR 0540
      C          LRLAYR 0550
      C
      C          IMPLICIT REAL(L,M)
      C          DATA RBAR/8.31436E+03/
      C
      C          MU=EXP(A*ALOG(TE)+B)
      C          T=TE+0.5*(0.9*T0-TE)+0.22*(T0-TE)
      C          RE=PE*VE*LBNOZ*MW/(RBAR*T*MU)
      C          DELTA=5.2*LBNOZ/(SQRT(RE)*(1.0+GEOFAC*0.732))
      C          END

```

```

SUBROUTINE LCAS(A2A1,GA,GP,GR,MWAMWR,MWPMWR,MI,MR1,PR1PI,Q12,
-TA0TR1,WA2WR1,FLOW,GM,MWMWNR,NM2,PM2PR1,PM0PR0,TM2TR1,TM0TR0,
-XM2XR1,ZSEP)
C
C
C*****
C* LASER CAVITY ANALYSIS SUBROUTINE (LCAS)
C*****
C
C SUBROUTINE LCAS IS A SIMPLIFIED FLOW MODEL TO ASSESS QUALITATIVELY
C THE EFFECTS OF AREA CHANGE, CHEMICAL REACTION, AND MASS ADDITION ON
C THE LASER CAVITY FLOW. THE FLOW MODEL IS BASED ON THE ASSUMPTION
C OF A ONE-DIMENSIONAL FLOW OF AN IDEAL, HOMOGENEOUS GAS THROUGH A
C CHANNEL WITH A LINEAR VARIATION IN AREA, A RATE OF REACTION SUCH
C THAT THE HEAT RELEASE IS LINEAR WITH THE AXIAL COORDINATE, AND A
C NON-REACTIVE MASS ADDITION PROPORTIONAL TO THE RATE OF REACTION.
C
C INPUT VARIABLES:
C
C A2A1 = EXIT-TO-ENTRANCE AREA RATIO
C GA = GAMMA OF THE PURGE GAS
C GP = GAMMA OF THE PRODUCT GAS
C GR = GAMMA OF THE REACTANT GAS
C MWAMWR = PURGE-TO-REACTANT MOLECULAR WEIGHT RATIO
C MWPMWR = PRODUCT-TO-REACTANT MOLECULAR WEIGHT RATIO
C MI = INITIAL MACH NUMBER FOR A ZUKOSKI SEPARATION CRITERIA
C MR1 = MACH NUMBER OF THE REACTANT STREAM AT THE ENTRANCE
C PR1PI = REACTANT-TO-INITIAL STATIC PRESSURE RATIO
C Q12 = DIMENSIONLESS HEAT RELEASE
C TA0TR1 = PURGE STAGNATION-TO-REACTANT STATIC TEMPERATURE RATIO
C WA2WR1 = PURGE-TO-REACTANT MASS FLOW RATIO
C
C OUTPUT VARIABLES:
C
C FLOW = CHOKE/SEPARATION FLAG
C GM = GAMMA OF THE MIXED STREAM
C MWMWNR = MIXED-TO-REACTANT MOLECULAR WEIGHT RATIO
C NM2 = MACH NUMBER OF THE MIXED STREAM AT THE CAVITY EXIT
C PM2PR1 = MIXED-TO-REACTANT STATIC PRESSURE RATIO
C PM0PR0 = MIXED-TO-REACTANT STAGNATION PRESSURE RATIO
C TM2TR1 = MIXED-TO-REACTANT STATIC TEMPERATURE RATIO
C TM0TR0 = MIXED-TO-REACTANT STAGNATION TEMPERATURE RATIO
C XM2XR1 = MIXED-TO-REACTANT MOLAR FLOW RATIO
C ZSEP = SEPARATION LENGTH-TO-TOTAL CAVITY LENGTH RATIO
C*****
C
C IMPLICIT REAL(L,M)
C DIMENSION FP(3),MSQ(3),TMTR1(3),Z(3)
C DATA CHOKE/5HCHOKE/,SEP/3HSEP/

```


88

N=0	LCAS	1200
CALL LCFS(A2A1,GA,GP,GR,MWAMWR,MWPMWR,MSQ(J),Q1,Q2,TAOTR1,	LCAS	1210
-TMTR1(J),WA2WR1,Z(J),FMSQ,FTM,DUM1,GM,MWMMWR,XMXR1)	LCAS	1220
C1=FMSQ*DZRK1	LCAS	1230
D1=FTM*DZRK1	LCAS	1240
Z(J+1)=Z(J)+DZRK1/2.0	LCAS	1250
MSQ(J+1)=MSQ(J)+C1/2.0	LCAS	1260
TMTR1(J+1)=TMTR1(J)+D1/2.0	LCAS	1270
GO TO 104	LCAS	1280
101 CALL LCFS(A2A1,GA,GP,GR,MWAMWR,MWPMWR,MSQ(J+1),Q1,Q2,TAOTR1,	LCAS	1290
-TMTR1(J+1),WA2WR1,Z(J+1),FMSQ,FTM,DUM1,GM,MWMMWR,XMXR1)	LCAS	1300
C2=FMSQ*DZRK1	LCAS	1310
D2=FTM*DZRK1	LCAS	1320
MSQ(J+1)=MSQ(J)+C2/2.0	LCAS	1330
TMTR1(J+1)=TMTR1(J)+D2/2.0	LCAS	1340
GO TO 104	LCAS	1350
102 CALL LCFS(A2A1,GA,GP,GR,MWAMWR,MWPMWR,MSQ(J+1),Q1,Q2,TAOTR1,	LCAS	1360
-TMTR1(J+1),WA2WR1,Z(J+1),FMSQ,FTM,DUM1,GM,MWMMWR,XMXR1)	LCAS	1370
C3=FMSQ*DZRK1	LCAS	1380
D3=FTM*DZRK1	LCAS	1390
Z(J+1)=Z(J)+DZRK1	LCAS	1400
MSQ(J+1)=MSQ(J)+C3	LCAS	1410
TMTR1(J+1)=TMTR1(J)+D3	LCAS	1420
GO TO 104	LCAS	1430
103 CALL LCFS(A2A1,GA,GP,GR,MWAMWR,MWPMWR,MSQ(J+1),Q1,Q2,TAOTR1,	LCAS	1440
-TMTR1(J+1),WA2WR1,Z(J+1),FMSQ,FTM,DUM1,GM,MWMMWR,XMXR1)	LCAS	1450
C4=FMSQ*DZRK1	LCAS	1460
D4=FTM*DZRK1	LCAS	1470
MSQ(J+1)=MSQ(J)+(C1+2.0*(C2+C3)+C4)/6.0	LCAS	1480
TMTR1(J+1)=TMTR1(J)+(D1+2.0*(D2+D3)+D4)/6.0	LCAS	1490
C	LCAS	1500
C	LCAS	1510
C*****	LCAS	1520
C*	LCAS	1530
C*	LCAS	1540
C*	LCAS	1550
C*	LCAS	1560
C*	LCAS	1570
C*	LCAS	1580
C*****	LCAS	1590
C	LCAS	1600
C	LCAS	1610
104 IF(MSQ(J).GT.1.0.AND.MSQ(J+1).GT.1.0) GO TO 105	LCAS	1620
IF(MSQ(J).LT.1.0.AND.MSQ(J+1).LT.1.0) GO TO 105	LCAS	1630
FLOW=CHOKE	LCAS	1640
WRITE(6,109)	LCAS	1650
RETURN	LCAS	1660
105 N=N+1	LCAS	1670
GO TO (101,102,103,106),N	LCAS	1680
106 CONTINUE	LCAS	1690
C	LCAS	1700
C	LCAS	1710
C*****	LCAS	1720
C*	LCAS	1730
C*	LCAS	1740
INTEGRATE D(LN(P))/DZ USING SIMPSON'S RULE		

C		*LCAS	1750
C	.....	*LCAS	1760
C		LCAS	1770
C		LCAS	1780
C		LCAS	1790
	DO 107 J=1,3	LCAS	1800
107	CALL LCFS(AZA1,GA,GP,GR,MWAMWR,MWPMWR,MSQ(J),Q1,Q2,TAOTR1,	LCAS	1810
	-TMTR1(J),WAZWR1,Z(J),DUM1,DUM2,FP(J),GM,MUMWR,XMXR1)	LCAS	1820
	LPMPR1=LPMPR1+(DZ/6.0)*(FP(1)+4.0*FP(2)+FP(3))	LCAS	1830
C		LCAS	1840
C	.....	LCAS	1850
C		*LCAS	1860
C	CHECK FOR FLOW SEPARATION	*LCAS	1870
C		*LCAS	1880
C	.....	LCAS	1890
C		LCAS	1900
C		LCAS	1910
	IF(FLOW,EO,SEP) GO TO 108	LCAS	1920
	PMP1=EXP(LPMPR1)*PR1PI	LCAS	1930
	IF(PMP1.LT.PSEPPI) GO TO 108	LCAS	1940
	FLOW=SEP	LCAS	1950
	ZSEP=Z(J)	LCAS	1960
	WRITE(6,110)(ZSEP,K=1,10)	LCAS	1970
108	CONTINUE	LCAS	1980
	MM2=SQRT(MSQ(3))	LCAS	1990
	PM2PR1=EXP(LPMPR1)	LCAS	2000
	PM2PR0=P0PM(GM,MM2)*PM2PR1/P0PM(GR,MR1)	LCAS	2010
	TM2TR1=TMTR1(3)	LCAS	2020
	TM2TR0=T0TM(GM,MM2)*TM2TR1/T0TM(GR,MR1)	LCAS	2030
	XMXR1=XMXR1	LCAS	2040
C		LCAS	2050
C	.....	LCAS	2060
C		*LCAS	2070
C		*LCAS	2080
C	FORMAT STATEMENTS	*LCAS	2090
C		*LCAS	2100
C	.....	LCAS	2110
C		LCAS	2120
C		LCAS	2130
109	FORMAT(*,10(T2,*WARNING !!!! THE CAVITY FLOW HAS CHOKED*,/))	LCAS	2140
110	FORMAT(*,10(T2,*WARNING !!!! THE CAVITY FLOW HAS SEPARATED AT	ZLCAS	2150
	-SEP =*,E13.6,/))	LCAS	2160
	END	LCAS	2170

```

SUBROUTINE LCFS(A2A1,GA,GP,GR,MWAMWR,MWPMWR,MSQ,Q1,Q2,TAGTR1,
-TMTR1,WA2WR1,Z,FMSQ,FTM,FP,GM,MUMMW,R,XMR1)
C
C
C.....LCFS 0100
C          LCFS 0110
C          LCFS 0120
C          LCFS 0130
C          LCFS 0140
C          *LCFS 0150
C          *LCFS 0160
C          *LCFS 0170
C          *LCFS 0180
C          LCFS 0190
C.....LCFS 0200
C          *LCFS 0210
C          *LCFS 0220
C          *LCFS 0230
C          *LCFS 0240
C INPUT VARIABLES:
C          *LCFS 0250
C          *LCFS 0260
C A2A1 = EXIT-TO-ENTRANCE AREA RATIO
C GA = GAMMA OF THE PURGE GAS
C GP = GAMMA OF THE PRODUCT GAS
C GR = GAMMA OF THE REACTANT GAS
C MWAMWR = PURGE-TO-REACTANT MOLECULAR WEIGHT RATIO
C MWPMWR = PRODUCT-TO-REACTANT MOLECULAR WEIGHT RATIO
C MSQ = (MIXED STREAM MACH NUMBER)**2
C Q1 = HEAT RELEASE COEFFICIENT
C Q2 = HEAT RELEASE COEFFICIENT
C TAGTR1 = PURGE STAGNATION-TO-REACTANT STATIC TEMPERATURE RATIO
C TMTR1 = MIXED-TO-REACTANT STATIC TEMPERATURE RATIO
C WA2WR1 = PURGE-TO-REACTANT MASS FLOW RATIO
C Z = DIMENSIONLESS AXIAL COORDINATE
C          *LCFS 0390
C          *LCFS 0400
C OUTPUT VARIABLES:
C          *LCFS 0410
C          *LCFS 0420
C FMSQ = D(M**2)/DZ
C FP = D(LN(P))/DZ
C FTM = DTH/DZ
C GM = GAMMA OF THE MIXED STREAM
C MUMMW = MIXED-TO-REACTANT MOLECULAR WEIGHT RATIO
C XMR1 = MIXED-TO-REACTANT MOLAR FLOW RATIO
C          *LCFS 0480
C          *LCFS 0490
C.....LCFS 0500
C          LCFS 0510
C          LCFS 0520
C          LCFS 0530
C          LCFS 0540
C          LCFS 0550
C.....LCFS 0560
C          *LCFS 0570
C          *LCFS 0580
C          *LCFS 0590
C.....LCFS 0600
C          LCFS 0610
C          LCFS 0620
C          LCFS 0630
C          LCFS 0640
C          LCFS 0650
C          LCFS 0660
C          LCFS 0670
C          LCFS 0680
C          LCFS 0690
C          LCFS 0700
C          LCFS 0710
C          LCFS 0720
C          LCFS 0730
C          LCFS 0740
C          LCFS 0750
C          LCFS 0760
C          LCFS 0770
C          LCFS 0780
C          LCFS 0790
C          LCFS 0800
C          LCFS 0810
C          LCFS 0820
C          LCFS 0830
C          LCFS 0840
C          LCFS 0850
C          LCFS 0860
C          LCFS 0870
C          LCFS 0880
C          LCFS 0890
C          LCFS 0900
C          LCFS 0910
C          LCFS 0920
C          LCFS 0930
C          LCFS 0940
C          LCFS 0950
C          LCFS 0960
C          LCFS 0970
C          LCFS 0980
C          LCFS 0990
C          LCFS 1000

```

CHEMICAL LASER ANALYSIS PROGRAM (CLAP)
OVERLAY LDS

C		LCFS	0650
C		LCFS	0660
C	*****	LCFS	0670
C		LCFS	0680
C		LCFS	0690
C		LCFS	0700
C	*****	LCFS	0710
C		LCFS	0720
C		LCFS	0730
	GA1=GA/(GA-1,0)	LCFS	0740
	GA2=1.0/(GA-1.0)	LCFS	0750
	GP1=GP/(GP-1,0)	LCFS	0760
	GP2=1.0/(GP-1.0)	LCFS	0770
	GR1=GR/(GR-1,0)	LCFS	0780
	GR2=1.0/(GR-1.0)	LCFS	0790
	MWRMWA=1.0/MWRMWR	LCFS	0800
	MWRMWP=1.0/MWRMWP	LCFS	0810
		LCFS	0820
C		LCFS	0830
C	*****	LCFS	0840
C		LCFS	0850
C		LCFS	0860
C		LCFS	0870
C	*****	LCFS	0880
C		LCFS	0890
C		LCFS	0900
	F1=2.0*((Q2-Q1)*Z+Q1)/(Q2+Q1)	LCFS	0910
	F2=((Q1-Q2)*Z-2.0*Q1)*Z/(Q2+Q1)	LCFS	0920
	F3=((Q2-Q1)*Z+2.0*Q1)*Z/(Q2+Q1)	LCFS	0930
	GM=GFUNC1(GR1,MWRMWP*GP1,MWRMWA*GA1)/GFUNC1(GR2,MWRMWP*GP2,	LCFS	0940
	-MWRMWA*GA2)	LCFS	0950
	MWRMWR=GFUNC1(1.0,1.0,1.0)/GFUNC1(1.0,MWRMWP,MWRMWA)	LCFS	0960
	Q=(Q2-Q1)*Z+Q1	LCFS	0970
	XMXR1=GFUNC1(1.0,MWRMWP,MWRMWA)	LCFS	0980
C		LCFS	0990
C		LCFS	1000
C	*****	LCFS	1010
C		LCFS	1020
C		LCFS	1030
C		LCFS	1040
C	FA = (1/4) (OA/DZ)	LCFS	1050
C	FH = (1/CPH*TM) (DH/DZ)	LCFS	1060
C	FMSO = D(M**2)/DZ	LCFS	1070
C	FTM = DTM/DZ	LCFS	1080
C		LCFS	1090
C	*****	LCFS	1100
C		LCFS	1110
C		LCFS	1120
	FA=(A2A1-1.0)/((A2A1-1.0)*Z+1.0)	LCFS	1130
	FGM=GFUNC2(MWRMWP*GP1,MWRMWA*GA1,GR1)/GFUNC1(GR1,MWRMWP*GP1,	LCFS	1140
	-MWRMWA*GA1)-GFUNC2(MWRMWP*GP2,MWRMWA*GA2,GR2)/GFUNC1(GR2,MWRMWP*	LCFS	1150
	-GP2,MWRMWA*GA2)	LCFS	1160
	FM=(1/GM-1.0)/GM*(GR1*Q/TMTR1-(GA1*MWRMWA*(1.0-TACTR1/TMTR1)+	LCFS	1170
	-MSO*GM/(2.0*MWRMWR))*WA2WR1*F1/XMXR1	LCFS	1180
	FMMH=GFUNC2(0.0,1.0,0.0)/GFUNC1(1.0,1.0,1.0)-GFUNC2(MWRMWP,MWRMWA,	LCFS	1190

APPENDIX C
SUBROUTINE LCFS

CHEMICAL LASER ANALYSIS PROGRAM (CLAP)
OVERLAY LDS

PAGE C-29

-1.0)/OFUNC1(1.0,MURMWP,MURMWA)	LCFS	1200
FXM=OFUNC2(MURMWP,MURMWA,1.0)/OFUNC1(1.0,MURMWP,MURMWA)	LCFS	1210
FMSQ=MSQ*((2.0*(GM-1.0)*MSQ)+((1.0*(GM*MSQ)+(FXM*FMWM)-FA)*(1.0+	LCFS	1220
-GM*MSQ)*(FM-FMWM)-FGM)/(1.0-MSQ)	LCFS	1230
FPARM=MSQ*(FA-FM*FMWM-(2.0*(GM-1.0)*MSQ)*(FMWM*FXM))/(1.0-MSQ)	LCFS	1240
FTM=TMTR)*((GM-1.0)*MSQ*(FA-(1.0*GM*MSQ)*(FXM*FMWM)+FMWM)+(1.0-GM*LCFS	LCFS	1250
-MSQ)*FM)/(1.0-MSQ)	LCFS	1260
END	LCFS	1270

```

SUBROUTINE LPNCS(DPE,DPS,DSE,GEOMPN,GEOMSN,HNB,LDSS?,LPNOZ,NSPNOZ,LPNCS 0100
- PKFRAC,P0,T0,AEASF,AEASG,AKMSC,AKMSE,AKNST,FAIL,GC,GE,ME,MW,NPNOZ,LPNCS 0110
- PE,RE,T%) LPNCS 0120
C LPNCS 0130
C LPNCS 0140
C.....LPNCS 0150
C* LPNCS 0160
C* LASER PRIMARY NOZZLE CALCULATION SUBROUTINE (LPNCS) LPNCS 0170
C* LPNCS 0180
C.....LPNCS 0190
C LPNCS 0200
C.....LPNCS 0210
C* LPNCS 0220
C* GIVEN A LASER NOZZLE CONFIGURATION AND PRIMARY COMBUSTOR PRESSURE LPNCS 0230
C* (TEMPERATURE), SUBROUTINE LPNCS CALCULATES THE PRIMARY COMBUSTOR LPNCS 0240
C* TEMPERATURE (PRESSURE) REQUIRED TO ACHIEVE A GIVEN AVAILABLE LPNCS 0250
C* FLUORINE FLUX. LPNCS 0260
C* LPNCS 0270
C* INPUT VARIABLES: LPNCS 0280
C* LPNCS 0290
C* DFORMF = CONTROL VARIABLE SUCH THAT: LPNCS 0300
C* = "DFM" FOR A DF CHEMICAL LASER LPNCS 0310
C* = "MHF" FOR A HF CHEMICAL LASER LPNCS 0320
C* DPE = PRIMARY NOZZLE EXIT DIAMETER (M) LPNCS 0330
C* DPS = D%, PRIMARY NOZZLE (M) LPNCS 0340
C* DSE = SECONDARY NOZZLE EXIT DIAMETER (M) LPNCS 0350
C* FOAA = FREE FLUORINE FLUX (KMOLE/S-M2) LPNCS 0360
C* GEOMPN = PRIMARY NOZZLE GEOMETRY CONTROL VARIABLE SUCH THAT: LPNCS 0370
C* = "AXM" FOR AXISYMMETRIC NOZZLES LPNCS 0380
C* = "SDM" FOR SLIT NOZZLES LPNCS 0390
C* GEOMSN = SECONDARY NOZZLE GEOMETRY CONTROL VARIABLE SUCH THAT: LPNCS 0400
C* = "AXM" FOR AXISYMMETRIC NOZZLES LPNCS 0410
C* = "SDM" FOR SLIT NOZZLES LPNCS 0420
C* HNB = HEIGHT OF NOZZLE BANK (M) LPNCS 0430
C* LPNOZ = LENGTH OF PRIMARY NOZZLE (M) LPNCS 0440
C* NSPNOZ = NUMBER OF SECONDARY-TO-PRIMARY NOZZLES LPNCS 0450
C* PKFRAC = NOZZLE PACKING FRACTION LPNCS 0460
C* XFPP1 = MOLE FRACTION OF CF4 LPNCS 0470
C* XFPP2 = MOLE FRACTION OF F2 LPNCS 0480
C* XFPP3 = MOLE FRACTION OF F LPNCS 0490
C* XFPP4 = MOLE FRACTION OF HF LPNCS 0500
C* XFPP5 = MOLE FRACTION OF HE LPNCS 0510
C* XFPP6 = MOLE FRACTION OF N2 LPNCS 0520
C* LPNCS 0530
C* INPUT/OUTPUT VARIABLES: LPNCS 0540
C* LPNCS 0550
C* LDSS? = CONTROL VARIABLE SUCH THAT: LPNCS 0560
C* = "P10" FOR P0 AS INPUT AND T0 AS OUTPUT VARIABLES LPNCS 0570
C* = "T10" FOR T0 AS INPUT AND P0 AS OUTPUT VARIABLES LPNCS 0580
C* P0 = COMBUSTOR OR NOZZLE STAGNATION PRESSURE (PA) LPNCS 0590
C* T0 = COMBUSTOR OR NOZZLE STAGNATION TEMPERATURE (K) LPNCS 0600
C* LPNCS 0610
C* OUTPUT VARIABLES: LPNCS 0620
C* LPNCS 0630
C* AEASE = A/A%, EFFECTIVE LPNCS 0640

```

```

C* AEASO = A/A*, GEOMETRIC                                *LPNCS 0650
C* AKMSC = TOTAL EFFECTIVE NOZZLE EXIT AREA FOR PRIMARY FLOW PER *LPNCS 0660
C*        KMOLF/S OF PRIMARY FLOW BASED ON THE COMBUSTOR TEMPERATURE *LPNCS 0670
C*        (S-M2/KMOLF) *LPNCS 0680
C* AKMSE = TOTAL EFFECTIVE NOZZLE EXIT AREA FOR PRIMARY FLOW PER *LPNCS 0690
C*        KMOLF/S OF PRIMARY FLOW BASED ON THE EXIT TEMPERATURE *LPNCS 0700
C*        (S-M2/KMOLF) *LPNCS 0710
C* AKMST = TOTAL AREA OF NOZZLE BANK PER KMOLF/S OF PRIMARY FLOW *LPNCS 0720
C*        BASED ON THE EXIT TEMPERATURE (S-M2/KMOLF) *LPNCS 0730
C* FAIL = ERROR FLAG *LPNCS 0740
C* GC = GAMMA OF THE PRIMARY STREAM BASED ON THE COMBUSTOR *LPNCS 0750
C*        TEMPERATURE *LPNCS 0760
C* GE = GAMMA OF THE PRIMARY STREAM BASED ON THE EXIT TEMPERATURE *LPNCS 0770
C* ME = MACH NUMBER AT THE NOZZLE EXIT *LPNCS 0780
C* MW = MOLECULAR WEIGHT OF THE PRIMARY STREAM (KG/KMOLF) *LPNCS 0790
C* NPN07 = NUMBER OF PRIMARY NOZZLES PER KMOLF/S OF PRIMARY FLOW *LPNCS 0800
C*        (S/KMOLF) *LPNCS 0810
C* PF = STATIC PRESSURE AT THE NOZZLE EXIT (PA) *LPNCS 0820
C* RE = REYNOLDS NUMBER AT THE NOZZLE EXIT *LPNCS 0830
C* TE = STATIC TEMPERATURE AT THE NOZZLE EXIT (K) *LPNCS 0840
C* *LPNCS 0850
C* NOTE: ALL CALCULATIONS ARE PERFORMED IN SI UNITS *LPNCS 0860
C* *LPNCS 0870
C* *LPNCS 0880
C *LPNCS 0890
C *LPNCS 0900
C *LPNCS 0910
C *LPNCS 0920
C *LPNCS 0930
C *LPNCS 0940
C *LPNCS 0950
C *LPNCS 0960
C *LPNCS 0970
C *LPNCS 0980
C *LPNCS 0990
C *LPNCS 1000
C *LPNCS 1010
C *LPNCS 1020
C *LPNCS 1030
C *LPNCS 1040
C *LPNCS 1050
C *LPNCS 1060
C *LPNCS 1070
C *LPNCS 1080
C *LPNCS 1090
C *LPNCS 1100
C *LPNCS 1110
C *LPNCS 1120
C *LPNCS 1130
C *LPNCS 1140
C *LPNCS 1150
C *LPNCS 1160
C *LPNCS 1170
C *LPNCS 1180
C *LPNCS 1190

```

IMPLICIT REAL(M)
REAL LANOZ,LPNOZ,NSPNOZ,NPNOZ

DIMENSION XF(11)

COMMON/CCS3/DFORMF
COMMON/CCS4/FDAA
COMMON/CCS13/XFPP1,XFPP4,XFPP5,XFPPA
COMMON/CCS14/XFPP2
COMMON/CCS15/XFPP3

DATA PI/3.14159265358979/,RBAR/8.31434E+03/
DATA AX/2HAX/,HF/2MHF/,SUP/3HSUP/,YES/3MYFS/

FUNCTION STATEMENTS

TOTM(G,M)=1.0+0.5*(G-1.0)*M*M
POPM(G,M)=TOTM(G,M)**(G/(G-1.0))
WR(G,M)=M*SQRT(G*TOTM(G,M))
AASN(G,M)=(1.0/M)*(2.0*TOTM(G,M)/(G+1.0))**((0.5*(G+1.0)/(G-1.0))

C*		•LPNCS	1200
C*		•LPNCS	1210
C*	CALCULATE THE PRIMARY STREAM VISCOSITY	•LPNCS	1220
C*	COEFFICIENTS AND MOLECULAR WEIGHT RATIO	•LPNCS	1230
C*	.....	•LPNCS	1240
C		LPNCS	1250
C		LPNCS	1260
	XF(1)=XFPP1	LPNCS	1270
	XF(2)=XFPP2	LPNCS	1280
	XF(3)=XFPP3	LPNCS	1290
	XF(6)=XFPP5	LPNCS	1300
	XF(7)=XFPP6	LPNCS	1310
	IF(DFORMF,EQ,MF) GO TO 101	LPNCS	1320
	XF(4)=XFPP4	LPNCS	1330
	XF(5)=0.0	LPNCS	1340
	GO TO 102	LPNCS	1350
101	XF(4)=0.0	LPNCS	1360
	XF(5)=XFPP4	LPNCS	1370
102	CALL VISC(1,7,XF,A,R)	LPNCS	1380
	CALL CPCALC(1,7,T0,XF,GC,MW)	LPNCS	1390
C		LPNCS	1400
C		LPNCS	1410
C*	.....	•LPNCS	1420
C*		•LPNCS	1430
C*	NOZZLE GEOMETRY CALCULATIONS	•LPNCS	1440
C*		•LPNCS	1450
C*	.....	•LPNCS	1460
C		LPNCS	1470
C		LPNCS	1480
	IF(GEOMPN,NE,AX) GO TO 103	LPNCS	1490
	GEOPAC=1.0	LPNCS	1500
	AEASQ=DPE*DPE/(DPS*DPS)	LPNCS	1510
	AS=PI*DPS*DPS/4.0	LPNCS	1520
	C1=DPE*DPE*PI/4.0	LPNCS	1530
	GO TO 104	LPNCS	1540
103	GEOPAC=0.0	LPNCS	1550
	AEASQ=DPE/DPS	LPNCS	1560
	AS=DPS*MNB	LPNCS	1570
	C1=DPE*MNB	LPNCS	1580
104	LBNOZ=SQRT(LPNOZ*LPNOZ+((DPE-DPS)/2.0)**2)	LPNCS	1590
	IF(GEOMSN,FQ,AX) AFAC=(C1*DSE*DSE*NSPNOZ*PI/4.0)/PKFRAC	LPNCS	1600
	IF(GEOMSN,NE,AX) AFAC=(C1*DSE*MNB*NSPNOZ)/PKFRAC	LPNCS	1610
C		LPNCS	1620
C		LPNCS	1630
C*	.....	•LPNCS	1640
C*		•LPNCS	1650
C*	CALCULATE THE PRIMARY FLOW RATES	•LPNCS	1660
C*		•LPNCS	1670
C*	.....	•LPNCS	1680
C		LPNCS	1690
C		LPNCS	1700
	AKMST=XFPP3/FDAA	LPNCS	1710
	NPNOZ=AKMST/AFAC	LPNCS	1720
	XP=1.0/NPNOZ	LPNCS	1730
	WP=XP*MW	LPNCS	1740

C	LPNCS 1750
C	LPNCS 1760
C	LPNCS 1770
C	LPNCS 1780
C	LPNCS 1790
C	LPNCS 1800
C	LPNCS 1810
C	LPNCS 1820
C	LPNCS 1830
C	LPNCS 1840
C	LPNCS 1850
C	LPNCS 1860
C	LPNCS 1870
C	LPNCS 1880
C	LPNCS 1890
C	LPNCS 1900
C	LPNCS 1910
C	LPNCS 1920
C	LPNCS 1930
C	LPNCS 1940
C	LPNCS 1950
C	LPNCS 1960
C	LPNCS 1970
C	LPNCS 1980
C	LPNCS 1990
C	LPNCS 2000
C	LPNCS 2010
C	LPNCS 2020
C	LPNCS 2030
C	LPNCS 2040
C	LPNCS 2050
C	LPNCS 2060
C	LPNCS 2070
C	LPNCS 2080
C	LPNCS 2090
C	LPNCS 2100
C	LPNCS 2110
C	LPNCS 2120
C	LPNCS 2130
C	LPNCS 2140
C	LPNCS 2150
C	LPNCS 2160
C	LPNCS 2170
C	LPNCS 2180
C	LPNCS 2190
C	LPNCS 2200
C	LPNCS 2210
C	LPNCS 2220
C	LPNCS 2230
C	LPNCS 2240
C	LPNCS 2250
C	LPNCS 2260
C	LPNCS 2270
C	LPNCS 2280
C	LPNCS 2290

```

C
C
C.....
C0
C0          ITERATE TO FIND XPO=PA
C0
C.....
C          LPNCS 1820
C          LPNCS 1830
C          IF (LDSSZ.EQ.3HT10) GO TO 10A
C          NTYPE=1
C          NIT=1
C          TO=100.0
C          DO 10A ITER=1,100
C          CALL CPALC(1,7,TO,XF,OC,MW)
C          PS=MP*SQRT(RHAR*TO/MW)/(AS*WM(OC,1.0))
C          XPO=PS*P0PM(OC,1.0)
C          CALL ITER(TO,2900.0,9.0E-06,1.0,XPO,P0,9.0E-06,NIT,NTYPE,XNEG,
C          -YNFR,XPOS,YPOS,NSIGN1,NSIGN2)
C          IF (NTYPE.EQ.3) GO TO 107
C          IF (TO.GT.3000.0) GO TO 111
10A  CONTINUE
C          GO TO 111
10A  PS=MP*SQRT(RHAR*TO/MW)/(AS*WM(OC,1.0))
C          P0=PS*P0PM(OC,1.0)
C
C
C.....
C0
C0          ITERATE ME TO ESTABLISH THE NOZZLE EXIT CONDITIONS
C0
C.....
C          LPNCS 2060
C          LPNCS 2070
C          LPNCS 2080
C          NTYPE=1
C          NIT=1
C          CALL MAAS(OC,1.0,AEASE,SUP,9.0E-06,MSUPD,FAIL)
C          IF (FAIL.EQ.YES) GO TO 110
C          DELME=MSUPD-1.0
C          ME=MSUPD
C          DO 10A ITER=1,100
C          AEASE=AAASH(OC,ME)
C          PE=P0/P0PM(OC,ME)
C          TE=TO/T0TM(OC,ME)
C          VE=ME*SQRT(OC*RBAR*TE/MW)
C          CALL LRLAYR(A,B,GEOFAC,LRNOZ,MW,PE,TE,TO,VE,DELTA,RE)
C          DPFE=DPF-2.0*DELTA
C          XAEASE=DPFE/DPS
C          IF (AFOMPH.EQ.4X) XAEASE=XAEASE*XAEASE
C          SIGMA=AEASE-XAEASE*1.0
C          ERROR=AFASE*9.0E-06
C          CALL ITER(ME,DELME,9.0E-06,-1.0,SIGMA,1.0,ERROR,NIT,NTYPE,XNEG,
C          -YNFR,XPOS,YPOS,NSIGN1,NSIGN2)
C          IF (NTYPE.EQ.3) GO TO 100
C          IF (ME.LT.1.0.OR.ME.GT.MSUPD) GO TO 112

```

APPENDIX C
SUBROUTINE LPNCS

CHEMICAL LASER ANALYSIS PROGRAM (CLAP)
OVERLAY L05

PAGE C-34

100	CONTINUE	LPNCS	2300
	GO TO 114	LPNCS	2310
100	AF=AEASE*43	LPNCS	2320
C		LPNCS	2330
C		LPNCS	2340
C	.....	LPNCS	2350
C		LPNCS	2360
C	RECALCULATE THE PRIMARY STREAM PROPERTIES	LPNCS	2370
C	BASED ON THE NOZZLE EXIT TEMPERATURE	LPNCS	2380
C		LPNCS	2390
C	.....	LPNCS	2400
C		LPNCS	2410
C		LPNCS	2420
C	CALL CPCALC(1,7,TE,XF,WF,MW)	LPNCS	2430
C		LPNCS	2440
C		LPNCS	2450
C	.....	LPNCS	2460
C		LPNCS	2470
C	CALCULATE THE TOTAL EFFECTIVE NOZZLE EXIT AREA FOR PRIMARY FLOW	LPNCS	2480
C		LPNCS	2490
C	.....	LPNCS	2500
C		LPNCS	2510
C		LPNCS	2520
C	AKMSC=AF*NPNOZ	LPNCS	2530
	AKMSE=AKMSC*WM(GC,MF)/WM(OF,MF)	LPNCS	2540
	RETURN	LPNCS	2550
C		LPNCS	2560
C		LPNCS	2570
C	.....	LPNCS	2580
C		LPNCS	2590
C	FAILURE INDICATORS	LPNCS	2600
C		LPNCS	2610
C	.....	LPNCS	2620
C		LPNCS	2630
C		LPNCS	2640
110	WRITE(A,P01)	LPNCS	2650
	RETURN	LPNCS	2660
111	WRITE(A,P02)	LPNCS	2670
	GO TO 113	LPNCS	2680
112	WRITE(A,P03)	LPNCS	2690
	GO TO 114	LPNCS	2700
113	WRITE(A,P04)	LPNCS	2710
	GO TO 114	LPNCS	2720
114	WRITE(A,P05)	LPNCS	2730
115	WRITE(A,P06)A,R,GC,MW,ME,MSUPD,RE,WP,TE,TO,PE,FS,EPD,PO,XAEASE,	LPNCS	2740
	-AEASE	LPNCS	2750
	FAIL=VFS	LPNCS	2760
C		LPNCS	2770
C		LPNCS	2780
C	.....	LPNCS	2790
C		LPNCS	2800
C	FORMAT STATEMENTS	LPNCS	2810
C		LPNCS	2820
C	.....	LPNCS	2830
C		LPNCS	2840

```

C
P01  FORMAT(00,12,0SUBROUTINE MAAS WAS CALLED FROM SUBROUTINE0,1,12,0 LPNCS 2850
      -0LPNCS FOR THE CALCULATION OF MSUPD FROM AFAS00) LPNCS 2860
P02  FORMAT(010,12,0TO HAS EXCEEDED THE LIMITS OF SUBROUTINE CPALC0,1,LPNCS 2870
      -12,0PROGRAM TERMINATED IN SUBROUTINE LPNCS0) LPNCS 2880
P03  FORMAT(010,12,0IMPOSSIBLE VALUE FOR ME0,1,12,0PROGRAM TERMINATED ILPNCS 2890
      -N SUBROUTINE LPNCS0) LPNCS 2900
P04  FORMAT(010,12,0CONVERGENCE FAILURE IN SUBROUTINE LPNCS FOR T0 SUCHLPNCS 2910
      - THAT X000P00) LPNCS 2920
P05  FORMAT(010,12,0CONVERGENCE FAILURE IN SUBROUTINE LPNCS FOR M0 SUCHLPNCS 2930
      - THAT XAFAS0AFAS0) LPNCS 2940
P06  FORMAT(000,12,0A      00,F13,0,T30,0R      00,F13,0,1, LPNCS 2950
      -12,0CC      00,F13,0,T30,0MB      00,F13,0,0 NO/MOL0,1, LPNCS 2960
      -12,0MF      00,F13,0,T30,0MSUPD      00,F13,0,1, LPNCS 2970
      -12,0RZ      00,F13,0,T30,0MP      00,F13,0,0 NO/S0,1, LPNCS 2980
      -12,0TF      00,F13,0,0 NO,T30,0TO      00,F13,0,0 NO,1, LPNCS 2990
      -12,0PF      00,F13,0,0 PA0,T30,0PS      00,F13,0,0 PA0,1, LPNCS 3000
      -12,0PR0      00,F13,0,0 PA0,T30,0PD      00,F13,0,0 PA0,1, LPNCS 3010
      -12,0AFAS0      00,F13,0,T30,0AFAS0      00,F13,0,1 LPNCS 3020
      END LPNCS 3030

```

[illegible]

101

```

      XF(9)=0.0
      GO TO 102
101  XF(8)=0.0
      XF(4)=XFSR)
102  CALL VTSC(6.9,XF,4,8)
      CALL CPCALC(6.9,T0,XF,8C,MW)
C
C
C.....LSNC51 1200
C.....LSNC51 1210
C.....LSNC51 1220
C.....LSNC51 1230
C.....LSNC51 1240
C.....LSNC51 1250
C.....LSNC51 1260
C.....LSNC51 1270
C.....LSNC51 1280
C.....LSNC51 1290
C.....LSNC51 1300
C.....LSNC51 1310
C.....LSNC51 1320
C.....LSNC51 1330
C.....LSNC51 1340
C.....LSNC51 1350
C.....LSNC51 1360
C.....LSNC51 1370
C.....LSNC51 1380
C.....LSNC51 1390
C.....LSNC51 1400
C.....LSNC51 1410
C.....LSNC51 1420
C.....LSNC51 1430
C.....LSNC51 1440
C.....LSNC51 1450
C.....LSNC51 1460
C.....LSNC51 1470
C.....LSNC51 1480
C.....LSNC51 1490
C.....LSNC51 1500
C.....LSNC51 1510
C.....LSNC51 1520
C.....LSNC51 1530
C.....LSNC51 1540
C.....LSNC51 1550
C.....LSNC51 1560
C.....LSNC51 1570
C.....LSNC51 1580
C.....LSNC51 1590
C.....LSNC51 1600
C.....LSNC51 1610
C.....LSNC51 1620
C.....LSNC51 1630
C.....LSNC51 1640
C.....LSNC51 1650
C.....LSNC51 1660
C.....LSNC51 1670
C.....LSNC51 1680
C.....LSNC51 1690
C.....LSNC51 1700
C.....LSNC51 1710
C.....LSNC51 1720
C.....LSNC51 1730
C.....LSNC51 1740

      IF(MFOMSN,NE,AX) GO TO 103
      GEOPAC=1.0
      AEAS6=DE*DE/(DS*DS)
      *S=PI*DS*DS/4.0
      GO TO 104
103  GEOPAC=0.0
      AEAS6=DE/DS
      AS=DS*MNR
104  LKN0Z=SQRT(LSNOZ*LSNOZ+((DE-DS)/2.0)**2)
C
C
C.....LSNC51 1460
C.....LSNC51 1470
C.....LSNC51 1480
C.....LSNC51 1490
C.....LSNC51 1500
C.....LSNC51 1510
C.....LSNC51 1520
C.....LSNC51 1530
C.....LSNC51 1540
C.....LSNC51 1550
C.....LSNC51 1560
C.....LSNC51 1570
C.....LSNC51 1580
C.....LSNC51 1590
C.....LSNC51 1600
C.....LSNC51 1610
C.....LSNC51 1620
C.....LSNC51 1630
C.....LSNC51 1640
C.....LSNC51 1650
C.....LSNC51 1660
C.....LSNC51 1670
C.....LSNC51 1680
C.....LSNC51 1690
C.....LSNC51 1700
C.....LSNC51 1710
C.....LSNC51 1720
C.....LSNC51 1730
C.....LSNC51 1740

      NSNOZ=NSPNOZ*NPNOZ
      XS=RL*(XFP2*0.5*XFP3)/(XFSR)*NSNOZ)
      VS=XS*MW
      PS=NS*SQRT(RBAR*TO/MW)/(AS*WM(8C,1,0))
      PO=PS*POPM(8C,1,0)
C
C
C.....LSNC51 1590
C.....LSNC51 1600
C.....LSNC51 1610
C.....LSNC51 1620
C.....LSNC51 1630
C.....LSNC51 1640
C.....LSNC51 1650
C.....LSNC51 1660
C.....LSNC51 1670
C.....LSNC51 1680
C.....LSNC51 1690
C.....LSNC51 1700
C.....LSNC51 1710
C.....LSNC51 1720
C.....LSNC51 1730
C.....LSNC51 1740

      NTYPE=1
      NIT=1
      CALL MAAS(8C,1.0,AEAS6,SUP,5,DE-06,MSUPD,FAIL)
      IF(FAIL,EQ,YES) GO TO 107
      DELME=MSUPD-1.0
      ME=MSUPD
      DO 105 ITER1=1,100
      AFASE=AASH(8C,ME)

```

```

PE=PO/PAPM(GC,ME)
TF=TC/TATM(GC,ME)
VF=ME*SQRT(GC*RHAR*TF/MW)
CALL LRLAYR(A,B,GE,FC,LNOZ,MW,PE,TE,TO,VF,DELTA,MF)
DEF=DE-P,0*DELTA
XAFASE=DEF/DS
IF(GEOMSN,EQ,AX) XAFASE=XAFASE*XAFASE
SIGMA=XAFASE-XAEASF*1.0
ERROR=XAEASF*5,DE-0A
CALL ITER(ME,DELME,5,DE-06,-1.0,SIGMA,1.0,ERROR,NIT,NTYPE,XNEG,
-YNF0,XPOS,YPOS,NSIGN1,NSIGN2)
IF(NTYPE,EQ,3) GO TO 106
IF(ME,LT,1.0,OR,MF,GT,MSUPD) GO TO 108
105 CONTINUE
GO TO 109
106 AEE=XAFASE*AS
C
C
C.....
C* RECALCULATE THE SECONDARY STREAM PROPERTIES
C* BASED ON THE NOZZLE EXIT TEMPERATURE
C*.....
C LSNC51 1750
C LSNC51 1760
C LSNC51 1770
C LSNC51 1780
C LSNC51 1790
C LSNC51 1800
C LSNC51 1810
C LSNC51 1820
C LSNC51 1830
C LSNC51 1840
C LSNC51 1850
C LSNC51 1860
C LSNC51 1870
C LSNC51 1880
C LSNC51 1890
C LSNC51 1900
C LSNC51 1910
C LSNC51 1920
C LSNC51 1930
C*.....
C*
C*
C*
C*
C*.....
C LSNC51 1940
C LSNC51 1950
C LSNC51 1960
C LSNC51 1970
C LSNC51 1980
C LSNC51 1990
C LSNC51 2000
C LSNC51 2010
C LSNC51 2020
C LSNC51 2030
C*.....
C*
C*
C*
C*
C*.....
C LSNC51 2040
C LSNC51 2050
C LSNC51 2060
C LSNC51 2070
C LSNC51 2080
C LSNC51 2090
C LSNC51 2100
C LSNC51 2110
C LSNC51 2120
C LSNC51 2130
C LSNC51 2140
C LSNC51 2150
C LSNC51 2160
C LSNC51 2170
C*.....
C*
C*
C*
C*
C*.....
C LSNC51 2180
C LSNC51 2190
C LSNC51 2200
C LSNC51 2210
C LSNC51 2220
C LSNC51 2230
C LSNC51 2240
C LSNC51 2250
C LSNC51 2260
C LSNC51 2270
C LSNC51 2280
C LSNC51 2290
107 WRITE(A,201)
RETURN
108 WRITE(6,202)
GO TO 110
109 WRITE(6,203)

```



```

110  WRITE(6,204) A,R,GC,MW,MF,MSUPD,RE,WS,TE,T0,PE,PS,P0,XAEASE,AEASE  LSNCS1 2300
      FAIL=YES  LSNCS1 2310
C  LSNCS1 2320
C  LSNCS1 2330
C***** LSNCS1 2340
C*  LSNCS1 2350
C*  LSNCS1 2360
C*  LSNCS1 2370
C***** LSNCS1 2380
C  LSNCS1 2390
C  LSNCS1 2400
201  FORMAT('00,T2,SUBROUTINE MAAS WAS CALLED FROM SUBROUTINE',/,T2,  LSNCS1 2410
      -'LSNCS1 FOR THE CALCULATION OF MSUPD FROM AF450')  LSNCS1 2420
202  FORMAT('01,T2,IMPOSSIBLE VALUE FOR ME',/,T2,PROGRAM TERMINATLD  LSNCS1 2430
      -N SUBROUTINE LSNCS1*)  LSNCS1 2440
203  FORMAT('01,T2,CONVERGENCE FAILURE IN SUBROUTINE LSNCS1 FOR ME SUC  LSNCS1 2450
      -H THAT XAEASE=AEASE*)  LSNCS1 2460
204  FORMAT('00,T2,A  =,E13.6,T38,B  =,E13.6,/,  LSNCS1 2470
      -T2,BC  =,E13.6,T38,MW  =,E13.6, K0/KMOLE,/,  LSNCS1 2480
      -T2,ME  =,E13.6,T38,MSUPD  =,E13.6,/,  LSNCS1 2490
      -T2,RE  =,E13.6,T38,WS  =,E13.6, K0/S,/,  LSNCS1 2500
      -T2,TE  =,E13.6, K,T38,T0  =,E13.6, K,/,  LSNCS1 2510
      -T2,PE  =,E13.6, PA,T38,PS  =,E13.6, PA,/,  LSNCS1 2520
      -T2,P0  =,E13.6, PA,T38,XAEASE  =,E13.6,/,  LSNCS1 2530
      -T2,AEASE  =,E13.6)  LSNCS1 2540
      END  LSNCS1 2550

```

```

      SUBROUTINE LSNC52(DE,DS,GEOMSN,MNB,LSNOZ,NPNOZ,NSPNOZ,T0,AEASE,
      -AEASG,AKMSC,AKMSE,FAIL,GC,GE,ME,MW,NSNOZ,PF,P0,RE,TF,XKMS)
      C
      C
      C.....
      C*
      C*          LASER SECONDARY NOZZLE CALCULATION SUBROUTINE (LSNC52)
      C*
      C*.....
      C
      C.....
      C*
      C* GIVEN A CONSTANT-AREA LASER NOZZLE CONFIGURATION, SUBROUTINE LSNC52
      C* CALCULATES THE SECONDARY COMBUSTOR OR STAGNATION PRESSURE REQUIRED
      C* TO ACHIEVE A GIVEN LASER CAVITY MIXTURE RATIO.
      C*
      C* INPUT VARIABLES:
      C*
      C* DFORMF = CONTROL VARIABLE SUCH THAT:
      C*          "DF" FOR A DF CHEMICAL LASER
      C*          "HF" FOR A HF CHEMICAL LASER
      C* DE      = SECONDARY NOZZLE EXIT DIAMETER (M)
      C* DS      = DS (M)
      C* GEOMSN = SECONDARY NOZZLE GEOMETRY CONTROL VARIABLE SUCH THAT:
      C*          "AX" FOR AXISYMMETRIC NOZZLES
      C*          "SD" FOR SLIT NOZZLES
      C* MNB      = HEIGHT OF NOZZLE BANK (M)
      C* LSNOZ    = LENGTH OF SECONDARY NOZZLE (M)
      C* NPNOZ    = NUMBER OF PRIMARY NOZZLES PER KMOLE/S OF PRIMARY FLOW
      C*             (S/KMOLE)
      C* NSPNOZ   = NUMBER OF SECONDARY-TO-PRIMARY NOZZLES
      C* RL        = LASER CAVITY MIXTURE RATIO
      C* T0        = COMBUSTOR OR NOZZLE STAGNATION TEMPERATURE (K)
      C* XFPP2     = MOLE FRACTION OF F2 IN PRIMARY STREAM
      C* XFPP3     = MOLE FRACTION OF F IN PRIMARY STREAM
      C* XFSR1     = MOLE FRACTION OF D2 IN SECONDARY STREAM
      C* XFSR2     = MOLE FRACTION OF HF IN SECONDARY STREAM
      C* XFSR3     = MOLE FRACTION OF N2 IN SECONDARY STREAM
      C*
      C* OUTPUT VARIABLES:
      C*
      C* AEASE     = A/A*, EFFECTIVE
      C* AEASG     = A/A*, GEOMETRIC
      C* AKMSC     = TOTAL EFFECTIVE NOZZLE EXIT AREA FOR SECONDARY FLOW PER
      C*             KMOLE/S OF PRIMARY FLOW BASED ON THE COMBUSTOR TEMPERATURE
      C*             (S-M2/KMOLE)
      C* AKMSE     = TOTAL EFFECTIVE NOZZLE EXIT AREA FOR SECONDARY FLOW PER
      C*             KMOLE/S OF PRIMARY FLOW BASED ON THE EXIT TEMPERATURE
      C*             (S-M2/KMOLE)
      C* FAIL      = ERROR FLAG
      C* GC        = GAMMA OF THE SECONDARY STREAM BASED ON THE COMBUSTOR
      C*             TEMPERATURE
      C* GE        = GAMMA OF THE SECONDARY STREAM BASED ON THE EXIT
      C*             TEMPERATURE
      C* ME        = MACH NUMBER AT THE NOZZLE EXIT

```

```

C* MW      = MOLECULAR WEIGHT OF THE SECONDARY STREAM (KG/KMOLE)
C* NSNOZ   = NUMBER OF SECONDARY NOZZLES PER KMOLF/S OF PRIMARY FLOW
C*         (S.KMOLE)
C* PE      = STATIC PRESSURE AT THE NOZZLE EXIT (PA)
C* P0      = COMBUSTOR OR NOZZLE STAGNATION PRESSURE (PA)
C* RE      = REYNOLDS NUMBER AT THE NOZZLE EXIT
C* TE      = STATIC TEMPERATURE AT THE NOZZLE EXIT (K)
C* XKMS    = TOTAL SECONDARY MOLAR FLOW RATE PER KMOLE/S OF PRIMARY
C*         FLOW
C* NOTE: ALL CALCULATIONS ARE PERFORMED IN SI UNITS
C*****
C
C      IMPLICIT REAL(M)
C      REAL LSN07,NPN02,NSN07,NSPNO2
C
C      DIMENSION XF(11)
C
C      COMMON/CCS3/DFORMF
C      COMMON/CCSR/RL
C      COMMON/CCS14/XFPP2
C      COMMON/CCS15/XFPP3
C      COMMON/CCS16/XFSR1,XFSR2,XFSR3
C
C      DATA PI/3.14159265358979/,RBAR/8.31434E+03/
C      DATA AX/2HAX/,HF/2HHF/,SUP/3HSUP/,YES/3HYES/
C
C*****
C
C      FUNCTION STATEMENTS
C*****
C
C      TOTM(G,M)=1.0+0.5*(G-1.0)*M*M
C      POPM(G,M)=TOTM(G,M)**(G/(G-1.0))
C      WM(G,M)=M*SQRT(G*TOTM(G,M))
C
C*****
C
C      CALCULATE THE SECONDARY STREAM PROPERTIES
C      BASED ON THE COMBUSTOR TEMPERATURE
C*****
C
C      XF(6)=XFSR2
C      XF(7)=XFSR3
C      IF (DFORMF.EQ.HF) GO TO 101
C      XF(8)=XFSR1
C      XF(9)=0.0

```

APPENDIX C
SUBROUTINE LSNC52

CHEMICAL LASER ANALYSIS PROGRAM (CLAP)
OVERLAY L05

PAGE C-43

```

      GO TO 102
101  XF(A)=0.0
      XF(0)=XFSP1
102  CALL VISC(6,9,XF,A,R)
      CALL CPCALC(6,9,T0,XF,GC,MW)
C
C
C.....
C*
C*          NOZZLE GEOMETRY CALCULATIONS
C*
C.....
C
C          AEAS0=.0
C          AEASE=AEAS0
C          IF (GEOMSN,EQ,AX) AS=PI*DS*DS/4.0
C          IF (GEOMSN,NE,AX) AS=DS*MNR
C
C
C.....
C*
C*          CALCULATE THE SECONDARY FLOW RATES
C*
C.....
C
C          NSNOZ=NSPNOZ*NPNOZ
C          XS=RL*(XFP2+0.5*XFP3)/(XFSR1*NSNOZ)
C          WS=XS*MW
C
C
C.....
C*
C*          CALCULATE THE NOZZLE EXIT CONDITIONS
C*
C.....
C
C          ME=.0
C          PE=AS*SQRT(RBAR*T0/MW)/(AS*WM(GC,ME))
C          TF=T0/1.1*TM(GC,ME)
C          VE=ME*SQRT(GC*RBAR*TF/MW)
C          POS=PE*POPH(GC,ME)
C
C
C.....
C*
C*          CALCULATE THE FRICTION FACTOR
C*
C.....
C
C          IF (GEOMSN,EQ,AX) GO TO 103
C          CALL LRLAYR(A,B,0.0,LSNOZ,MW,PE,TF,T0,VE,DUMMY,RE)

```

LSNC52 1200
 LSNC52 1210
 LSNC52 1220
 LSNC52 1230
 LSNC52 1240
 LSNC52 1250
 LSNC52 1260
 LSNC52 1270
 *LSNC52 1280
 *LSNC52 1290
 *LSNC52 1300
 LSNC52 1310
 LSNC52 1320
 LSNC52 1330
 LSNC52 1340
 LSNC52 1350
 LSNC52 1360
 LSNC52 1370
 LSNC52 1380
 LSNC52 1390
 LSNC52 1400
 *LSNC52 1410
 *LSNC52 1420
 *LSNC52 1430
 LSNC52 1440
 LSNC52 1450
 LSNC52 1460
 LSNC52 1470
 LSNC52 1480
 LSNC52 1490
 LSNC52 1500
 LSNC52 1510
 *LSNC52 1520
 *LSNC52 1530
 *LSNC52 1540
 *LSNC52 1550
 LSNC52 1560
 LSNC52 1570
 LSNC52 1580
 LSNC52 1590
 LSNC52 1600
 LSNC52 1610
 LSNC52 1620
 LSNC52 1630
 LSNC52 1640
 LSNC52 1650
 *LSNC52 1660
 *LSNC52 1670
 *LSNC52 1680
 *LSNC52 1690
 LSNC52 1700
 LSNC52 1710
 LSNC52 1720
 LSNC52 1730
 LSNC52 1740

CHEMICAL LASER ANALYSIS PROGRAM (CLAP)
OVERLAY LOS

```

F=0.14*RF**(-1/4)
MYN1A=P.0*DE*HMH/(DE*HMH)
FFLD=4.0*F*LSN07/MYD1A
DO TO 10A
103 M1=EXP(A*ALOG(TF)+R)
RF=WS*NS/(H*H*AS)
FX=1.0F+10
DO 104 I=1.1000
C1=RF*SQRT(4.0*FX)
C2=0.0*P.0*ALOG10(C1)
F=1.0/(4.0*C2*C2)
ERROR=(FX-F)*100.0/FX
IF(ABS(ERROR).LT.5.0E-06) GO TO 105
104 FX=F
DO TO 103
105 FFLD=4.0*F*LSN07/DE
C
C
C*****
C=
C=
C=
C=
C*****
106 C1=(OC-1.0)/2.0
C2=(OC+1.0)/2.0
C3=C2/OC
XM2=1.0F+10
DO 107 I=1.1000
C4=1.0-XM2
C5=OC*XM2
C6=C2*XM2
C7=1.0+C3*XM2
M=C4/C5+C3*ALOG(C6/C7)-FFLD
MP=-(C4*OC*C4)/(C5*OC)+C3*(C2*C7-C1*C6)/(C7*C6)
M2=XM2-M/MP
ERROR=(XM2-M2)*100.0/XM2
IF(ABS(ERROR).LT.5.0E-06) GO TO 10A
107 XM2=M2
DO TO 110
108 P0P05=SQRT((((1.0+C1*MP)/C2)**(C2/C1))/MP)
P0=P0P05*P05
C
C
C*****
C=
C=
C=
C=
C*****
RECALCULATE THE SECONDARY STREAM PROPERTIES
BASED ON THE NOZZLE EXIT TEMPERATURE
C*****
C=
C=
C=
C=
C*****
CALL CPCALC(6.0,TF,XF,DE,MW)
C
C

```

```

C.....LSNCS2 2300
C*                                *LSNCS2 2310
C*      CALCULATE THE TOTAL SECONDARY MOLAR FLOW RATE AND    *LSNCS2 2320
C*      EFFECTIVE NOZZLE EXIT AREA FOR SECONDARY FLOW        *LSNCS2 2330
C*                                *LSNCS2 2340
C.....LSNCS2 2350
C*                                *LSNCS2 2360
C*                                *LSNCS2 2370
C*                                *LSNCS2 2380
C*                                *LSNCS2 2390
C*                                *LSNCS2 2400
C*                                *LSNCS2 2410
C*                                *LSNCS2 2420
C*                                *LSNCS2 2430
C.....LSNCS2 2440
C*                                *LSNCS2 2450
C*                                *LSNCS2 2460
C*                                *LSNCS2 2470
C.....LSNCS2 2480
C*                                *LSNCS2 2490
C*                                *LSNCS2 2500
109  WRITE(6,201)                                *LSNCS2 2510
      GO TO 111                                    *LSNCS2 2520
110  WRITE(6,202)                                *LSNCS2 2530
111  WRITE(6,203)GC,MW,XM2,M2,FX,F,RE,FFLD        *LSNCS2 2540
      FAIL=YFS                                     *LSNCS2 2550
C*                                *LSNCS2 2560
C*                                *LSNCS2 2570
C.....LSNCS2 2580
C*                                *LSNCS2 2590
C*                                *LSNCS2 2600
C*                                *LSNCS2 2610
C.....LSNCS2 2620
C*                                *LSNCS2 2630
C*                                *LSNCS2 2640
201  FORMAT(*1*,T2,*CONVERGENCE FAILURE IN SUBROUTINE LSNCS2 FOR FX=F*)LSNCS2 2650
202  FORMAT(*1*,T2,*CONVERGENCE FAILURE IN SUBROUTINE LSNCS2 FOR M2=XM2LSNCS2 2660
      -*LSNCS2 2670
203  FORMAT(*0*,T2,*GC      **E13.6,T38,*MW      **E13.6,* KG/KMOLE*,/,LSNCS2 2680
      -T2,*XM2      **E13.6,T38,*M2      **E13.6,/,LSNCS2 2690
      -T2,*FX      **E13.6,T38,*F      **E13.6,/,LSNCS2 2700
      -T2,*RE      **E13.6,T38,*FFLD      **E13.6)LSNCS2 2710
      FND                                         LSNCS2 2720

```

```

SUBROUTINE MAAS(G,MINI,AAS,FLOW,ERROR,MNEW,FAIL)
C
C
C.....
C*
C*
C* SUBROUTINE MAAS
C*
C.....
C
C.....
C* SUBROUTINE MAAS CALCULATES THE MACH NUMBER (M) GIVEN THE AREA RATIO
C* (A/A*) BY LINEAR ITERATION.
C*
C* INPUT VARIABLES:
C*
C* AAS    = THE AREA RATIO A/A*
C* ERROR  = MAX PERCENT DEVIATION IN MOLD AND MNEW FOR A SOLUTION
C* FLOW   = CONTROL VARIABLE SUCH THAT:
C*         = "SUB" FOR THE SUBSONIC BRANCH
C*         = "SUP" FOR THE SUPERSONIC BRANCH
C* G      = SPECIFIC HEAT RATIO
C* MINI   = INITIAL VALUE OF MACH NUMBER
C*
C* OUTPUT VARIABLES:
C*
C* FAIL    = ERROR FLAG
C* MNEW    = FINAL VALUE OF MACH NUMBER
C*
C.....
C
C
C      IMPLICIT REAL(M)
C      DATA YES/3HYES/,SUP/3HSUP/
C
C.....
C*
C*
C* CALCULATE CONSTANTS
C*
C.....
C
C      G1=(G-1.0)/2.0
C      G1I=1.0/G1
C      G2=2.0/(G+1.0)
C      G2I=1.0/G2
C      G4=(G+1.0)/(2.0*(G-1.0))
C      G4I=1.0/G4
C
C.....
C*
C*
C* CALCULATE THE SUPERSONIC BRANCH
C*
C.....

```

```

MAAS 0100
MAAS 0110
MAAS 0120
MAAS 0130
MAAS 0140
MAAS 0150
MAAS 0160
MAAS 0170
MAAS 0180
MAAS 0190
MAAS 0200
MAAS 0210
MAAS 0220
MAAS 0230
MAAS 0240
MAAS 0250
MAAS 0260
MAAS 0270
MAAS 0280
MAAS 0290
MAAS 0300
MAAS 0310
MAAS 0320
MAAS 0330
MAAS 0340
MAAS 0350
MAAS 0360
MAAS 0370
MAAS 0380
MAAS 0390
MAAS 0400
MAAS 0410
MAAS 0420
MAAS 0430
MAAS 0440
MAAS 0450
MAAS 0460
MAAS 0470
MAAS 0480
MAAS 0490
MAAS 0500
MAAS 0510
MAAS 0520
MAAS 0530
MAAS 0540
MAAS 0550
MAAS 0560
MAAS 0570
MAAS 0580
MAAS 0590
MAAS 0600
MAAS 0610
MAAS 0620
MAAS 0630
MAAS 0640

```

C.....	MAAS	0650
C	MAAS	0660
C	MAAS	0670
MOLD=MINI	MAAS	0680
IF (FLOW,NE,SUP) GO TO 2	MAAS	0690
DO 1 J=1,200	MAAS	0700
C1=(MOLD*AAS)**64I	MAAS	0710
MNEW=SQRT(61I*(62I*C1-1.0))	MAAS	0720
XERROR=(MNEW-MOLD)*100.0/MOLD	MAAS	0730
MOLD=MNEW	MAAS	0740
IF (ABS(XERROR).LT.ERROR) RETURN	MAAS	0750
1 CONTINUE	MAAS	0760
GO TO 4	MAAS	0770
C	MAAS	0780
C	MAAS	0790
C.....	MAAS	0800
C*	MAAS	0810
C* CALCULATE THE SUBSONIC BRANCH	MAAS	0820
C*	MAAS	0830
C.....	MAAS	0840
C	MAAS	0850
C	MAAS	0860
2 DO 3 J=1,200	MAAS	0870
C1=1.0+61*MOLD*MOLD	MAAS	0880
MNEW=((62*C1)**64)/AAS	MAAS	0890
XERROR=(MNEW-MOLD)*100.0/MOLD	MAAS	0900
MOLD=MNEW	MAAS	0910
IF (ABS(XERROR).LT.ERROR) RETURN	MAAS	0920
3 CONTINUE	MAAS	0930
C	MAAS	0940
C	MAAS	0950
C.....	MAAS	0960
C*	MAAS	0970
C* CONVERGENCE FAILURE	MAAS	0980
C*	MAAS	0990
C.....	MAAS	1000
C	MAAS	1010
C	MAAS	1020
4 WRITE(6,5)FLOW,G,MINI,MNEW,AAS,XERROR,ERROR	MAAS	1030
FAIL=YES	MAAS	1040
5 FORMAT(10,T2,CONVERGENCE FAILURE FOR A3,SONIC 2,	MAAS	1050
-0BRANCH IN SUBROUTINE MAAS,/,	MAAS	1060
-T2,G =,E13.6,2X,MINI =,E13.6,/,	MAAS	1070
-T2,MNEW =,E13.6,2X,AAS =,E13.6,/,	MAAS	1080
-T2,XERROR =,E13.6,2X,ERROR =,E13.6)	MAAS	1090
END	MAAS	1100


```

SUBROUTINE OUTLOS                                OUTLOS 0100
C                                                OUTLOS 0110
C                                                OUTLOS 0120
C.....OUTLOS 0130
C*                                                OUTLOS 0140
C*                OUTPUT SUBROUTINE (OUTLOS)    OUTLOS 0150
C*                                                OUTLOS 0160
C.....OUTLOS 0170
C                                                OUTLOS 0180
C.....OUTLOS 0190
C*                                                OUTLOS 0200
C*  SUBROUTINE OUTLOS PRINTS THE LASER DEVICE SECTION RESULTS OF OUTLOS 0210
C*  PROGRAM CLAP IN SI UNITS ON TERMINALS WITH A MINIMUM OF 132 OUTLOS 0220
C*  CHARACTERS PER LINE. OUTLOS 0230
C*                                                OUTLOS 0240
C.....OUTLOS 0250
C                                                OUTLOS 0260
C                                                OUTLOS 0270
C  IMPLICIT REAL(L,M,N) OUTLOS 0280
C                                                OUTLOS 0290
C  COMMON/CCS11/W7W2 OUTLOS 0300
C                                                OUTLOS 0310
C  COMMON/LDS2/D1,D1S,D3,D3S,GEOMPN,GEOMSN,LDS2,LPNOZ,LSNOZ,NSPNOZ, OUTLOS 0320
- PKFRAC,P10,T10,T30,T70 OUTLOS 0330
C                                                OUTLOS 0340
C  COMMON/LDS3/A1,A1A1SF,A1A1SO,A2,A3,A3A3SF,A3A3SO,A4,A5,A6,B1,B2, OUTLOS 0350
- G3,G4,G5,G6,G7,LSEP,MW1,MW2,MW3,MW4,MW5,MW6,MW7,M1,M2,M3,M4,M5,M6, OUTLOS 0360
- NPNOZ,NSNOZ,P1,P2,P3,P10,P4,P5,P50,P6,P60,RE1,RE3,KFN,R1,R10,R2, OUTLOS 0370
- R20,R3,R30,R4,R40,P5,P50,R6,R60,T1,T2,T20,T3,T4,T40,T5,T50,T6,T60, OUTLOS 0380
- W3W1,W5W2,W6W2,W7W2,X3X1,X4X2,X5X2,X6X2,X7X2,X8X2 OUTLOS 0390
C                                                OUTLOS 0400
C  COMMON/LDS4/AR,GR,MWA,MW,PA,PA0,RR,R60,TA,TAN OUTLOS 0410
C                                                OUTLOS 0420
C  COMMON/LDS5/BRFRAC,CANGLE,MHASE,MNR,LCAV OUTLOS 0430
C                                                OUTLOS 0440
C  COMMON/LDS6/P20,P40,W4W2 OUTLOS 0450
C                                                OUTLOS 0460
C  COMMON/MAIN2/FLOW OUTLOS 0470
C                                                OUTLOS 0480
C  DATA CHOKE,3MCHOKE/,SEP,3MSEP/ OUTLOS 0490
C                                                OUTLOS 0500
C.....OUTLOS 0510
C*                                                OUTLOS 0520
C*                OUTPUT INITIAL DATA OUTLOS 0530
C*                                                OUTLOS 0540
C*                                                OUTLOS 0550
C.....OUTLOS 0560
C                                                OUTLOS 0570
C                                                OUTLOS 0580
C  WRITE(20,201) OUTLOS 0590
  IF(LDS2.EQ.3NP10) WRITE(20,202)RRFRAC,CANGLE,D1,D1S,D3,D3S, OUTLOS 0600
-GEOMPN,GEOMSN,MHASE,MNR,LCAV,LPNOZ,LSNOZ,NSPNOZ,PKFRAC,P10,T30,T70 OUTLOS 0610
  IF(LDS2.EQ.3MT10) WRITE(20,203)RRFRAC,CANGLE,D1,D1S,D3,D3S, OUTLOS 0620
-GEOMPN,GEOMSN,MHASE,MNR,LCAV,LPNOZ,LSNOZ,NSPNOZ,PKFRAC,T10,T30,T70 OUTLOS 0630
C                                                OUTLOS 0640

```

	OUTPUT RESULTANT DATA	OUTLDS	
C		0650	
C		0660	
C		0670	
C		0680	
C		0690	
C		0700	
C		0710	
C		0720	
	WRITE (20,204) A1,A1A1SE,A1A1SG,G1,MW1,M1,NPNOZ,P1,P10,RE1,R1,R10.	0730	
	-T1,T10	0740	
	WRITE (20,205) A2,G2,MW2,M2,P2,P20,R2,R20,T2,T20	0750	
	WRITE (20,206) A3,A3A3SE,A3A3SG,G3,MW3,M3,NSNOZ,P3,P30,RE3,R3,R30.	0760	
	-T3,T30,M3M1,X3X1	0770	
	WRITE (20,207) A4,G4,MW4,M4,P4,P40,R4,R40,T4,T40,MW2,X4X2	0780	
	WRITE (20,208) A5,G5,MW5,M5,P5,P50,R5,R50,T5,T50,MW2,X5X2	0790	
	WRITE (20,209) A6,G6,MW6,M6,P6,P60,R6,R60,T6,T60,MW2,X6X2	0800	
	WRITE (20,210) G7,MW7,T70,M7M2,X7X2	0810	
	IF (FLOW,EQ,SEP) GO TO 101	0820	
	IF (FLOW,EQ,CHOK) GO TO 102	0830	
	WRITE (20,211) A8,G8,MW8,M8,P8,P80,REA,R8,R80,TA,T80,MW2,X8X2	0840	
	RETURN	0850	
101	WRITE (20,212)	0860	
	WRITE (20,213) A8,G8,LSEP,MW8,M8,P8,P80,REA,R8,R80,TA,T80,MW2,X8X2	0870	
	RETURN	0880	
102	WRITE (20,214)	0890	
C		0900	
C		0910	
C		0920	
C		0930	
C		0940	
C		0950	
C		0960	
C		0970	
C		0980	
201	FORMAT (10,Y55,*LASER DEVICE SECTION*,//,T66,*INITIAL DATA:*)	0990	
202	FORMAT (100,T32,*BRFRAC **E13.6,T66,*CANGLE **E13.6,* RAD*,//,	1000	
	-T32,*D1 **E13.6,* M*,T66,*D1S **E13.6,* M*,//,	1010	
	-T32,*D3 **E13.6,* M*,T66,*D3S **E13.6,* M*,//,	1020	
	-T32,*GEOMPN **A13,T66,*GEOMSN **A13,/,	1030	
	-T32,*HRASE **E13.6,* M*,T66,*HNR **E13.6,* M*,//,	1040	
	-T32,*LCAV **E13.6,* M*,T66,*LPNOZ **E13.6,* M*,//,	1050	
	-T32,*LSNOZ **E13.6,* M*,T66,*NSPNOZ **E13.6,/,	1060	
	-T32,*PKFRAC **E13.6,T66,*P10 **E13.6,* P*,//,	1070	
	-T32,*T30 **E13.6,* K*,T66,*T70 **E13.6,* K*,	1080	
203	FORMAT (100,T32,*BRFRAC **E13.6,T66,*CANGLE **E13.6,* RAD*,//,	1090	
	-T32,*D1 **E13.6,* M*,T66,*D1S **E13.6,* M*,//,	1100	
	-T32,*D3 **E13.6,* M*,T66,*D3S **E13.6,* M*,//,	1110	
	-T32,*GEOMPN **A13,T66,*GEOMSN **A13,/,	1120	
	-T32,*HRASE **E13.6,* M*,T66,*HNR **E13.6,* M*,//,	1130	
	-T32,*LCAV **E13.6,* M*,T66,*LPNOZ **E13.6,* M*,//,	1140	
	-T32,*LSNOZ **E13.6,* M*,T66,*NSPNOZ **E13.6,/,	1150	
	-T32,*PKFRAC **E13.6,T66,*P10 **E13.6,* K*,//,	1160	
	-T32,*T30 **E13.6,* K*,T66,*T70 **E13.6,* K*,	1170	
204	FORMAT (100,T59,*RESULTANT DATA*,//,T23,*POINT 1 PRIMARY NOZZLE	1180	
	-XIT - CONDITIONS BASED ON THE NOZZLE STAGNATION*,//,T32,*COMBUSTOR	1190	

```

-1) TEMPERATURE,/,/,
-T32,0A)    =,E13.6, S-M2/KMOLE,T66,0A1A1SE =,E13.6,/, OUTLDS 1200
-T32,0A1A1SG =,E13.6,T66,0A1 =,E13.6,/, OUTLDS 1210
-T32,0MW1    =,E13.6, K6/KMOLE,T66,0M1 =,E13.6,/, OUTLDS 1220
-T32,0NPNOZ  =,E13.6, S/KMOLE,T66,0P1 =,E13.6, PA,/, OUTLDS 1230
-T32,0P10    =,E13.6, PA,T66,0P1 =,E13.6,/, OUTLDS 1240
-T32,0R1     =,E13.6, K6/M3,T66,0R10 =,E13.6, K6/M3,/, OUTLDS 1250
-T32,0T1     =,E13.6, K,T66,0T10 =,E13.6, K,/, OUTLDS 1260
205 FORMAT(00,T23,POINT 2 PRIMARY NOZZLE EXIT - CONDITIONS BASED ON OUTLDS 1270
-ON THE NOZZLE EXIT,/,T32,TEMPERATURE,/,/, OUTLDS 1280
-T32,0A2     =,E13.6, S-M2/KMOLE,T66,0A2 =,E13.6,/, OUTLDS 1290
-T32,0MW2    =,E13.6, K6/KMOLE,T66,0M2 =,E13.6,/, OUTLDS 1300
-T32,0P2     =,E13.6, PA,T66,0P2 =,E13.6, PA,/, OUTLDS 1310
-T32,0R2     =,E13.6, K6/M3,T66,0R20 =,E13.6, K6/M3,/, OUTLDS 1320
-T32,0T2     =,E13.6, K,T66,0T20 =,E13.6, K,/, OUTLDS 1330
206 FORMAT(00,T23,POINT 3 SECONDARY NOZZLE EXIT - CONDITIONS BASED OUTLDS 1340
-ON THE NOZZLE STAGNATION,/,T32,(COMBUSTOR) TEMPERATURE,/,/, OUTLDS 1350
-T32,0A3     =,E13.6, S-M2/KMOLE,T66,0A3A3SE =,E13.6,/, OUTLDS 1360
-T32,0A3A3SG =,E13.6,T66,0A3 =,E13.6,/, OUTLDS 1370
-T32,0MW3    =,E13.6, K6/KMOLE,T66,0M3 =,E13.6,/, OUTLDS 1380
-T32,0NSMOZ  =,E13.6, S/KMOLE,T66,0P3 =,E13.6, PA,/, OUTLDS 1390
-T32,0P30    =,E13.6, PA,T66,0P3 =,E13.6,/, OUTLDS 1400
-T32,0R3     =,E13.6, K6/M3,T66,0R30 =,E13.6, K6/M3,/, OUTLDS 1410
-T32,0T3     =,E13.6, K,T66,0T30 =,E13.6, K,/, OUTLDS 1420
-T32,0MW3M1  =,E13.6,T66,0X3X1 =,E13.6,/, OUTLDS 1430
207 FORMAT(00,T23,POINT 4 SECONDARY NOZZLE EXIT - CONDITIONS BASED OUTLDS 1440
-ON THE NOZZLE EXIT,/,T32,TEMPERATURE,/,/, OUTLDS 1450
-T32,0A4     =,E13.6, S-M2/KMOLE,T66,0A4 =,E13.6,/, OUTLDS 1460
-T32,0MW4    =,E13.6, K6/KMOLE,T66,0M4 =,E13.6,/, OUTLDS 1470
-T32,0P4     =,E13.6, PA,T66,0P40 =,E13.6, PA,/, OUTLDS 1480
-T32,0R4     =,E13.6, K6/M3,T66,0R40 =,E13.6, K6/M3,/, OUTLDS 1490
-T32,0T4     =,E13.6, K,T66,0T40 =,E13.6, K,/, OUTLDS 1500
-T32,0MW4X2  =,E13.6,T66,0X4X2 =,E13.6,/, OUTLDS 1510
208 FORMAT(01,T23,POINT 5 CONSTANT-AREA MIXING REGION EXIT,/,/, OUTLDS 1520
-T32,0A5     =,E13.6, S-M2/KMOLE,T66,0A5 =,E13.6,/, OUTLDS 1530
-T32,0MW5    =,E13.6, K6/KMOLE,T66,0M5 =,E13.6,/, OUTLDS 1540
-T32,0P5     =,E13.6, PA,T66,0P50 =,E13.6, PA,/, OUTLDS 1550
-T32,0R5     =,E13.6, K6/M3,T66,0R50 =,E13.6, K6/M3,/, OUTLDS 1560
-T32,0T5     =,E13.6, K,T66,0T50 =,E13.6, K,/, OUTLDS 1570
-T32,0MW5X2  =,E13.6,T66,0X5X2 =,E13.6,/, OUTLDS 1580
209 FORMAT(00,T23,POINT 6 ISENTROPIC EXPANSION REGION EXIT,/,/, OUTLDS 1590
-T32,0A6     =,E13.6, S-M2/KMOLE,T66,0A6 =,E13.6,/, OUTLDS 1600
-T32,0MW6    =,E13.6, K6/KMOLE,T66,0M6 =,E13.6,/, OUTLDS 1610
-T32,0P6     =,E13.6, PA,T66,0P60 =,E13.6, PA,/, OUTLDS 1620
-T32,0R6     =,E13.6, K6/M3,T66,0R60 =,E13.6, K6/M3,/, OUTLDS 1630
-T32,0T6     =,E13.6, K,T66,0T60 =,E13.6, K,/, OUTLDS 1640
-T32,0MW6X2  =,E13.6,T66,0X6X2 =,E13.6,/, OUTLDS 1650
210 FORMAT(00,T23,POINT 7 MIRROR PURGE CONDITIONS,/,/, OUTLDS 1660
-T32,0G7     =,E13.6,T66,0MW7 =,E13.6, K6/KMOLE,/, OUTLDS 1670
-T32,0T70    =,E13.6, K,T66,0T7M2 =,E13.6,/, OUTLDS 1680
-T32,0TX7    =,E13.6,/, OUTLDS 1690
211 FORMAT(00,T23,POINT 8 LASER CAVITY EXIT,/,/, OUTLDS 1700
-T32,0A8     =,E13.6, S-M2/KMOLE,T66,0A8 =,E13.6,/, OUTLDS 1710
-T32,0MW8    =,E13.6, K6/KMOLE,T66,0M8 =,E13.6,/, OUTLDS 1720
-T32,0P8     =,E13.6, PA,T66,0P80 =,E13.6, PA,/, OUTLDS 1730

```

```

-T32,0REA      **E13.6,T6A,0RR      **E13.6,0 K8/M30,/.      OUTLOS 1750
-T32,0RAN      **F13.6,0 K8/M30,T6A,0T8      **E13.6,0 K8,/.      OUTLOS 1760
-T32,0T80      **F13.6,0 K8,T66,0W8W2      **F13.6,0,/.      OUTLOS 1770
-T32,0XAX2     **E13.6)      OUTLOS 1780
212  FORMAT(00,T23,0WARNING: THE CAVITY FLOW HAS SEPARATED. ALL FURTHER OUTLOS 1790
      -ER RESULTS SHOULD BE USED,/,T32,0WITH CAUTION,0)      OUTLOS 1800
213  FORMAT(00,T23,0POINT A LASER CAVITY EXIT,/,/,      OUTLOS 1810
      -T32,0AA      **E13.6,0 S-M2/KMOLE,T66,08A      **E13.6,0,/.      OUTLOS 1820
      -T32,0L9FP      **F13.6,0 M8,T66,0W8      **F13.6,0 K8/KMOLE,/,      OUTLOS 1830
      -T32,0MA      **E13.6,T6A,0PB      **E13.6,0 PA,/,      OUTLOS 1840
      -T32,0PAN      **E13.6,0 PA,T66,0RFR      **E13.6,0,/.      OUTLOS 1850
      -T32,0RA      **F13.6,0 K8/M30,T6A,0R80      **E13.6,0 K8/M30,/,      OUTLOS 1860
      -T32,0TA      **F13.6,0 K8,T66,0T80      **F13.6,0 K8,/,      OUTLOS 1870
      -T32,0W8W2     **E13.6,T6A,0XAX2      **E13.6)      OUTLOS 1880
214  FORMAT(00,T23,0WARNING: THE CAVITY FLOW HAS CHOKED. ALL FURTHER OUTLOS 1890
      -CALCULATIONS HAVE,/,T32,0REEN DISCONTINUED,0)      OUTLOS 1900
      END      OUTLOS 1910

```

```

SUBROUTINE VISC(NS1,NS2,XF,A,B)
C
C
C.....VISC 0100
C          VISC 0110
C          VISC 0120
C          VISC 0130
C          VISC 0140
C          VISC 0150
C          VISC 0160
C          VISC 0170
C          VISC 0180
C          VISC 0190
C          VISC 0200
C          SUBROUTINE VISC CALCULATES A RELATIONSHIP FOR THE ABSOLUTE
C          VISCOSITY OF GAS MIXTURES AS A FUNCTION OF TEMPERATURE. THIS
C          RELATIONSHIP IS OF THE FORM:
C          VISC 0210
C          VISC 0220
C          VISC 0230
C          VISC 0240
C          VISC 0250
C          VISC 0260
C          ALOG(MU)=A*ALOG(T)+B
C          VISC 0270
C          INPUT VARIABLES:
C          VISC 0280
C          VISC 0290
C          NS1      = DO LOOP LIMIT
C          NS2      = DO LOOP LIMIT
C          XF(I)    = MOLE FRACTION OF THE I-TH SPECIES
C          VISC 0300
C          VISC 0310
C          OUTPUT VARIABLES:
C          VISC 0320
C          VISC 0330
C          A        = SLOPE [ALOG(N-S/M2)/ALOG(K)]
C          B        = INTERSECT [ALOG(N-S/M2)]
C          VISC 0340
C          VISC 0350
C          NOTE: ALL CALCULATIONS ARE PERFORMED IN SI UNITS.
C          VISC 0360
C          VISC 0370
C          VISC 0380
C          VISC 0390
C          VISC 0400
C          VISC 0410
C          VISC 0420
C          IMPLICIT REAL(M)
C          REAL NUM
C          DIMENSION MU(11,15),MW(11),XF(11)
C          VISC 0430
C          VISC 0440
C          DATA MW/
C          VISC 0450
C          VISC 0460
C          CF4      F2      F      HF      DF      VISC 0470
C          -      BR.0047,   37.9968,   18.9984,   20.0064,   21.0125, VISC 0480
C             HE      N2      O2      H2      D      VISC 0490
C          -      4.00260,   28.0134,   4.02820,   2.01594,   2.01410, VISC 0500
C             M      VISC 0510
C          -      1.00797/ VISC 0520
C          VISC 0530
C          VISC 0540
C          VISC 0550
C          VISC 0560
C          VISC 0570
C          MU VALUES ARE STORED IN UNITS OF (1.0E+07 N-S/M2) AND TABULATED BY
C          TEMPERATURE (ROW) FROM 300 K TO 3100 K IN INCREMENTS OF 200 K AND
C          SPECIES (COLUMN).
C          VISC 0580
C          VISC 0590
C          VISC 0600
C          VISC 0610
C          VISCOSITY DATA WAS TAKEN FROM: NASA TECH REPORT R-132, TABLE III
C          EXCEPT THAT VALUES FOR D2, DF, AND D WERE CALCULATED FROM DATA FOR
C          H2, HF, AND H ASSUMING THE VISCOSITY TO BE PROPORTIONAL TO THE
C          VISC 0620
C          VISC 0630
C          VISC 0640

```

```

C* SQUARE ROOT OF THE MOLECULAR WEIGHT RATIO.          *VISC 0650
C*                                                         *VISC 0660
C*****                                                    *VISC 0670
C                                                         VISC 0680
C                                                         VISC 0690
C                                                         VISC 0700
C      DATA ((MU(I,J),I=1,9),J=1,15)/
C      CF4  F2  F  HF  DF  HE  N2  O2  H2
C      - 176.7, 236.2, 213.7, 125.3, 131.9, 203.9, 177.7, 126.1, 89.2,
C      - 262.7, 346.0, 313.0, 206.2, 213.2, 283.5, 252.7, 178.3, 126.1,
C      - 333.6, 436.5, 394.9, 277.3, 284.3, 352.2, 315.6, 221.6, 156.8,
C      - 394.9, 516.8, 467.5, 339.9, 346.9, 414.2, 371.0, 240.8, 184.5,
C      - 452.8, 589.5, 533.3, 396.6, 403.6, 471.4, 422.7, 297.6, 210.5,
C      - 504.2, 656.5, 593.8, 448.5, 455.6, 525.1, 471.8, 331.8, 234.7,
C      - 554.0, 719.6, 651.0, 496.9, 504.3, 575.8, 517.9, 344.0, 257.5,
C      - 606.3, 780.7, 706.3, 542.2, 549.9, 624.3, 561.7, 394.7, 279.2,
C      - 645.0, 840.4, 760.2, 585.2, 593.3, 670.7, 603.7, 424.1, 300.0,
C      - 689.0, 897.1, 811.6, 626.5, 634.9, 715.4, 644.0, 452.5, 320.1,
C      - 731.5, 951.9, 861.1, 666.2, 681.8, 758.6, 683.8, 479.8, 339.4,
C      - 772.5, 1004.9, 909.0, 704.5, 721.0, 800.5, 720.8, 506.3, 358.2,
C      - 812.2, 1056.3, 955.6, 741.4, 758.7, 841.3, 757.5, 532.1, 376.4,
C      - 850.8, 1106.4, 1000.8, 777.2, 795.4, 880.9, 793.3, 557.1, 394.1,
C      - 888.4, 1155.2, 1045.0, 811.8, 830.8, 919.7, 828.1, 581.7, 411.5/
C      DATA ((MU(I,J),I=10,11),J=1,15)/
C      D  H
C      - 105.9, 74.9,
C      - 147.3, 104.2,
C      - 183.6, 129.9,
C      - 216.3, 153.0,
C      - 246.2, 174.2,
C      - 274.2, 194.0,
C      - 300.8, 212.4,
C      - 326.1, 230.7,
C      - 350.7, 247.8,
C      - 373.7, 264.4,
C      - 396.2, 280.3,
C      - 416.1, 295.8,
C      - 434.5, 310.9,
C      - 460.1, 325.5,
C      - 480.3, 339.8/
C      VISC 0870
C      VISC 0880
C      VISC 0890
C      VISC 0900
C      VISC 0910
C      VISC 0920
C      VISC 0930
C      VISC 0940
C      VISC 0950
C      VISC 0960
C      VISC 0970
C      VISC 0980
C      VISC 0990
C      VISC 1000
C      VISC 1010
C      VISC 1020
C      VISC 1030
C      VISC 1040
C      VISC 1050
C      VISC 1060
C      VISC 1070
C* CALCULATE THE ABSOLUTE VISCOSITY OF THE MIXTURE. REF: BIRD, *VISC 1080
C* STEWART, & LIGHTFOOT, P.24. *VISC 1090
C* *VISC 1100
C*****                                                    *VISC 1110
C                                                         VISC 1120
C                                                         VISC 1130
C      SX=0.0
C      SX2=0.0
C      SY=0.0
C      SXY=0.0
C      DO 103 K=1,15
C      SUMI=0.0
C      VISC 1140
C      VISC 1150
C      VISC 1160
C      VISC 1170
C      VISC 1180
C      VISC 1190

```

DO 102 I=NS1,NS2	VISC	1200
SUMJ=0.0	VISC	1210
DO 101 J=NS1,NS2	VISC	1220
R1=MW(I)/MW(J)	VISC	1230
R2=MU(I,K)/MU(J,K)	VISC	1240
C=1.0*SQRT(R2/SQRT(R1))	VISC	1250
PHI=C*C/SQRT(8.0*(1.0+R1))	VISC	1260
DEN=XF(J)*PHI	VISC	1270
101 SUMJ=SUMJ+DEN	VISC	1280
NUM=XF(I)*MU(I,K)	VISC	1290
DIV=NUM/SUMJ	VISC	1300
102 SUMI=SUMI+DIV	VISC	1310
MUMIX=SUMI*1.0E-07	VISC	1320
C	VISC	1330
C	VISC	1340
C*****	VISC	1350
C*	*VISC	1360
C* PERFORM A LINEAR LEAST SQUARES FIT FOR ALOG(MUMIX) AS A FUNCTION OF	*VISC	1370
C* ALOG(T).	*VISC	1380
C*	*VISC	1390
C*****	VISC	1400
C	VISC	1410
C	VISC	1420
T=100.0*(FLOAT(K)*2.0+1.0)	VISC	1430
X=ALOG(T)	VISC	1440
Y=ALOG(MUMIX)	VISC	1450
SX=SX+X	VISC	1460
SX2=SX2+X*X	VISC	1470
SY=SY+Y	VISC	1480
103 SXY=SXY+X*Y	VISC	1490
A=(15.0*SXY-SX*SY)/(15.0*SX2-SX*SX)	VISC	1500
B=(SY/15.0)-A*(SX/15.0)	VISC	1510
END	VISC	1520

Appendix D. CHEMICAL LASER ANALYSIS PROGRAM (CLAP) – OVERLAY PRS


```

OVERLAY (PRS,3.0)
PROGRAM PRS

C
C .....
C*
C*          PRESSURE RECOVERY OVERLAY (PRS)
C*
C* .....
C
C .....
C* OVERLAY PRS CONTROLS THE PRESSURE RECOVERY CALCULATIONS FOR PROGRAM
C* CLAP.
C*
C*          GENERAL NOTATION SCHEME
C*
C* A : AREA PER KMOL/S OF LASER PRIMARY FLOW (S-M2/KMOLF)
C* G : (GAMMA) SPECIFIC HEAT RATIO
C* M : MACH NUMBER
C* MW: MOLECULAR WEIGHT (KG/KMOLF)
C* P : PRESSURE (PA)
C* R : DENSITY (KG/M3)
C* T : TEMPERATURE (K)
C* W : MASS FLOW RATE (KG/S)
C* X : MOLAR FLOW RATE (KMOLF/S)
C*
C* REPEATED LETTERS INDICATE RATIOS.
C* EXAMPLE: A2A1 = A2/A1
C*
C* VARIABLES ARE DESIGNATED AS TO LOCATION BY THE FOLLOWING:
C*
C* POINT 1: LASER CAVITY EXIT
C* POINT 2: NORMAL SHOCK DIFFUSER EXIT
C* POINT 3: SUBSONIC DIFFUSER EXIT
C* POINT 4: EJECTOR SECONDARY NOZZLE EXIT
C* POINT 5: EJECTOR PRIMARY NOZZLE EXIT
C* POINT 6: EJECTOR MIXING TUBE EXIT
C* POINT 7: SUPSONIC DIFFUSER EXIT
C* EXAMPLE: M4 = EJECTOR PRIMARY NOZZLE EXIT MACH NUMBER
C*
C* G1 INDICATES STAGNATION CONDITIONS
C* EXAMPLE: T20 = NORMAL SHOCK DIFFUSER EXIT STAGNATION TEMPERATURE
C*
C* VARIABLES NOT FOLLOWING THIS SCHEME ARE DEFINED AS REQUIRED.
C* .....
C
C          IMPLICIT REAL (L,M,N)
C
C          COMMON/LDS1/LDSS1
C
C          COMMON/LDS4/A1,G1,MW1,M1,P1,P10,R1,R10,T1,T10
C

```

```

PRS 0100
PRS 0110
PRS 0120
PRS 0130
PRS 0140
PRS 0150
PRS 0160
PRS 0170
PRS 0180
PRS 0190
PRS 0200
PRS 0210
PRS 0220
PRS 0230
PRS 0240
PRS 0250
PRS 0260
PRS 0270
PRS 0280
PRS 0290
PRS 0300
PRS 0310
PRS 0320
PRS 0330
PRS 0340
PRS 0350
PRS 0360
PRS 0370
PRS 0380
PRS 0390
PRS 0400
PRS 0410
PRS 0420
PRS 0430
PRS 0440
PRS 0450
PRS 0460
PRS 0470
PRS 0480
PRS 0490
PRS 0500
PRS 0510
PRS 0520
PRS 0530
PRS 0540
PRS 0550
PRS 0560
PRS 0570
PRS 0580
PRS 0590
PRS 0600
PRS 0610
PRS 0620
PRS 0630
PRS 0640

```

C	COMMON/MAIN1/FAIL	PRS	0650
C	COMMON/PRS1/PRSS1	PRS	0660
C	COMMON/PRS2/ 2,A3,A4,A7,ETA23,ETA67,G2,G3,G4,G6,G7,MW2,MW3,MW4,	PRS	0670
	-MW6,MW7,M2,M4,M6,M7,P2,P20,P3,P30,P4,P40,P5,P6,P60,P70,R2,R20,	PRS	0680
	-R3,R30,R4,R40,R5,R50,R6,P60,R7,R70,T2,T20,T3,T30,T4,T40,T5,T6,T60,	PRS	0690
	-T7,T70,W2W1,W3W1,W4W1,W6W1,W7W1,X2X1,X3X1,X4X1,X5X1,X6X1,X7X1	PRS	0700
C	COMMON/PRS3/A3A2,A7A6,ETA12,LIMIT,MW5,P7,T50	PRS	0710
C	COMMON/PRS4/A5,A6,M5,M5W1	PRS	0720
C	COMMON/PRS5/EJECT	PRS	0730
C	COMMON/PRS6/G5,P50	PRS	0740
C	DATA RBAR/8.31434E+03/	PRS	0750
	DATA CAE/3MCAE/,MO/2HNO/,SSE/3HSSE/,YES/3HYES/	PRS	0760
C		PRS	0770
C		PRS	0780
C*		PRS	0790
C*		PRS	0800
C*		PRS	0810
C*		PRS	0820
C*		PRS	0830
C*		PRS	0840
C*		PRS	0850
C*		PRS	0860
C*		PRS	0870
C*		PRS	0880
C*		PRS	0890
C*		PRS	0900
C*		PRS	0910
C*		PRS	0920
C*		PRS	0930
C*		PRS	0940
C*		PRS	0950
C*		PRS	0960
C*		PRS	0970
C*		PRS	0980
C*		PRS	0990
C*		PRS	1000
C*		PRS	1010
C*		PRS	1020
C*		PRS	1030
C*		PRS	1040
C*		PRS	1050
C*		PRS	1060
C*		PRS	1070
C*		PRS	1080
C*		PRS	1090
C*		PRS	1100
C*		PRS	1110
C*		PRS	1120
C*		PRS	1130
C*		PRS	1140
C*		PRS	1150
C*		PRS	1160
C*		PRS	1170
C*		PRS	1180
C*		PRS	1190

CHEMICAL LASER ANALYSIS PROGRAM (CLAP)
OVERLAY PRS

PAGE 0- 3

142

C*		*P	1750
C*	OPTIMUM CONSTANT-AREA, SUBSONIC-SUPERSONIC EJECTOR CALCULATIONS	*P	1760
C*		*PR	1770
C*****		PRS	1780
C		PRS	1790
C		PRS	1800
	MW5MW4=MW5/MW4	PRS	1810
	P50P4=P50/P40	PRS	1820
	P7P40=P7/P40	PRS	1830
	T50T40=T50/T40	PRS	1840
	CALL CAEOS(A7A6,G4,G5,MW5MW4,P50P40,P7P40,T50T40,A6A5,ETA67,FAIL,	PRS	1850
	-G6,MW6MW5,M4,M5,M6,M7,P5P4,P6P5,P60P50,P7P6,P70P60,T5T4,T6T5,	PRS	1860
	-T60T50,T7T6,T70T60,M5W4)	PRS	1870
	IF (FAIL.EQ.YES) GO TO 106	PRS	1880
	MW6=MW6MW5*MW5	PRS	1890
	P5=P50/P0PM(G5,M5)	PRS	1900
	P4=P5/P5P4	PRS	1910
	P6=P6P5*P5	PRS	1920
	P60=P60P50*P50	PRS	1930
	T5=T50/T07M(G5,M5)	PRS	1940
	T4=T5/T5T4	PRS	1950
	T6=T6T5*T5	PRS	1960
	T60=T60T50*T50	PRS	1970
	R4=RHO(P4,T4,MW4)	PRS	1980
	R40=RHO(P40,T40,MW4)	PRS	1990
	R5=RHO(P5,T5,MW5)	PRS	2000
	R50=RHO(P50,T50,MW5)	PRS	2010
	R6=RHO(P6,T6,MW6)	PRS	2020
	R60=RHO(P60,T60,MW6)	PRS	2030
	M5W]=M5W4*M4W1	PRS	2040
	M6W]=M5W1*M4W1	PRS	2050
	X5X1=M5W]*MW1/MW5	PRS	2060
	X6X1=X5X1*X4X1	PRS	2070
	A6=A1*M6W1*(P1/P6)*SORT((MW1/MW6)*(T60/T10))*(WK(G1,M1)/WM(G6,M6))	PRS	2080
	A5=A6/A6A5	PRS	2090
	A4=A6-A5	PRS	2100
	GO TO 103	PRS	2110
C		PRS	2120
C		PRS	2130
C*****		PRS	2140
C*		*PRS	2150
C*	OPTIMUM CONSTANT-AREA, SUPERSONIC-SUPERSONIC EJECTOR CALCULATIONS	*PRS	2160
C*		*PR*	2170
C*****		PRS	2180
C		PRS	2190
C		PRS	2200
102	MW5MW1=MW5/MW1	PRS	2210
	P50P1=P50/P1	PRS	2220
	P7P1=P7/P1	PRS	2230
	T50T10=T50/T10	PRS	2240
	CALL SSEOS(A7A6,G1,G5,LIMIT,MW5MW1,M1,P50P1,P7P1,T50T10,A6A5,	PRS	2250
	-ETA67,FAIL,G6,MW6MW5,M5,M6,M7,P5P1,P50P10,P6P5,P60P50,P7P6,P70P60,PRS	PRS	2260
	-T5T1,T6T5,T60T50,T7T6,T70T60,M5W1)	PRS	2270
	IF (FAIL.EQ.YES) GO TO 107	PRS	2280
	A5=A1/(A6A5-1.0)	PRS	2290

PS=PSP1*P1	PRS	2300
TS=TS11*P1	PRS	2310
RS=RHO(P5,T5,MW5)	PRS	2320
R50=RHO(P50,T50,MW5)	PRS	2330
X5X1=MW51/MW5MW1	PRS	2340
A6=A645*AS	PRS	2350
MW6=MW6MW5*MW5	PRS	2360
PA=P6P4*P4	PRS	2370
P60=P60P50*P50	PRS	2380
T6=T6T5*P5	PRS	2390
T60=T60T50*P50	PRS	2400
M6M1=MW51*1.0	PRS	2410
X6X1=X5X1*1.0	PRS	2420
C	PRS	2430
C	PRS	2440
C.....	PRS	2450
C*	PRS	2460
C* SURSONIC DIFFUSER CALCULATIONS	PRS	2470
C*	PRS	2480
C.....	PRS	2490
C	PRS	2500
C	PRS	2510
103 A7=A7AA*AA	PRS	2520
B7=B6	PRS	2530
MW7=MW6	PRS	2540
P70=P70P60*P60	PRS	2550
T7=T7T6*P6	PRS	2560
T70=T70T60*P60	PRS	2570
R7=RHO(P7,T7,MW7)	PRS	2580
R70=RHO(P70,T70,MW7)	PRS	2590
M7M1=MW61	PRS	2600
X7X1=X6X1	PRS	2610
C	PRS	2620
C	PRS	2630
C.....	PRS	2640
C*	PRS	2650
C* OUTPUT RESULTS	PRS	2660
C*	PRS	2670
C.....	PRS	2680
C	PRS	2690
C	PRS	2700
WRITE(6,205)(P3,M5,K=1,10)	PRS	2710
104 CALL OUTPRS	PRS	2720
GO TO 206	PRS	2730
C	PRS	2740
C	PRS	2750
C.....	PRS	2760
C*	PRS	2770
C* FAILURE INDICATORS	PRS	2780
C*	PRS	2790
C.....	PRS	2800
C	PRS	2810
C	PRS	2820
105 WRITE(6,201)	PRS	2830
GO TO 206	PRS	2840

APPENDIX D
PROGRAM PRS

CHEMICAL LASER ANALYSIS PROGRAM (CLAP)
OVERLAY PRS

PAGE D- 6

106	WRITE(A,202)	PRS	2850
	GO TO 206	PRS	2860
107	WRITE(A,203)	PRS	2870
C		PRS	2880
C		PRS	2890
C	.....	PRS	2900
C		*PRS	2910
C	FORMAT STATEMENTS	*PRS	2920
C		*PRS	2930
C	.....	*PRS	2940
201	FORMAT(*0,T2,*PROGRAM TERMINATED IN SUBROUTINE SDR AS CALLED FROM	PRS	2950
	- SUBROUTINE PRS*)	PRS	2960
202	FORMAT(*0,T2,*SUBROUTINE CAEOS WAS CALLED FROM SUBROUTINE PRS*)	PRS	2970
203	FORMAT(*0,T2,*SUBROUTINE SSEOS WAS CALLED FROM SUBROUTINE PRS*)	PRS	2980
204	FORMAT(*0,10(T2,*NOTE: P3 =*,E13.6,* PA M3 =*,E13.6,/))	PRS	2990
205	FORMAT(*10,10(T2,*NOTE: P3 =*,E13.6,* PA M5 =*,E13.6,/))	PRS	3000
206	END	PRS	3010

```

      SURROUTINE CAEFC(GS,GP,MS1,MP1,APIAM3,PS1PP1,FAIL)
C
C
C.....
C*
C*      CONSTANT-AREA EJECTOR FARRI CRITERION SURROUTINE (CAEFC)
C*
C*.....
C
C.....
C*
C* SUBROUTINE CAEFC PERFORMS THE CONSTANT-AREA, SUBSONIC-SUPERSONIC
C* EJECTOR FARRI CRITERION CALCULATIONS BY ONE-DIMENSIONAL ANALYSIS
C* FOR A SUPERSONIC PRIMARY (MP1>1) AND A SUBSONIC SECONDARY (MS1<1)
C* WHICH CHOKES IN THE EJECTOR SHROUD (MS2=1). THIS EJECTOR ANALYSIS
C* IS BASED ON THE CONSTANT-AREA SHROUD, EJECTOR ANALYSIS OF FARRI.
C* REFERENCE: NACA TM 1410.
C*
C* INPUT VARIABLES:
C*
C* GS      = SECONDARY GAMMA
C* GP      = PRIMARY GAMMA
C* MS1     = SECONDARY MACH NO. AT THE MIXING TUBE ENTRANCE
C* MP1     = PRIMARY MACH NO. AT THE MIXING TUBE ENTRANCE
C* APIAM3  = PRIMARY-TO-MIXING TUBE AREA RATIO
C*
C* OUTPUT VARIABLES:
C*
C* PS1PP1  = SECONDARY-TO-PRIMARY STATIC PRESSURE RATIO
C* FAIL    = ERROR FLAG
C*
C.....
C
C      IMPLICIT REAL(M)
C      DATA YES/3HYES/,PART/4HPART/,SUP/3HSUP/
C
C.....
C*
C*      GAS DYNAMIC FUNCTIONS
C*
C*.....
C
C      TOTM(G,M)=1.0+0.5*(G-1.0)*M*M
C      PPOH(G,M)=TOTM(G,M)**(-G/(G-1.0))
C      AASH(G,M)=((2.0*TOTM(G,M)/(G+1.0))**(0.5*(G+1.0)/(G-1.0)))/M
C
C.....
C*
C*      FARRI'S CRITERION APPLIES ONLY WHEN
C*      (MS1.LE.1.0) AND (PS1PP1.LE.1.0).
C*
C*.....

```

```

C.....CAEFC 0650
C      CAEFC 0660
C      CAEFC 0670
      IF(MS1.GT.(1.0)) GO TO 103      CAEFC 0680
      IF((1.-MS1).LT.(1.E-4)) GO TO 102      CAEFC 0690
C      CAEFC 0700
C      CAEFC 0710
C.....CAEFC 0720
C*      *CAEFC 0730
C*      CALCULATE MP2 AT STATION (2) WHERE MS2=1.0 FROM      *CAEFC 0740
C*      THE AREA RATIO FOR STREAM (P) AT STATION (2).      *CAEFC 0750
C*      *CAEFC 0760
C.....CAEFC 0770
C      CAEFC 0780
C      CAEFC 0790
      AP2APS=(AASH(OP,MP1)/AP1AM3)*((1.-(1.-AP1AM3)/AASH(OS,MS1))      CAEFC 0800
      CALL MAAS(OP,MP1,AP2APS,SUP,5.0E-06,MP2,FAIL)      CAEFC 0810
      IF(FAIL,EQ,YES) GO TO 107      CAEFC 0820
      IF(MP2.LT,MP1) GO TO 110      CAEFC 0830
      IF((MP2/MP1-1.).LT.(1.E-4)) GO TO 101      CAEFC 0840
C      CAEFC 0850
C      CAEFC 0860
C.....CAEFC 0870
C*      *CAEFC 0880
C*      CALCULATE STATIC PRESSURE RATIO PS1PP1 BASED ON FABRI'S CRITERION.      *CAEFC 0890
C*      *CAEFC 0900
C.....CAEFC 0910
C      CAEFC 0920
C      CAEFC 0930
      VD=(1.0-AP1AM3)*((1.0+OS*(MS1**2))-      CAEFC 0940
      -(PP0H(OS,1.0)/PP0H(OS,MS1))*((1.0+OS)/AASH(OS,MS1)))      CAEFC 0950
      VN=(PP0H(OP,MP2)/PP0H(OP,MP1))*AP1AM3*(AASH(OP,MP2)/      CAEFC 0960
      -AASH(OP,MP1))*((1.0+OP*(MP2**2))-AP1AM3*(1.0+OP*(MP1**2)))      CAEFC 0970
      PS1PP1=VN/VD      CAEFC 0980
      IF(PS1PP1.LE.(0.0)) GO TO 105      CAEFC 0990
      IF(PS1PP1.GT.(1.0)) GO TO 101      CAEFC 1000
      RETURN      CAEFC 1010
C      CAEFC 1020
C      CAEFC 1030
C.....CAEFC 1040
C*      *CAEFC 1050
C*      MS1 IS APPROXIMATELY 1.0 AND MP2 IS APPROXIMATELY MP1.      *CAEFC 1060
C*      *CAEFC 1070
C.....CAEFC 1080
C      CAEFC 1090
C      CAEFC 1100
101  IF(MS1.LT.1.0) GO TO 110      CAEFC 1110
102  PS1PP1=1.0      CAEFC 1120
      RETURN      CAEFC 1130
C      CAEFC 1140
C      CAEFC 1150
C.....CAEFC 1160
C*      *CAEFC 1170
C*      ERROR MESSAGES      *CAEFC 1180
C*      *CAEFC 1190

```


APPENDIX D
SUBROUTINE CAEFC

CHEMICAL LASER ANALYSIS PROGRAM (CLAP)
OVERLAY PRS

PAGE D- 9

C.....	CAEFC	1200
C	CAEFC	1210
C	CAEFC	1220
103 WRITE(A,104)	CAEFC	1230
104 FORMAT(*),T2,*ERROR IN SUBROUTINE CAEFC: M51>1*)	CAEFC	1240
GO TO 109	CAEFC	1250
105 WRITE(6,106)	CAEFC	1260
106 FORMAT(*),T2,*ERROR IN SUBROUTINE CAEFC: P51PP!<0*)	CAEFC	1270
GO TO 109	CAEFC	1280
107 WRITE(6,108)	CAEFC	1290
108 FORMAT(*),T2,*SUBROUTINE MAAS WAS CALLED FROM SUBROUTINE CAEFC*)	CAEFC	1300
109 FAIL=YES	CAEFC	1310
RETURN	CAEFC	1320
110 FAIL=PART	CAEFC	1330
END	CAEFC	1340

```
SUBROUTINE CAEOCV(GS,GP,MWSMWP,TSTPT0,MS1,MP1,APIAM3,PS1PP1,  
-FLOW,WSWP,GM,MWMWMP,TMOTPO,MM3,PP0PS0,PM3PS0,PM3PP1,FAIL)  
C  
C  
C.....CAEOCV 0100  
C* CAEOCV 0110  
C* CAEOCV 0120  
C* CAEOCV 0130  
C* CAEOCV 0140  
C* CAEOCV 0150  
C* CONSTANT-AREA EJECTOR OVERALL CONTROL VOLUME SUBROUTINE (CAEOCV) *CAEOCV 0160  
C* CAEOCV 0170  
C* CAEOCV 0180  
C* CAEOCV 0190  
C* CAEOCV 0200  
C* CAEOCV 0210  
C* CAEOCV 0220  
C* SUBROUTINE CAEOCV PERFORMS THE CONSTANT-AREA EJECTOR, OVERALL *CAEOCV 0230  
C* CONTROL VOLUME CALCULATIONS BY ONE-DIMENSIONAL ANALYSIS FROM INLET *CAEOCV 0240  
C* SECTION (1) TO MIXED SECTION (3). *CAEOCV 0250  
C* CAEOCV 0260  
C* INPUT VARIABLES: *CAEOCV 0270  
C* CAEOCV 0280  
C* GS = SECONDARY GAMMA *CAEOCV 0290  
C* GP = PRIMARY GAMMA *CAEOCV 0300  
C* MWSMWP = SECONDARY-TO-PRIMARY MOLECULAR WEIGHT RATIO *CAEOCV 0310  
C* TSTPT0 = SECONDARY-TO-PRIMARY STAGNATION TEMPERATURE RATIO *CAEOCV 0320  
C* MS1 = SECONDARY MACH NO. AT THE MIXING TUBE ENTRANCE *CAEOCV 0330  
C* MP1 = PRIMARY MACH NO. AT THE MIXING TUBE ENTRANCE *CAEOCV 0340  
C* APIAM3 = PRIMARY-TO-MIXING TUBE AREA RATIO *CAEOCV 0350  
C* PS1PP1 = SECONDARY-TO-PRIMARY STATIC PRESSURE RATIO *CAEOCV 0360  
C* FLOW = CONTROL VARIABLE SUCH THAT: *CAEOCV 0370  
C* = "SUB" FOR THE SUBSONIC SOLUTION *CAEOCV 0380  
C* = "SUP" FOR THE SUPERSONIC SOLUTION *CAEOCV 0390  
C* OUTPUT VARIABLES: *CAEOCV 0400  
C* CAEOCV 0410  
C* WSWP = SECONDARY-TO-PRIMARY MASS FLOW RATIO *CAEOCV 0420  
C* GM = MIXED STREAM GAMMA *CAEOCV 0430  
C* MWMWMP = MIXED STREAM-TO-PRIMARY MOLECULAR WEIGHT RATIO *CAEOCV 0440  
C* TMOTPO = MIXED STREAM-TO-PRIMARY STAGNATION TEMPERATURE RATIO *CAEOCV 0450  
C* MM3 = MIXED STREAM MACH NO. AT THE MIXING TUBE EXIT *CAEOCV 0460  
C* PP0PS0 = PRIMARY-TO-SECONDARY STAGNATION PRESSURE RATIO *CAEOCV 0470  
C* PM3PS0 = MIXED STREAM STATIC-TO-SECONDARY STAGNATION PRESSURE RATIO *CAEOCV 0480  
C* PM3PP1 = MIXED STREAM-TO-PRIMARY STATIC PRESSURE RATIO *CAEOCV 0490  
C* FAIL = ERROR FLAG *CAEOCV 0500  
C* CAEOCV 0510  
C* CAEOCV 0520  
C* CAEOCV 0530  
C* CAEOCV 0540  
C* CAEOCV 0550  
C* CAEOCV 0560  
C* CAEOCV 0570  
C* CAEOCV 0580  
C* CAEOCV 0590  
C* CAEOCV 0600  
C* CAEOCV 0610  
C* CAEOCV 0620  
C* CAEOCV 0630  
C* CAEOCV 0640
```

```

C
      WM(6,M)=M*SQRT(0*(1+.5*(G-1.)*(M**2)))
      T(6,M)=(1+.6*(M**2))/(M*SQRT(1+.5*(G-1.)*(M**2)))
      PPOH(6,M)=(1+.5*(G-1.)*(M**2))*(-G/(G-1.))
C
C.....
C*
C*      EJECTOR MASS FLOW RATIO
C*
C.....
C
      CO=SQRT(MWSHWP/TS0TP0)
      WSWP=PS[PP]*(1.-AP[AM3]/AP[AM3]*CO*(WM(6,MS1)/WM(6P,MP1)))
      CPSCPP=(6S/6P)*((6P-1.)/(6S-1.))/MWSHWP
C
C.....
C*
C*      MIXED FLOW PROPERTIES
C*
C.....
C
      MWMHWP=(1.+WSWP)/(1.+(WSWP/MWSHWP))
      6M=1./((1.-((6P-1.)/6P)*((1.+(WSWP/MWSHWP))/(1.+CPSCPP*WSWP))))
      TM0TP0=(1.+WSWP*CPSCPP*TS0TP0)/(1.+WSWP*CPSCPP)
C
C.....
C*
C*      SOLVE FOR M3
C*
C.....
C
      C1=SQRT((TS0TP0/MWSHWP)*(6P/6S))
      C2=SQRT(TM0TP0/MWMHWP*(6P/6M))
      TM3=(T(6P,MP1)+C1*WSWP*T(6S,MS1))/((1.+WSWP)*C2)
      TM3MIN=SQRT(2.*(6M+1.))
      IF(TM3,LT, TM3MIN) GO TO 10
      C3=(TM3**2-2.*6M)
      C4=((6M-1.)/2.)*(TM3**2)-6M**2)
      C5=SQRT(C3**2+4.*C4)
      MSQD3M=(-C3-C5)/(2.*C4)
      MSQD3P=(-C3+C5)/(2.*C4)
C
C.....
C*
C*      DETERMINE TWO POSSIBLE MIXED-FLOW MACH NO. SOLUTIONS
C*
C.....

```

CAEOCV 0650
 CAEOCV 0660
 CAEOCV 0670
 CAEOCV 0680
 CAEOCV 0690
 CAEOCV 0700
 CAEOCV 0710
 CAEOCV 0720
 CAEOCV 0730
 CAEOCV 0740
 CAEOCV 0750
 CAEOCV 0760
 CAEOCV 0770
 CAEOCV 0780
 CAEOCV 0790
 CAEOCV 0800
 CAEOCV 0810
 CAEOCV 0820
 CAEOCV 0830
 CAEOCV 0840
 CAEOCV 0850
 CAEOCV 0860
 CAEOCV 0870
 CAEOCV 0880
 CAEOCV 0890
 CAEOCV 0900
 CAEOCV 0910
 CAEOCV 0920
 CAEOCV 0930
 CAEOCV 0940
 CAEOCV 0950
 CAEOCV 0960
 CAEOCV 0970
 CAEOCV 0980
 CAEOCV 0990
 CAEOCV 1000
 CAEOCV 1010
 CAEOCV 1020
 CAEOCV 1030
 CAEOCV 1040
 CAEOCV 1050
 CAEOCV 1060
 CAEOCV 1070
 CAEOCV 1080
 CAEOCV 1090
 CAEOCV 1100
 CAEOCV 1110
 CAEOCV 1120
 CAEOCV 1130
 CAEOCV 1140
 CAEOCV 1150
 CAEOCV 1160
 CAEOCV 1170
 CAEOCV 1180
 CAEOCV 1190

C		CAEOCV 1200
	IF(MSQD3M.GE.(0.0)) MM3M=SQRT(MSQD3M)	CAEOCV 1210
	IF(MSQD3P.GE.(0.0)) MM3P=SQRT(MSQD3P)	CAEOCV 1220
	MM3=MM3P	CAEOCV 1230
	IF(FLOW.FQ.SUP) MM3=MM3M	CAEOCV 1240
C		CAEOCV 1250
C		CAEOCV 1260
C	.....	CAEOCV 1270
C		CAEOCV 1280
C		CAEOCV 1290
C	CALCULATE PRESSURE RATIOS	CAEOCV 1300
C	.....	CAEOCV 1310
C		CAEOCV 1320
C		CAEOCV 1330
C		CAEOCV 1340
	C6=SQRT(TM0TP0/MWMMWP)	CAEOCV 1350
	PM3PP1=C6*AP1AM3*(1.+WSUP)*(NM(GP,MP1)/NM(GM,MM3))	CAEOCV 1360
	PP0PS0=(PP0M(GS,MS1)/PP0M(GP,MP1))/PS1PP1	CAEOCV 1370
	PM3PS0=PM3PP1*(PP0M(GS,MS1)/PS1PP1)	CAEOCV 1380
	RETURN	CAEOCV 1390
C		CAEOCV 1400
C		CAEOCV 1410
C	.....	CAEOCV 1420
C		CAEOCV 1430
C	ERROR MESSAGES	CAEOCV 1440
C	.....	CAEOCV 1450
C		CAEOCV 1460
C		CAEOCV 1470
C		CAEOCV 1480
10	FAIL=PART	CAEOCV 1490
	END	

```

SUBROUTINE CAEOS(A7A6,GS,GP,MWPMWS,P50P40,P7P40,T50T40,A6A5,ETA67,CAEOS 0100
-FAIL,GM,MWMMWP,M4,M5,M6,M7,P5P4,P6P5,P60P50,P7P6,P70P60,T5T4,T6T5,CAEOS 0110
-T60T50,T7T6,T70T60,WPWS) CAEOS 0120
C CAEOS 0130
C CAEOS 0140
C*****CAEOS 0150
C* CAEOS 0160
C* SURSONIC-SUPERSONIC EJECTOR OPTIMIZATION SUBROUTINE (CAEOS) CAEOS 0170
C* CAEOS 0180
C*****CAEOS 0190
C CAEOS 0200
C*****CAEOS 0210
C* CAEOS 0220
C* CAEOS IS A SUBROUTINE FOR OPTIMIZING A CONSTANT-AREA, SUBSONIC- CAEOS 0230
C* SUPERSONIC EJECTOR-SUBSONIC DIFFUSER SUBSYSTEM BY ONE-DIMENSIONAL CAEOS 0240
C* ANALYSIS. THE OPTIMUM IS TAKEN TO BE THAT CONFIGURATION WHICH CAEOS 0250
C* REQUIRES THE MINIMUM DRIVER MASS FLOW FOR A GIVEN DRIVER STAGNATION CAEOS 0260
C* PRESSURE AND GIVEN COMPRESSION RATIO. CAEOS 0270
C* CAEOS 0280
C* INPUT VARIABLES: CAEOS 0290
C* CAEOS 0300
C* A7A6 = SUBSONIC DIFFUSER EXIT-TO-ENTRANCE AREA RATIO CAEOS 0310
C* GS = SECONDARY GAMMA CAEOS 0320
C* GP = PRIMARY GAMMA CAEOS 0330
C* MWPMWS = PRIMARY-TO-SECONDARY MOLECULAR WEIGHT RATIO CAEOS 0340
C* P50P40 = PRIMARY-TO-SECONDARY STAGNATION PRESSURE RATIO CAEOS 0350
C* P7P40 = SUBSONIC DIFFUSER EXIT STATIC-TO-SECONDARY STAGNATION CAEOS 0360
C* PRESSURE RATIO CAEOS 0370
C* T50T40 = PRIMARY-TO-SECONDARY STAGNATION TEMPERATURE RATIO CAEOS 0380
C* CAEOS 0390
C* OUTPUT VARIABLES: CAEOS 0400
C* CAEOS 0410
C* A6A5 = MIXING TUBE-TO-PRIMARY NOZZLE EXIT AREA RATIO CAEOS 0420
C* ETA67 = SUBSONIC DIFFUSER COEFFICIENT CAEOS 0430
C* FAIL = ERROR FLAG CAEOS 0440
C* GM = MIXED STREAM GAMMA CAEOS 0450
C* MWMMWP = MIXED STREAM-TO-PRIMARY MOLECULAR WEIGHT RATIO CAEOS 0460
C* M4 = SECONDARY MACH NO. AT THE MIXING TUBE ENTRANCE CAEOS 0470
C* M5 = PRIMARY MACH NO. AT THE MIXING TUBE ENTRANCE CAEOS 0480
C* M6 = MIXED STREAM MACH NO. AT THE MIXING TUBE EXIT CAEOS 0490
C* M7 = MACH NO. AT THE SUBSONIC DIFFUSER EXIT CAEOS 0500
C* P5P4 = PRIMARY-TO-SECONDARY STATIC PRESSURE RATIO CAEOS 0510
C* P6P5 = MIXED STREAM-TO-PRIMARY STATIC PRESSURE RATIO CAEOS 0520
C* P60P50 = MIXED STREAM-TO-PRIMARY STAGNATION PRESSURE RATIO CAEOS 0530
C* P7P6 = SUBSONIC DIFFUSER EXIT-TO-ENTRANCE STATIC PRESSURE RATIO CAEOS 0540
C* P70P60 = SUBSONIC DIFFUSER EXIT-TO-ENTRANCE STAGNATION PRESSURE CAEOS 0550
C* RATIO CAEOS 0560
C* T5T4 = PRIMARY-TO-SECONDARY STATIC TEMPERATURE RATIO CAEOS 0570
C* T6T5 = MIXED STREAM-TO-PRIMARY STATIC TEMPERATURE RATIO CAEOS 0580
C* T6 T50 = MIXED STREAM-TO-PRIMARY STAGNATION TEMPERATURE RATIO CAEOS 0590
C* T7T6 = SUBSONIC DIFFUSER EXIT-TO-ENTRANCE STATIC TEMPERATURE CAEOS 0600
C* RATIO CAEOS 0610
C* T70T60 = SUBSONIC DIFFUSER EXIT-TO-ENTRANCE STAGNATION TEMPERATURE CAEOS 0620
C* RATIO CAEOS 0630
C* WPWS = PRIMARY-TO-SECONDARY MASS FLOW RATIO CAEOS 0640

```

```

C* .....*CAEOS 0650
C .....*CAEOS 0660
C .....CAEOS 0670
C .....CAEOS 0680
C      IMPLICIT REAL(M) .....CAEOS 0690
C      REAL NO .....CAEOS 0700
C      DATA NO/2HNO/,SUR/3HSUR/,YES/3HYES/ .....CAEOS 0710
C .....CAEOS 0720
C .....CAEOS 0730
C .....CAEOS 0740
C .....*CAEOS 0750
C .....*CAEOS 0760
C .....*CAEOS 0770
C .....*CAEOS 0780
C .....CAEOS 0790
C .....CAEOS 0800
C      TOTM(G,M)=1.0+0.5*(G-1.0)*M*M .....CAEOS 0810
C      POPM(G,M)=TOTM(G,M)**(G/(G-1.0)) .....CAEOS 0820
C .....CAEOS 0830
C .....CAEOS 0840
C .....*CAEOS 0850
C .....*CAEOS 0860
C .....*CAEOS 0870
C .....*CAEOS 0880
C .....*CAEOS 0890
C .....CAEOS 0900
C .....CAEOS 0910
C      MWSMWP=1.0/MWPMWS .....CAEOS 0920
C      T40T50=1.0/T50T40 .....CAEOS 0930
C      NTYPE1=1 .....CAEOS 0940
C      NIT1=1 .....CAEOS 0950
C      M4=1.0 .....CAEOS 0960
C      DO 110 ITER1=1,1000 .....CAEOS 0970
C .....CAEOS 0980
C .....CAEOS 0990
C .....*CAEOS 1000
C .....*CAEOS 1010
C .....*CAEOS 1020
C .....*CAEOS 1030
C .....*CAEOS 1040
C .....CAEOS 1050
C .....CAEOS 1060
C .....CAEOS 1070
C .....CAEOS 1080
C .....CAEOS 1090
C .....CAEOS 1100
C .....CAEOS 1110
C .....CAEOS 1120
C .....*CAEOS 1130
C .....*CAEOS 1140
C .....*CAEOS 1150
C .....*CAEOS 1160
C .....*CAEOS 1170
C .....CAEOS 1180
C .....CAEOS 1190

```

NTYPE3=1	CAEOS	1200
NIT3=1	CAEOS	1210
M5=1.01	CAEOS	1220
DO 106 ITER3=1,1000	CAEOS	1230
C	CAEOS	1240
C	CAEOS	1250
C*****	CAEOS	1260
C*	*CAEOS	1270
C*	*CAEOS	1280
C*	*CAEOS	1290
C*****	CAEOS	1300
C	CAEOS	1310
C	CAEOS	1320
A6A6=1.0/A6A5	CAEOS	1330
IF(M4,NE.1.0) GO TO 101	CAEOS	1340
P4P5=1.0	CAEOS	1350
GO TO 102	CAEOS	1360
101 CALL CAFFC(GS,GP,M4,M5,A5A6,P4P5,FAIL)	CAEOS	1370
IF(FAIL,EQ.YES) GO TO 112	CAEOS	1380
IF(FAIL,NE.NO) GO TO 103	CAEOS	1390
102 CALL CAEOCV(GS,GP,MWSMWP,T40T50,M4,M5,A5A6,P4P5,SUR,WSWP,GM,	CAEOS	1400
-MWSMWP,T40T50,M6,XP50P40,P6P40,P4P5,FAIL)	CAEOS	1410
IF(FAIL,EQ.YES) GO TO 113	CAEOS	1420
IF(FAIL,EQ.NO) GO TO 105	CAEOS	1430
C	CAEOS	1440
C	CAEOS	1450
C*****	CAEOS	1460
C*	*CAEOS	1470
C*	*CAEOS	1480
C*	*CAEOS	1490
C*	*CAEOS	1500
C*****	CAEOS	1510
C	CAEOS	1520
C	CAEOS	1530
103 M5=M5+0.5	CAEOS	1540
IF(M5,GT.10.0) GO TO 104	CAEOS	1550
FAIL=NO	CAEOS	1560
GO TO 106	CAEOS	1570
C	CAEOS	1580
C	CAEOS	1590
C*****	CAEOS	1600
C*	*CAEOS	1610
C*	*CAEOS	1620
C*	*CAEOS	1630
C*	*CAEOS	1640
C*****	CAEOS	1650
C	CAEOS	1660
C	CAEOS	1670
104 A6A5=A6A5-0.5	CAEOS	1680
IF(A6A5,LE.1.0) GO TO 109	CAEOS	1690
FAIL=NO	CAEOS	1700
GO TO 108	CAEOS	1710
C	CAEOS	1720
C	CAEOS	1730
C*****	CAEOS	1740

C*		*CAEOS	1750
C*	CALCULATIONS FOR SUBSONIC DIFFUSER	*CAEOS	1760
C*		*CAEOS	1770
C*****		*CAEOS	1780
C		CAEOS	1790
C		CAEOS	1800
105	CALL SDS(GM,M6,A7A6,M7,P7P6,P70P60,T7T6,T70T60,ETA67,FAIL)	CAEOS	1810
	IF(FAIL,EQ.YES) GO TO 114	CAEOS	1820
	XP7P40=P7P6*P6P40	CAEOS	1830
C		CAEOS	1840
C		CAEOS	1850
C*****		CAEOS	1860
C*	TEST FOR XP7P40=P7P40 AND INCREMENT M5	*CAEOS	1870
C*		*CAEOS	1880
C*		*CAEOS	1890
C*****		CAEOS	1900
C		CAEOS	1910
C		CAEOS	1920
	CALL ITER(M5,0.5,5.0E-06,-1.0,XP7P40,P7P40,1.0E-01,NIT3,NTYPE3,	CAEOS	1930
	-XNE63,YNE63,XPOS3,YPOS3,NSIGN3,NSIGN4)	CAEOS	1940
	IF(NTYPE3,EQ.3) GO TO 107	CAEOS	1950
106	CONTINUE	CAEOS	1960
	GO TO 116	CAEOS	1970
C		CAEOS	1980
C		CAEOS	1990
C*****		CAEOS	2000
C*	TEST FOR XP50P40=P50P40 AND INCREMENT A6A5	*CAEOS	2010
C*		*CAEOS	2020
C*		*CAEOS	2030
C*****		CAEOS	2040
C		CAEOS	2050
C		CAEOS	2060
107	CALL ITER(A6A5,0.5,5.0E-06,-1.0,XP50P40,P50P40,1.0E-01,NIT2,	CAEOS	2070
	-NTYPE2,XNE62,YNE62,XPOS2,YPOS2,NSIGN1,NSIGN2)	CAEOS	2080
	IF(NTYPE2,EQ.3) GO TO 109	CAEOS	2090
108	CONTINUE	CAEOS	2100
	GO TO 117	CAEOS	2110
C		CAEOS	2120
C		CAEOS	2130
C*****		CAEOS	2140
C*		*CAEOS	2150
C*	IF NO CAE SOLUTION EXISTS FOR CURRENT VALUE OF M4, INCREMENT M4 AND	*CAEOS	2160
C*	SEARCH FOR SOLUTION. IF SOLUTION FOUND, TEST FOR MINIMUM XWPWS AND	*CAEOS	2170
C*	INCREMENT M4.	*CAEOS	2180
C*		*CAEOS	2190
C*****		CAEOS	2200
C		CAEOS	2210
C		CAEOS	2220
109	XWPWS=1.0/WSWP	CAEOS	2230
	CALL MIN(M4,XWPWS,NTYPE1,NIT1,FAIL)	CAEOS	2240
	IF(FAIL,EQ.YES) GO TO 115	CAEOS	2250
	IF(NTYPE1,EQ.4) GO TO 111	CAEOS	2260
110	CONTINUE	CAEOS	2270
	GO TO 118	CAEOS	2280
111	WPWS=XWPWS	CAEOS	2290

P5P4=1.0/P4P5	CAEOS	2300
P60P50=P6P5*P0PM(GM,M6)/P0PM(OP,M5)	CAEOS	2310
T5T4=T50T40*T0TM(GS,M4)/T0TM(OP,M5)	CAEOS	2320
T6T5=T60T50*T0TM(OP,M5)/T0TM(GM,M4)	CAEOS	2330
RETURN	CAEOS	2340
C	CAEOS	2350
C	CAEOS	2360
C.....	CAEOS	2370
C*	*CAEOS	2380
C>	*CAEOS	2390
C*	*CAEOS	2400
C.....	CAEOS	2410
C	CAEOS	2420
C	CAEOS	2430
112 WRITE(6,201)	CAEOS	2440
RETURN	CAEOS	2450
113 WRITE(6,202)	CAEOS	2460
RETURN	CAEOS	2470
114 WRITE(6,203)	CAEOS	2480
RETURN	CAEOS	2490
115 WRITE(6,204)	CAEOS	2500
RETURN	CAEOS	2510
116 WRITE(6,205)M4,A6A5,M5,XP7P40,P7P40	CAEOS	2520
GO TO 119	CAEOS	2530
117 WRITE(6,206)M4,M5,A6A5,XP50P40,P50P40	CAEOS	2540
GO TO 119	CAEOS	2550
118 WRITE(6,207)M5,A6A5,M4,XWPWS	CAEOS	2560
119 FAIL=YES	CAEOS	2570
C	CAEOS	2580
C	CAEOS	2590
C.....	CAEOS	2600
C*	*CAEOS	2610
C*	*CAEOS	2620
C*	*CAEOS	2630
C.....	CAEOS	2640
C	CAEOS	2650
C	CAEOS	2660
201 FORMAT(00,T2,PROGRAM TERMINATED IN SUBROUTINE CAEFC,/,	CAEOS	2670
-T2,AS CALLED FROM SUBROUTINE CAEOS*)	CAEOS	2680
202 FORMAT(00,T2,PROGRAM TERMINATED IN SUBROUTINE CAEOCV,/,	CAEOS	2690
-T2,AS CALLED FROM SUBROUTINE CAEOS*)	CAEOS	2700
203 FORMAT(00,T2,PROGRAM TERMINATED IN SUBROUTINE SDS,/,	CAEOS	2710
-T2,AS CALLED FROM SUBROUTINE CAEOS*)	CAEOS	2720
204 FORMAT(00,T2,PROGRAM TERMINATED IN SUBROUTINE MIN,/,	CAEOS	2730
-T2,AS CALLED FROM SUBROUTINE CAEOS*)	CAEOS	2740
205 FORMAT(00,T2,CONVERGENCE FAILURE IN SUBROUTINE CAFOS,/,	CAEOS	2750
-T2,FOR M5 SUCH THAT XP7P40=P7P40,/,	CAEOS	2760
-T2,M4 =,E13.6,T26,A6A5 =,E13.6,/,	CAEOS	2770
-T2,M5 =,E13.6,T26,XP7P40 =,E13.5,/,	CAEOS	2780
-T2,P7P40 =,E13.6)	CAEOS	2790
206 FORMAT(00,T2,CONVERGENCE FAILURE IN SUBROUTINE CAFOS,/,	CAEOS	2800
-T2,FOR A6A5 SUCH THAT XP50P40=P50P40,/,	CAEOS	2810
-T2,M4 =,E13.6,T26,M5 =,E13.6,/,	CAEOS	2820
-T2,A6A5 =,E13.6,T26,XP50P40 =,E13.5,/,	CAEOS	2830
-T2,P50P40 =,E13.6)	CAEOS	2840

APPENDIX D
SUBROUTINE CAEOS

CHEMICAL LASER ANALYSIS PROGRAM (CLAP)
OVERLAY PRS

PAGE'D-18

```

207  FORMAT(*0*,T2,*CONVERGENCE FAILURE IN SUBROUTINE CAEOS*,/,
      -T2,*FOR M4 SUCH THAT XWPMS = MINIMUM WPMS*,//,
      -T2,*M5      =*,E13.6,T26,*A6A5  =*,E13.6,/,
      -T2,*M4      =*,E13.6,T26,*XWPMS  =*,F13.6)
      END

```

```

CAEOS 2850
CAEOS 2860
CAEOS 2870
CAEOS 2880
CAEOS 2890

```

```

SUBROUTINE INPRS
C
C
C.....INPRS 0100
C.....INPRS 0110
C.....INPRS 0120
C.....INPRS 0130
C*.....INPRS 0140
C*          INPUT SUBROUTINE (INPRS)
C*.....INPRS 0150
C*.....INPRS 0160
C*.....INPRS 0170
C.....INPRS 0180
C.....INPRS 0190
C*.....INPRS 0200
C* SURROUTINE INPRS CONTROLS THE INPUT OF INITIAL DATA FOR THE
C* PRESSURE RECOVERY SECTION.
C*.....INPRS 0210
C*.....INPRS 0220
C*.....INPRS 0230
C* INPUT/OUTPUT VARIABLES:
C*.....INPRS 0240
C*.....INPRS 0250
C* A3A2  = SUBSONIC DIFFUSER EXIT-TO-ENTRANCE AREA RATIO
C* A7A6  = SUBSONIC DIFFUSER EXIT-TO-ENTRANCE AREA RATIO
C* EJECT = CONTROL VARIABLE SUCH THAT:
C*        = "NO" FOR NO PRESSURE RECOVERY SUBSYSTEM
C*        = "DIF" FOR A SUPERSONIC-SUBSONIC DIFFUSER SUBSYSTEM
C*        = "CAE" FOR A CONSTANT-AREA, SUBSONIC-SUPERSONIC EJECTOR
C*        = "SSE" FOR A CONSTANT-AREA, SUPERSONIC-SUPERSONIC EJECTOR
C*        = "SSE" FOR A CONSTANT-AREA, SUPERSONIC-SUPERSONIC EJECTOR
C*        = "SSE" FOR A CONSTANT-AREA, SUPERSONIC-SUPERSONIC EJECTOR
C*.....INPRS 0300
C*.....INPRS 0310
C*.....INPRS 0320
C*.....INPRS 0330
C*.....INPRS 0340
C*.....INPRS 0350
C*.....INPRS 0360
C*.....INPRS 0370
C*.....INPRS 0380
C*.....INPRS 0390
C*.....INPRS 0400
C*.....INPRS 0410
C*.....INPRS 0420
C*.....INPRS 0430
C*.....INPRS 0440
C*.....INPRS 0450
C*.....INPRS 0460
C*.....INPRS 0470
C*.....INPRS 0480
C*.....INPRS 0490
C*.....INPRS 0500
C.....INPRS 0510
C.....INPRS 0520
C.....INPRS 0530
C.....INPRS 0540
C.....INPRS 0550
C.....INPRS 0560
C.....INPRS 0570
C.....INPRS 0580
C.....INPRS 0590
C.....INPRS 0600
C.....INPRS 0610
C.....INPRS 0620
C.....INPRS 0630
C.....INPRS 0640
C
C
C      IMPLICIT REAL (L,M,N)
C
C      COMMON/MAINS/SETPRS
C
C      COMMON/PRS1/PRSS1
C
C      COMMON/PRS3/A3A2,A7A6,ETA12,LIMIT,MW5,P7,T50
C
C      COMMON/PRS5/EJECT
C
C      COMMON/PRS6/G5,P50

```

	DATA CAE/3MCAE/,NO/2MNO/,SSE/3MSSE/	INPRS 0650
C		INPRS 0660
	NAMLIST/NLPRS/A3A2,A7A6,ETA12,05,MW5,P50,P7,T50	INPRS 0670
C		INPRS 0680
C		INPRS 0690
C	.....	INPRS 0700
C*		*INPRS 0710
C*	SET DEFAULT VALUES	*INPRS 0720
C*		*INPRS 0730
C	.....	INPRS 0740
C		INPRS 0750
C		INPRS 0760
	IF(SETPRS.EQ.NO) GO TO 101	INPRS 0770
	A3A2=3.0	INPRS 0780
	A7A6=3.0	INPRS 0790
	EJECT=CAE	INPRS 0800
	ETA12=0.75	INPRS 0810
	05=1.29	INPRS 0820
	LIMIT=3MZSP	INPRS 0830
	MW5=20.204	INPRS 0840
	P50=3.10264E+06	INPRS 0850
	P7=1.01325E+05	INPRS 0860
	T50=2.8148E+03	INPRS 0870
	SETPRS=NO	INPRS 0880
C		INPRS 0890
C		INPRS 0900
C	.....	INPRS 0910
C*		*INPRS 0920
C*	CONTROL STATEMENTS	*INPRS 0930
C*		*INPRS 0940
C	.....	INPRS 0950
C		INPRS 0960
C		INPRS 0970
101	WRITE(6,201)	INPRS 0980
	READ(5,202)PRSS1	INPRS 0990
	IF(PRSS1.EQ.NO) RETURN	INPRS 1000
	WRITE(6,203)	INPRS 1010
	READ(5,202)PRSS2	INPRS 1020
	IF(PRSS2.EQ.NO) GO TO 102	INPRS 1030
	REWIND 3	INPRS 1040
	READ(3)A3A2,A7A6,EJECT,ETA12,05,LIMIT,MW5,P50,P7,T50	INPRS 1050
	RETURN	INPRS 1060
102	WRITE(6,204)	INPRS 1070
	READ(5,202)EJECT	INPRS 1080
	IF(EJECT.EQ.NO) RETURN	INPRS 1090
	IF(EJECT.EQ.CAE) GO TO 103	INPRS 1100
	IF(EJECT.EQ.SSE) GO TO 104	INPRS 1110
	WRITE(6,205)	INPRS 1120
	WRITE(6,206)A3A2,ETA12	INPRS 1130
	GO TO 105	INPRS 1140
103	WRITE(6,207)A3A2,A7A6,ETA12,05,MW5,P50,P7,T50	INPRS 1150
	GO TO 105	INPRS 1160
104	WRITE(6,208)	INPRS 1170
	READ(5,202)LIMIT	INPRS 1180
		INPRS 1190

```

WRITE(6,205)                                INPRS 1200
WRITE(6,209)A7A6,05,MW5,P50,P7,T50          INPRS 1210
105 READ(7,NLPRS)                             INPRS 1220
REWIND 3                                       INPRS 1230
WRITE(3)A3A2,A7A6,EJECT,ETA12,05,LIMIT,MW5,P50,P7,T50 INPRS 1240
C                                              INPRS 1250
C                                              INPRS 1260
C*****INPRS 1270
C*                                           INPRS 1280
C*           FORMAT STATEMENTS              INPRS 1290
C*                                           INPRS 1300
C*****INPRS 1310
C                                              INPRS 1320
C                                              INPRS 1330
201  FORMAT(*1,T2,*ARE NEW PRESSURE RECOVERY SECTION INPUTS REQUIRED? INPRS 1340
    -//)                                       INPRS 1350
202  FORMAT(A3)                               INPRS 1360
203  FORMAT(*0,T2,*SHOULD INPUT DATA BE READ FROM TAPE3?//) INPRS 1370
204  FORMAT(*1,T2,*INPUT THE PRESSURE RECOVERY SUBSYSTEM FROM THE FOLLOWING INPRS 1380
    LIST:*,//,T2,*NONE FOR NO PRESSURE RECOVERY SUBSYSTEM*,//,T2,INPRS 1390
    -,*DIF* FOR A SUPERSONIC-SUBSONIC DIFFUSER SUBSYSTEM*,//,T2,*CAE* INPRS 1400
    -FOR A CONSTANT-AREA, SUBSONIC-SUPERSONIC EJECTOR SUBSYSTEM*,//,T2,*INPRS 1410
    -*SSE* FOR A CONSTANT-AREA, SUPERSONIC-SUPERSONIC EJECTOR SUBSYSTEMINPRS 1420
    -//)                                       INPRS 1430
205  FORMAT(*1,T2,*INPUT DATA FOR THE PRESSURE RECOVERY SECTION BY NAMEINPRS 1440
    -ELIST*,//,T2,*CURRENT VALUES ARE:*)   INPRS 1450
206  FORMAT(* ,T2,*SNLPRS*,T26,*A3A2      **,E13.6,T50,*ETA12  **, INPRS 1460
    -E13.6,* S*,//)                          INPRS 1470
207  FORMAT(* ,T2,*SNLPRS*,T26,*A3A2      **,E13.6,T50,*A7A6   **, INPRS 1480
    -E13.6,/,T2,*ETA12  **,E13.6,T26,*05      **,E13.6,T50, INPRS 1490
    -*MW5      **,E13.6,/,T2,*P50      **,E13.6,T26,*P7      **,E13.6, INPRS 1500
    -T50,*T50      **,E13.6,* S*,//)        INPRS 1510
208  FORMAT(*1,T2,*INPUT THE LIMITING CONDITION FOR THE SUPERSONIC-SUPERSONIC INPRS 1520
    EJECTOR FROM THE*,//,T2,*FOLLOWING LIST:*,//,T2,*NONE* FOR INPRS 1530
    -THE UPPER LIMIT POINT*,//,T2,*ZSP* FOR THE ZUKOSKI SEPARATION POINTINPRS 1540
    -*,//,T2,*MPP* FOR THE MATCHED PRESSURE POINT*,//) INPRS 1550
209  FORMAT(* ,T2,*SNLPRS*,T26,*A7A6      **,E13.6,T50,*05      **, INPRS 1560
    -E13.6,/,T2,*MW5      **,E13.6,T26,*P50      **,E13.6,T50, INPRS 1570
    -*P7      **,E13.6,/,T2,*T50      **,E13.6,* S*,//) INPRS 1580
    END                                         INPRS 1590

```


APPENDIX D
SUBROUTINE ITER

CHEMICAL LASER ANALYSIS PROGRAM (CLAP)
OVERLAY PR3

PAGE D-23

C	ITER	0650
C	ITER	0660
C.....	ITER	0670
C*	*ITER	0680
C*	*ITER	0690
C*	*ITER	0700
C.....	ITER	0710
C	ITER	0720
C	ITER	0730
X=X*SIGN*DX	ITER	0740
GO TO 100	ITER	0750
C	ITER	0760
C	ITER	0770
C.....	ITER	0780
C*	*ITER	0790
C*	*ITER	0800
C*	*ITER	0810
C.....	ITER	0820
C	ITER	0830
C	ITER	0840
90 NTYPE=2	ITER	0850
NIT=NIT+1	ITER	0860
XSAVE=X	ITER	0870
RATIO=(XPOS-XNEG)/(YPOS-YNEG)	ITER	0880
X=XNEG+RATIO*(Y0IVFN-YNEG)	ITER	0890
IF(ABS(ERROR(X,XSAVE))-ERRORX) 90,90,100	ITER	0900
90 NTYPE=3	ITER	0910
100 END	ITER	0920

```

      SUBROUTINE MAAS(G,MINI,AAS,FLOW,ERROR,MNEW,FAIL)
      MAAS 0100
      C
      MAAS 0110
      C
      MAAS 0120
      C.....MAAS 0130
      C*
      MAAS 0140
      C*
      SUBROUTINE (MAAS)
      MAAS 0150
      C*
      MAAS 0160
      C.....MAAS 0170
      C
      MAAS 0180
      C.....MAAS 0190
      C*
      MAAS 0200
      C* SUBROUTINE MASS CALCULATES THE MACH NUMBER (M) GIVEN THE AREA RATIO
      MAAS 0210
      C* (A/A*) BY LINEAR ITERATION.
      MAAS 0220
      C*
      MAAS 0230
      C* INPUT VARIABLES:
      MAAS 0240
      C*
      MAAS 0250
      C* AAS = THE AREA RATIO A/A*
      MAAS 0260
      C* ERROR = MAX PERCENT DEVIATION IN MOLD AND MNEW FOR A SOLUTION
      MAAS 0270
      C* FLOW = CONTROL VARIABLE SUCH THAT:
      MAAS 0280
      C* = "SUB" FOR THE SUBSONIC BRANCH
      MAAS 0290
      C* = "SUP" FOR THE SUPERSONIC BRANCH
      MAAS 0300
      C* G = SPECIFIC HEAT RATIO
      MAAS 0310
      C* MINI = INITIAL VALUE OF MACH NUMBER
      MAAS 0320
      C*
      MAAS 0330
      C* OUTPUT VARIABLES:
      MAAS 0340
      C*
      MAAS 0350
      C* FAIL = ERROR FLAG
      MAAS 0360
      C* MNEW = FINAL VALUE OF MACH NUMBER
      MAAS 0370
      C*
      MAAS 0380
      C.....MAAS 0390
      C
      MAAS 0400
      C
      MAAS 0410
      IMPLICIT REAL(M)
      MAAS 0420
      DATA YES/3HYES/,SUP/3HSUP/
      MAAS 0430
      C
      MAAS 0440
      C
      MAAS 0450
      C.....MAAS 0460
      C*
      MAAS 0470
      C*
      CALCULATE CONSTANTS
      MAAS 0480
      C*
      MAAS 0490
      C.....MAAS 0500
      C
      MAAS 0510
      C
      MAAS 0520
      G1=(G-1.0)/2.0
      MAAS 0530
      G1I=1.0/G1
      MAAS 0540
      G2=2.0/(G+1.0)
      MAAS 0550
      G2I=1.0/G2
      MAAS 0560
      G4=(G+1.0)/(2.0*(G-1.0))
      MAAS 0570
      G4I=1.0/G4
      MAAS 0580
      C
      MAAS 0590
      C
      MAAS 0600
      C.....MAAS 0610
      C*
      MAAS 0620
      C*
      CALCULATE THE SUPERSONIC BRANCH
      MAAS 0630
      C*
      MAAS 0640

```


C.....	MAAS	0650
C	MAAS	0660
C	MAAS	0670
MOLD=MINT	MAAS	0680
IF (FLOW,NE,SUP) GO TO 2	MAAS	0690
DO 1 J=1,200	MAAS	0700
C1=(MOLD+AAS)**0.41	MAAS	0710
MNEW=SQRT(0.1*(0.21*C1-1.0))	MAAS	0720
XERROR=(MNEW-MOLD)*100.0/MOLD	MAAS	0730
MOLD=MNEW	MAAS	0740
IF (ABS(XERROR).LT.ERROR) RETURN	MAAS	0750
1 CONTINUE	MAAS	0760
GO TO 4	MAAS	0770
C	MAAS	0780
C	MAAS	0790
C.....	MAAS	0800
C*	MAAS	0810
CALCULATE THE SUBSONIC BRANCH	MAAS	0820
C*	MAAS	0830
C.....	MAAS	0840
C	MAAS	0850
C	MAAS	0860
2 DO 3 J=1,200	MAAS	0870
C1=1.0*0.1*MOLD*MOLD	MAAS	0880
MNEW=((0.2*C1)**0.4)/AAS	MAAS	0890
XERROR=(MNEW-MOLD)*100.0/MOLD	MAAS	0900
MOLD=MNEW	MAAS	0910
IF (ABS(XERROR).LT.ERROR) RETURN	MAAS	0920
3 CONTINUE	MAAS	0930
C	MAAS	0940
C	MAAS	0950
C.....	MAAS	0960
C*	MAAS	0970
CONVERGENCE FAILURE	MAAS	0980
C*	MAAS	0990
C.....	MAAS	1000
C	MAAS	1010
C	MAAS	1020
4 WRITE(6,5)FLOW,0,MINT,MNEW,AAS,XERROR,ERROR	MAAS	1030
FAIL=YES	MAAS	1040
4 FORMAT(*1*,T2,*CONVERGENCE FAILURE FOR *.A3,*SONIC *,	MAAS	1050
-0BRANCH IN SUBROUTINE MAAS*,/,	MAAS	1060
-T2,*0 =*,E13.6,2X,*MINT =*,E13.6,/,	MAAS	1070
-T2,*MNEW =*,E13.6,2X,*AAS =*,E13.6,/,	MAAS	1080
-T2,*XERROR =*,E13.6,2X,*ERROR =*,E13.6)	MAAS	1090
END	MAAS	1100

```

SUBROUTINE MIN(MS1,FUNC,NTYPE,NIT,FAIL)
C
C
C.....
C*
C*      MINIMIZATION SUBROUTINE (MIN)
C*
C*.....
C*
C* SUBROUTINE MIN, AS APPLIED TO A CONSTANT-AREA, SUBSONIC-SUPERSONIC
C* EJECTOR, PERFORMS A SEARCH AND INTERVAL HALVING PROCEDURE TO FIND
C* MS1 SUCH THAT FUNC(MS1) IS A MINIMUM.
C*
C* INPUT VARIABLES:
C*
C* FUNC = FUNCTION OF MS1
C*
C* INPUT/OUTPUT VARIABLES:
C*
C* MS1 = SECONDARY MACH NO. AT THE MIXING TUBE ENTRANCE
C* NIT = ITERATION NUMBER
C* NTYPE = 1.2 - SEARCH
C*        = 3.4 - SOLUTION
C*
C* OUTPUT VARIABLES:
C*
C* FAIL = ERROR FLAG
C*
C.....
C
C      IMPLICIT REAL(M)
C      REAL NO
C      DATA DX,XLOW,XERROR,YERROR/0.1,1.0E-03,0.025,1.0/
C      DATA YFS/3HYES/,NO/2HNO/,PART/4MPART/
C
C      ERROR(ACTUAL,GIVEN)=(ACTUAL-GIVEN)*100.0/GIVEN
C
C
C.....
C*
C*      NO CASE SOLUTION EXISTS FOR CURRENT VALUE OF
C*      MS1. INCREMENT MS1 AND SEARCH FOR SOLUTION.
C*
C*.....
C
C      IF(FAIL.NE.PART) GO TO 100
C      MS1=MS1-XERROR
C      IF(MS1.LT.XLOW) GO TO 10A
C      FAIL=NO
C      RETURN
100  IF(NIT.NE.1) GO TO 101

```

	DMS1=DX	MIN	0650
	MS1LOW=XLOW	MIN	0660
101	NIT=NIT+1	MIN	0670
	GO TO (102,104,107),NTYPE	MIN	0680
C		MIN	0690
C		MIN	0700
C	.....	MIN	0710
C*		*MIN	0720
C*	STORE UPPER BOUND FOR MS1	*MIN	0730
C*		*MIN	0740
C	.....	MIN	0750
C		MIN	0760
C		MIN	0770
102	X1=MS1	MIN	0780
	Y1=FUNC	MIN	0790
103	MS1=MS1-DMS1	MIN	0800
	IF (MS1.LT,MS1LOW) GO TO 108	MIN	0810
	NTYPE=2	MIN	0820
	RETURN	MIN	0830
C		MIN	0840
C		MIN	0850
C	.....	MIN	0860
C*		*MIN	0870
C*	STORE LOWER BOUND FOR MS1	*MIN	0880
C*		*MIN	0890
C	.....	MIN	0900
C		MIN	0910
C		MIN	0920
104	X2=MS1	MIN	0930
	Y2=FUNC	MIN	0940
	IF (Y2.GT,Y1) GO TO 105	MIN	0950
	GO TO 102	MIN	0960
C		MIN	0970
C		MIN	0980
C	.....	MIN	0990
C*		*MIN	1000
C*	TEST FUNC FOR MINIMUM AND INTERVAL HALVE	*MIN	1010
C*		*MIN	1020
C	.....	MIN	1030
C		MIN	1040
C		MIN	1050
105	IF (ABS(ERROR(Y2,Y1)).LE,YERROR) GO TO 106	MIN	1060
	DMS1=DMS1/2.0	MIN	1070
	IF (DMS1.LT,XERROR) GO TO 106	MIN	1080
	MS1LOW=X2	MIN	1090
	MS1=X1	MIN	1100
	GO TO 103	MIN	1110
C		MIN	1120
C		MIN	1130
C	.....	MIN	1140
C*		*MIN	1150
C*	MS1 FOR MIN FUNC HAS BEEN FOUND BUT SOLUTION WAS LOST	*MIN	1160
C*		*MIN	1170
C	.....	MIN	1180
C		MIN	1190

C		MIN	1200
106	IF(Y2,LF,Y1) GO TO 107	MIN	1210
	MS1=X1	MIN	1220
	NTYPE=1	MIN	1230
	RETURN	MIN	1240
C		MIN	1250
C		MIN	1260
C	.....	MIN	1270
C*		MIN	1280
C*	MS1 FOR MIN FUNC HAS BEEN FOUND AND SOLUTION SAVED	MIN	1290
C*		MIN	1300
C	.....	MIN	1310
C		MIN	1320
C		MIN	1330
107	NTYPE=4	MIN	1340
	RETURN	MIN	1350
C		MIN	1360
C		MIN	1370
C	.....	MIN	1380
C*		MIN	1390
C*	SEARCH FAILURE: NO CAE SOLUTION FOUND	MIN	1400
C*		MIN	1410
C	.....	MIN	1420
C		MIN	1430
C		MIN	1440
108	WRITE(A,201)MS1,MS1LOW,DMS1	MIN	1450
	FAIL=YES	MIN	1460
C		MIN	1470
C		MIN	1480
C	.....	MIN	1490
C*		MIN	1500
C*	FORMAT STATEMENTS	MIN	1510
C*		MIN	1520
C	.....	MIN	1530
C		MIN	1540
C		MIN	1550
201	FORMAT(11.2,1MS1 =,E13.6,2X,1BELOW LOWER LIMIT MS1 =, -E13.6,1.2,1FOR DMS1 =,E13.6) END	MIN	1560
		MIN	1570
		MIN	1580

```

      SURROUTINE NSDS(G,M1,RD,M2,P2P1,P2OP10,T2T1,T2OT10)
C
C
C.....
C*
C*          NORMAL SHOCK DIFFUSER SUBROUTINE (NSDS)
C*
C*.....
C
C.....
C*
C* SUBROUTINE NSDS CALCULATES THE PRESSURE RATIO ACROSS A CONSTANT-
C* AREA, SUPERSONIC DIFFUSER. THE STATIC PRESSURE RATIO IS TAKEN AS
C* RD*(PY/PX) FOR A NORMAL SHOCK AT THE ENTERING MACH NUMBER. ALL
C* OTHER PROPERTIES ARE CALCULATED FROM THE ISENTROPIC FLOW RELATIONS
C* TO BE CONSISTENT WITH THE ENTRANCE AND EXIT MACH NUMBERS.
C*
C* INPUT VARIABLES:
C*
C* G      = GAMMA
C* M1     = ENTRANCE MACH NUMBER
C* RD     = NORMAL SHOCK DIFFUSER COEFFICIENT
C*
C* OUTPUT VARIABLES:
C*
C* M2     = EXIT MACH NUMBER
C* P2P1   = EXIT-TO-ENTRANCE STATIC PRESSURE RATIO
C* P2OP10 = EXIT-TO-ENTRANCE STAGNATION PRESSURE RATIO
C* T2T1   = EXIT-TO-ENTRANCE STATIC TEMPERATURE RATIO
C* T2OT10 = EXIT-TO-ENTRANCE STAGNATION TEMPERATURE RATIO
C*
C.....
C
C          IMPLICIT REAL(M)
C
      TOTM(GX,MX)=1.0+0.5*(GX-1.0)*MX*MX
      POPM(GX,MX)=(1.0+0.5*(GX-1.0)*MX*MX)**(GX/(GX-1.0))
C
      M2=SQRT((2.0+(G-1.0)*M1*M1)/(2.0+G*M1*M1-G*1.0))
      P2P1=RD*(2.0+G*M1*M1-G*1.0)/(G*1.0)
      P1OP1=POPM(G,M1)
      P2OP2=POPM(G,M2)
      P2OP10=P2OP2*P2P1/P1OP1
      T2OT10=1.0
      T1OT1=TOTM(G,M1)
      T2OT2=TOTM(G,M2)
      T2T1=T1OT1*T2OT10/T2OT2
      END

```

NSDS 0100
 NSDS 0110
 NSDS 0120
 NSDS 0130
 NSDS 0140
 NSDS 0150
 NSDS 0160
 NSDS 0170
 NSDS 0180
 NSDS 0190
 NSDS 0200
 NSDS 0210
 NSDS 0220
 NSDS 0230
 NSDS 0240
 NSDS 0250
 NSDS 0260
 NSDS 0270
 NSDS 0280
 NSDS 0290
 NSDS 0300
 NSDS 0310
 NSDS 0320
 NSDS 0330
 NSDS 0340
 NSDS 0350
 NSDS 0360
 NSDS 0370
 NSDS 0380
 NSDS 0390
 NSDS 0400
 NSDS 0410
 NSDS 0420
 NSDS 0430
 NSDS 0440
 NSDS 0450
 NSDS 0460
 NSDS 0470
 NSDS 0480
 NSDS 0490
 NSDS 0500
 NSDS 0510
 NSDS 0520
 NSDS 0530
 NSDS 0540
 NSDS 0550
 NSDS 0560
 NSDS 0570
 NSDS 0580

```

SUBROUTINE OUTPRS                                OUTPRS 0100
C                                                OUTPRS 0110
C                                                OUTPRS 0120
C.....OUTPRS 0130
C*                                                *OUTPRS 0140
C*                OUTPUT SUBROUTINE (OUTPRS)    *OUTPRS 0150
C*                                                *OUTPRS 0160
C.....OUTPRS 0170
C                                                OUTPRS 0180
C.....OUTPRS 0190
C*                                                *OUTPRS 0200
C* SUBROUTINE OUTPRS PRINTS THE PRESSURE RECOVERY SECTION RESULTS OF *OUTPRS 0210
C* PROGRAM CLAP IN SI UNITS ON TERMINALS WITH A MINIMUM OF 132 *OUTPRS 0220
C* CHARACTERS PER LINE, *OUTPRS 0230
C*                                                *OUTPRS 0240
C.....OUTPRS 0250
C                                                OUTPRS 0260
C                                                OUTPRS 0270
C                IMPLICIT REAL(L,M)              OUTPRS 0280
C                                                OUTPRS 0290
C                COMMON/LDS4/A1,G1,MW1,M1,P1,P10,R1,R10,T1,T10 OUTPRS 0300
C                                                OUTPRS 0310
C                COMMON/PRS2/A2,A3,A4,A7,ETA23,ETA67,G2,G3,G4,G6,G7,MW2,MW3,MW4, OUTPRS 0320
C                -MW6,MW7,M2,M3,M4,M6,M7,P2,P20,P3,P30,P4,P40,P5,P6,P60,P70,R2,R20, OUTPRS 0330
C                -R3,R30,R4,R40,R5,R50,P6,R60,R7,R70,T2,T20,T3,T30,T4,T40,T5,T6,T60, OUTPRS 0340
C                -T7,T70,W2W1,W3W1,W4W1,W4W1,W7W1,X2X1,X3X1,X4X1,X5X1,X6X1,X7X1 OUTPRS 0350
C                                                OUTPRS 0360
C                COMMON/PRS3/A3A2,A7A6,ETA12,LIMIT,MW5,P7,T50 OUTPRS 0370
C                                                OUTPRS 0380
C                COMMON/PRS4/A5,A6,M5,M5W1 OUTPRS 0390
C                                                OUTPRS 0400
C                COMMON/PRS4/EJECT OUTPRS 0410
C                                                OUTPRS 0420
C                COMMON/PRS6/G5,P50 OUTPRS 0430
C                                                OUTPRS 0440
C                DATA CAE/3HCAE/,MPP/3HMPP/,SSE/3HSSE/,ULP/3HULP/,ZSP/3HZSP/ OUTPRS 0450
C                                                OUTPRS 0460
C.....OUTPRS 0470
C*                                                *OUTPRS 0480
C*                OUTPUT INITIAL DATA *OUTPRS 0490
C*                                                *OUTPRS 0500
C*                                                *OUTPRS 0510
C.....OUTPRS 0520
C                                                OUTPRS 0530
C                                                OUTPRS 0540
C                WRITE(20,201) OUTPRS 0550
C                IF(FEJECT.EQ.CAE) GO TO 101 OUTPRS 0560
C                IF(EJECT.EQ.SSE) GO TO 102 OUTPRS 0570
C                WRITE(20,202)A3A2,EJECT,ETA12 OUTPRS 0580
C                WRITE(20,203) OUTPRS 0590
C                GO TO 103 OUTPRS 0600
101 WRITE(20,203)A3A2,A7A6,EJECT,ETA12,G5,MW5,P50,P7,T50 OUTPRS 0610
C                WRITE(20,205) OUTPRS 0620
C                GO TO 103 OUTPRS 0630
102 WRITE(20,204)A7A6,EJECT,G5,LIMIT,MW5,P50,P7,T50 OUTPRS 0640

```

```

WRITE(20,206)
C
C
C*****
C*
C*
C*
C*
C*****
C
C
C
103 WRITE(20,207)A1,G1,MW1,M1,P1,P10,R1,R10,T1,T10
    IF(EJECT.EQ.SSE) GO TO 104
    WRITE(20,208)A2,ETA12,G2,MW2,M2,P2,P20,R2,P20,T2,T20,M2W1,X2X1
    WRITE(20,209)
    IF(EJECT.EQ.CAE) WRITE(20,210)
    WRITE(20,211)A3,ET23,G3,MW3,M3,P3,P30,R3,R30,T3,T30,M3W1,X3X1
    IF(EJECT.NE.CAE) RETURN
    WRITE(20,212)A4,G4,MW4,M4,P4,P40,R4,R40,T4,T40,M4W1,X4X1
    WRITE(20,213)
    GO TO 105
104 IF(LIMIT.EQ.ULP) WRITE(20,214)
    IF(LIMIT.EQ.ZSP) WRITE(20,215)
    IF(LIMIT.EQ.MPP) WRITE(20,216)
    WRITE(20,217)
105 WRITE(20,218)A5,G5,MW5,M5,P5,P50,R5,R50,T5,T50,M5W1,X5X1
    IF(EJECT.EQ.CAE) WRITE(20,219)
    IF(EJECT.EQ.SSE) WRITE(20,220)
    WRITE(20,221)A6,G6,MW6,M6,P6,P60,R6,R60,T6,T60,M6W1,X6X1
    WRITE(20,222)A7,ETA67,G7,MW7,M7,P7,P70,R7,R70,T7,T70,M7W1,X7X1
C
C
C*****
C*
C*
C*
C*
C*****
C
C
C
201 FORMAT(10,T54,0PRESSURE RECOVERY SECTION,/,T60,0INITIAL DATA,/)
202 FORMAT(00,T32,0A3A2 00,E13.6,T66,0EJECT 00,A13,/,
    -T32,0ETA12 00,E13.6)
203 FORMAT(00,T32,0A3A2 00,E13.6,T66,0ATA6 00,E13.6,/,
    -T32,0EJECT 00,A13,T66,0ETA12 00,E13.6,/,
    -T32,0G5 00,E13.6,T66,0MW5 00,E13.6,0 KG/KMOLE,/,
    -T32,0P50 00,E13.6,0 PA, 66,0P7 00,E13.6,0 PA,/,
    -T32,0T50 00,E13.6,0 K)
204 FORMAT(00,T32,0ATA6 00,E13.6,T66,0EJECT 00,A13,/,
    -T32,0G5 00,E13.6,T66,0LIMIT 00,A13,/,
    -T32,0MW5 00,E13.6,0 KG/KMOLE,0T66,0P50 00,E13.6,0 PA,/,
    -T32,0P7 00,E13.6,0 PA,0T66,0T50 00,E13.6,0 K)
205 FORMAT(00,T09,0RESULTANT DATA,/,T93,0POINT 1 LASER CAVITY EXIT,
    -T AND NORMAL SHOCK DIFFUSER ENTRANCE,/)
206 FORMAT(00,T59,0RESULTANT DATA,/,T03,0POINT 1 LASER CAVITY EXIT,
    -T AND CONSTANT-AREA SUPERSONIC-SUPERSONIC EJECTOR,/,T32,0SECONDARY,
    -Y ENTRANCE,/)

```

```

207  FORMAT(*0*,
      -T32,*A1      **E13.6,* S-M2/KMOLE*,T66,*G1      **E13.6,/,
      -T32,*MW1     **E13.6,* KG/KMOLE*,T66,*M1      **F13.6,/,
      -T32,*P1      **F13.6,* PA*,T66,*P10     **F13.6,* PA*,/,
      -T32,*R1      **E13.6,* KG/M3*,T66,*R10     **E13.6,* KG/M3*,/,
      -T32,*T1      **E13.6,* K*,T66,*T10     **E13.6,* K*,
08  FORMAT(*0*,T23,*POINT 2  NORMAL SHOCK DIFFUSER EXIT AND SUBSONIC
      -DIFFUSER ENTRANCE*,/,
      -T32,*A2      **E13.6,* S-M2/KMOLE*,T66,*ETA12  **E13.6,/,
      -T32,*G2      **E13.6,T66,*MW2     **E13.6,* KG/KMOLE*,/,
      -T32,*M2      **E13.6,T66,*P2      **E13.6,* PA*,/,
      -T32,*P20     **E13.6,* PA*,T66,*R2      **E13.6,* KG/M3*,/,
      -T32,*R20     **E13.6,* KG/M3*,T66,*T2      **E13.6,* K*,/,
      -T32,*T20     **E13.6,* K*,T66,*W2W1     **F13.6,/,
      -T32,*X2X1    **E13.6),
209  FORMAT(*0*,T23,*POINT 3  SUBSONIC DIFFUSER EXIT *)
210  FORMAT(*0*,T55,*AND SUDDEN ENLARGEMENT ENTRANCE*)
211  FORMAT(*0*,
      -T32,*A3      **E13.6,* S-M2/KMOLE*,T66,*ETA23  **E13.6,/,
      -T32,*G3      **E13.6,T66,*MW3     **E13.6,* KG/KMOLE*,/,
      -T32,*M3      **E13.6,T66,*P3      **E13.6,* PA*,/,
      -T32,*P30     **E13.6,* PA*,T66,*R3      **E13.6,* KG/M3*,/,
      -T32,*R30     **E13.6,* KG/M3*,T66,*T3      **E13.6,* K*,/,
      -T32,*T30     **E13.6,* K*,T66,*W3W1     **F13.6,/,
      -T32,*X3X1    **E13.6),
212  FORMAT(*0*,T23,*POINT 4  CONSTANT-AREA, SUBSONIC-SUPERSONIC EJECTO
      -R SECONDARY NOZZLE EXIT*,/,
      -T32,*A4      **E13.6,* S-M2/KMOLE*,T66,*G4      **E13.6,/,
      -T32,*MW4     **E13.6,* KG/KMOLE*,T66,*M4      **F13.6,/,
      -T32,*P4      **E13.6,* PA*,T66,*P40     **E13.6,* PA*,/,
      -T32,*R4      **E13.6,* KG/M3*,T66,*R40     **E13.6,* KG/M3*,/,
      -T32,*T4      **E13.6,* K*,T66,*T40     **E13.6,* K*,/,
      -T32,*W4W1    **E13.6,T66,*X4X1     **E13.6),
213  FORMAT(*0*,T23,*POINT 5  CONSTANT-AREA, SUBSONIC-SUPERSONIC EJECTO
      -R PRIMARY NOZZLE EXIT*)
214  FORMAT(*0*,T23,*NOTE:   THE UPPER LIMIT POINT WAS USED AS THE LIM
      -ITING CONDITION FOR*,/,T32,*THE CONSTANT-AREA, SUPERSONIC-SUPERSONO
      -IC EJECTOR*)
215  FORMAT(*0*,T23,*NOTE:   THE ZUKOSKI SEPARATION POINT WAS USED AS
      -THE LIMITING CONDITION FOR*,/,T32,*THE CONSTANT-AREA, SUPERSONIC-SO
      -UPERSONIC EJECTOR*)
216  FORMAT(*0*,T23,*NOTE:   THE MATCHED PRESSURE POINT WAS USED AS THO
      -E LIMITING CONDITION FOR*,/,T32,*THE CONSTANT-AREA, SUPERSONIC-SUP
      -ERSONIC EJECTOR*)
217  FORMAT(*0*,T23,*POINT 5  CONSTANT-AREA, SUPERSONIC-SUPERSONIC EJE
      -TOR PRIMARY NOZZLE EXIT*)
218  FORMAT(*0*,
      -T32,*A5      **E13.6,* S-M2/KMOLE*,T66,*G5      **E13.6,/,
      -T32,*MW5     **E13.6,* KG/KMOLE*,T66,*M5      **E13.6,/,
      -T32,*P5      **E13.6,* PA*,T66,*P50     **E13.6,* PA*,/,
      -T32,*R5      **E13.6,* KG/M3*,T66,*R50     **E13.6,* KG/M3*,/,
      -T32,*T5      **E13.6,* K*,T66,*T50     **E13.6,* K*,/,
      -T32,*W5W1    **E13.6,T66,*X5X1     **E13.6),
219  FORMAT(*1*,T23,*POINT 6  CONSTANT-AREA, SUBSONIC-SUPERSONIC EJECTO
      -R EXIT AND SUBSONIC*,/,T32,*DIFFUSER ENTRANCE*)

```



```

220  FORMAT(*0*,T23,*POINT 6  CONSTANT-AREA, SUPERSONIC-SUPERSONIC EJE,OUTPRS 1750
      -TOR EXIT AND SUBSONIC*,/,T32,*DIFFUSER ENTRANCE*) OUTPRS 1760
221  FORMAT(*0*,
      -T32,*A6      =*,E13.6,* S-M2/KMOLE*,T66,*06      =*,E13.6,/, OUTPRS 1780
      -T32,*MW6     =*,E13.6,* KG/KMOLE*,T66,*06      =*,E13.6,/, OUTPRS 1790
      -T32,*P6      =*,E13.6,* PA*,T66,*P60      =*,E13.6,* PA*,/, OUTPRS 1800
      -T32,*R6      =*,E13.6,* KG/M3*,T66,*R60      =*,E13.6,* KG/M3*,/, OUTPRS 1810
      -T32,*T6      =*,E13.6,* K*,T66,*Y60      =*,E13.6,* K*,/, OUTPRS 1820
      -T32,*W6W1     =*,E13.6,T66,*X6X1      =*,E13.6, OUTPRS 1830
222  FORMAT(*0*,T23,*POINT 7  SUBSONIC DIFFUSER EXIT*,/, OUTPRS 1840
      -T32,*A7      =*,E13.6,* S-M2/KMOLE*,T66,*FTA67      =*,E13.6,/, OUTPRS 1850
      -T32,*07      =*,E13.6,T66,*MW7      =*,E13.6,* KG/KMOLE*,/, OUTPRS 1860
      -T32,*07      =*,E13.6,T66,*P7      =*,E13.6,* PA*,/, OUTPRS 1870
      -T32,*P70     =*,E13.6,* PA*,T66,*R7      =*,E13.6,* KG/M3*,/, OUTPRS 1880
      -T32,*R70     =*,E13.6,* KG/M3*,T66,*T7      =*,E13.6,* K*,/, OUTPRS 1890
      -T32,*T70     =*,E13.6,* K*,T66,*W/W1      =*,E13.6,/, OUTPRS 1900
      -T32,*X7X1    =*,E13.6) OUTPRS 1910
      END OUTPRS 1920

```

```
SUBROUTINE SDS(G,M1,A2A1,M2,P2P1,P2OP10,T2T1,T2OT10,RD,
-FAIL)
C
C
C.....*SDS 0100
C*          *SDS 0110
C          *SDS 0120
C          *SDS 0130
C.....*SDS 0140
C*          *SDS 0150
C*          SUBSONIC DIFFUSER SUBROUTINE (SDS) *SDS 0160
C          *SDS 0170
C.....*SDS 0180
C          *SDS 0190
C.....*SDS 0200
C*          *SDS 0210
C* SUBROUTINE SDS CALCULATES THE PRESSURE RATIO ACROSS A CONICAL, *SDS 0220
C* SUBSONIC DIFFUSER WITH AN INCLUDED ANGLE OF 15 DEGREES. THE STATIC *SDS 0230
C* PRESSURE RATIO IS COMPUTED USING AN EMPIRICAL DIFFUSER EFFICIENCY. *SDS 0240
C* ALL OTHER PROPERTIES ARE CALCULATED FROM THE ISENTROPIC FLOW *SDS 0250
C* RELATIONS TO BE CONSISTENT WITH THE ENTRANCE AND EXIT MACH NUMBERS. *SDS 0260
C          *SDS 0270
C* THE SUBSONIC DIFFUSER EFFICIENCY GIVEN BY: *SDS 0280
C          *SDS 0290
C          *SDS 0300
C          *SDS 0310
C          *SDS 0320
C* IS LIMITED TO THE RANGE:  $0.2 < M1 < 0.5$ ,  $2.34 < A2/A1 < 5.2$  AND IS DERIVED *SDS 0330
C* FROM DATA IN THE FOLLOWING REFERENCES: *SDS 0340
C          *SDS 0350
C          *SDS 0360
C          *SDS 0370
C          *SDS 0380
C          *SDS 0390
C          *SDS 0400
C* THE SUBSONIC DIFFUSER COEFFICIENT IS DEFINED AS: *SDS 0410
C          *SDS 0420
C          *SDS 0430
C          *SDS 0440
C* INPUT VARIABLES: *SDS 0450
C          *SDS 0460
C* A2A1 = EXIT-TO-ENTRANCE AREA RATIO *SDS 0470
C* G = GAMMA *SDS 0480
C* M1 = ENTRANCE MACH NUMBER *SDS 0490
C          *SDS 0500
C* OUTPUT VARIABLES: *SDS 0510
C          *SDS 0520
C* FAIL = ERROR FLAG *SDS 0530
C* M2 = EXIT MACH NUMBER *SDS 0540
C* P2P1 = EXIT-TO-ENTRANCE STATIC PRESSURE RATIO *SDS 0550
C* P2OP10 = EXIT-TO-ENTRANCE STAGNATION PRESSURE RATIO *SDS 0560
C* RD = SUBSONIC DIFFUSER COEFFICIENT *SDS 0570
C* T2T1 = EXIT-TO-ENTRANCE STATIC TEMPERATURE RATIO *SDS 0580
C* T2OT10 = EXIT-TO-ENTRANCE STAGNATION TEMPERATURE RATIO *SDS 0590
C          *SDS 0600
C.....*SDS 0610
C          *SDS 0620
C          *SDS 0630
C          *SDS 0640
C
C
C          IMPLICIT REAL(M)
```

DATA YES/3MYES/,SUB/3MSUJ/	SDS	0650
C	SDS	0660
C	SDS	0670
C.....	SDS	0680
C*	*SDS	0690
C*	*SDS	0700
C*	*SDS	0710
C.....	SDS	0720
C	SDS	0730
C	SDS	0740
TOTM(GX,MX)=1.0+0.5*(GX-1.0)*MX*MX	SDS	0750
POPM(GX,MX)=(1.0+0.5*(GX-1.0)*MX*MX)**(GX/(GX-1.0))	SDS	0760
C	SDS	0770
C	SDS	0780
C.....	*SDS	0790
C*	*SDS	0800
C*	*SDS	0810
C*	*SDS	0820
C.....	SDS	0830
C	SDS	0840
C	SDS	0850
IF(A2A1.NF.1.0) GO TO 1	SDS	0860
M2=M1	SDS	0870
P2M1=1.0	SDS	0880
P2OP10=1.0	SDS	0890
T2Y1=1.0	SDS	0900
T2OT10=1.0	SDS	0910
RD=1.0	SDS	0920
RETURN	SDS	0930
C	SDS	0940
C	SDS	0950
C.....	SDS	0960
C*	*SDS	0970
C*	*SDS	0980
C*	*SDS	0990
C.....	SDS	1000
C	SDS	1010
C	SDS	1020
1 G2=P.0/(G+1.0)	SDS	1030
G4=(G+1.0)/(2.0*(G-1.0))	SDS	1040
C	SDS	1050
C	SDS	1060
C.....	*SDS	1070
C*	*SDS	1080
C*	*SDS	1090
C*	*SDS	1100
C.....	SDS	1110
C	SDS	1120
C	SDS	1130
A1A1S=(1.0/M1)*(G2*TOTM(G,M1))**G4	SDS	1140
A2A2S=A2A1*A1A1S	SDS	1150
CALL MA1S(G,M1,A2A2S,SUB,5.0E-06,M2,FAIL)	SDS	1160
IF(FAIL,FQ,YES) RETURN	SDS	1170
C	SDS	1180
C	SDS	1190

```

C.....SDS 1200
C*          *SDS 1210
C*          CALCULATE THE DIFFUSER EFFICIENCY          *SDS 1220
C*          *SDS 1230
C.....SDS 1240
C          SDS 1250
C          SDS 1260
C          EFF=0.002485*A2A1*A2A1*A2A1-0.024461*A2A1*A2A1-0.077229*
          -A2A1+1.048992          SDS 1270
C          SDS 1280
C          SDS 1290
C          SDS 1300
C.....SDS 1310
C*          *SDS 1320
C*          CALCULATE THE IDEAL STATIC PRESSURE RATIO          *SDS 1330
C*          *SDS 1340
C.....SDS 1350
C          SDS 1360
C          SDS 1370
C          P10P1=P0PM(G,M1)          SDS 1380
C          P20P2=P0PM(G,M2)          SDS 1390
C          P2P1=P10P1/P20P2          SDS 1400
C          RD=EFF*(1.0-EFF)/P2P1          SDS 1410
C          SDS 1420
C          SDS 1430
C.....SDS 1440
C*          *SDS 1450
C*          CALCULATE THE ACTUAL STATIC PRESSURE RATIO          *SDS 1460
C*          *SDS 1470
C.....SDS 1480
C          SDS 1490
C          SDS 1500
C          P2P1=RD*P2P1          SDS 1510
C          P20P10=P20P2*P2P1/P10P1          SDS 1520
C          T20T10=1.0          SDS 1530
C          T10T1=ToTM(G,M1)          SDS 1540
C          T20T2=ToTM(G,M2)          SDS 1550
C          T2T1=T10T1*T20T10/T20T2          SDS 1560
C          END          SDS 1570

```

```

      SUBROUTINE SSEOS(A7A6,GS,GP,LIMIT,MWPMWS,M1,P50P1,P7P1,T50T10,
      -A6A5,ETA67,FAIL,GM,MWMMWP,M5,M6,M7,P5P1,P50P10,P6P5,P60P50,P7P6,
      -P70P60,T5T1,T6T5,T60T50,T7T6,T70T60,MWMS)
C
C
C*****
C*
C* SUPersonic-SUPERSONIC EJECTOR OPTIMIZATION SUBROUTINE (SSEOS)
C*
C*****
C
C*****
C*
C* SSEOS IS A SUBROUTINE FOR OPTIMIZING A CONSTANT-AREA, SUPERSONIC-
C* SUPERSONIC EJECTOR-SUBSONIC DIFFUSER SUBSYSTEM BY ONE-DIMENSIONAL
C* ANALYSIS. THE OPTIMUM IS TAKEN TO BE THAT CONFIGURATION WHICH
C* REQUIRES THE MINIMUM DRIVER MASS FLOW FOR A GIVEN DRIVER STAGNATION
C* PRESSURE AND GIVEN COMPRESSION RATIO.
C*
C* INPUT VARIABLES:
C*
C* A7A6  = SUBSONIC DIFFUSER EXIT-TO-ENTRANCE AREA RATIO
C* GS    = SECONDARY GAMMA
C* GP    = PRIMARY GAMMA
C* LIMIT = CONTROL VARIABLE TO SET THE LIMITING CONDITION ON THE
C*         CONSTANT-AREA, SUPERSONIC-SUPERSONIC EJECTOR OPERATION
C* MWPMWS = PRIMARY-TO-SECONDARY MOLECULAR WEIGHT RATIO
C* M1    = SECONDARY MACH NO. AT THE MIXING TUBE ENTRANCE
C* P50P1 = PRIMARY STAGNATION-TO-SECONDARY STATIC PRESSURE RATIO
C* P7P1  = SUBSONIC DIFFUSER EXIT-TO-SECONDARY STATIC PRESSURE RATIO
C* T50T10 = PRIMARY-TO-SECONDARY STAGNATION TEMPERATURE RATIO
C*
C* OUTPUT VARIABLES:
C*
C* A6A5  = MIXING TUBE-TO-PRIMARY NOZZLE EXIT AREA RATIO
C* ETA67 = SUBSONIC DIFFUSER COEFFICIENT
C* FAIL  = ERROR FLAG
C* GM    = MIXED STREAM GAMMA
C* MWMMWP = MIXED STREAM-TO-PRIMARY MOLECULAR WEIGHT RATIO
C* M5    = PRIMARY MACH NO. AT THE MIXING TUBE ENTRANCE
C* M6    = MIXED STREAM MACH NO. AT THE MIXING TUBE EXIT
C* M7    = MACH NO. AT THE SUBSONIC DIFFUSER EXIT
C* P5P1  = PRIMARY-TO-SECONDARY STATIC PRESSURE RATIO
C* P50P10 = PRIMARY-TO-SECONDARY STAGNATION PRESSURE RATIO
C* P6P5  = MIXED STREAM-TO-PRIMARY STATIC PRESSURE RATIO
C* P60P50 = MIXED STREAM-TO-PRIMARY STAGNATION PRESSURE RATIO
C* P7P6  = SUBSONIC DIFFUSER EXIT-TO-ENTRANCE STATIC PRESSURE RATIO
C* P70P60 = SUBSONIC DIFFUSER EXIT-TO-ENTRANCE STAGNATION PRESSURE
C*         RATIO
C* T5T1  = PRIMARY-TO-SECONDARY STATIC TEMPERATURE RATIO
C* T6T5  = MIXED STREAM-TO-PRIMARY STATIC TEMPERATURE RATIO
C* T60T50 = MIXED STREAM-TO-PRIMARY STAGNATION TEMPERATURE RATIO
C* T7T6  = SUPERSONIC DIFFUSER EXIT-TO-ENTRANCE STATIC TEMPERATURE
C*         RATIO
C* T70T60 = SUBSONIC DIFFUSER EXIT-TO-ENTRANCE STAGNATION TEMPERATURE

```

```

C*      RATIO
C* WPM5  = PRIMARY-TO-SECONDARY MASS FLOW RATIO
C*
C*.....
C*      S9E0S 0650
C*      S9E0S 0660
C*      S9E0S 0670
C*      S9E0S 0680
C*      S9E0S 0690
C*      S9E0S 0700
C*      S9E0S 0710
C*      S9E0S 0720
C*      S9E0S 0730
C*      S9E0S 0740
C*      S9E0S 0750
C*.....
C*      S9E0S 0760
C*      S9E0S 0770
C*      S9E0S 0780
C*.....
C*      S9E0S 0790
C*      S9E0S 0800
C*      S9E0S 0810
C*      S9E0S 0820
C*      S9E0S 0830
C*      S9E0S 0840
C*      S9E0S 0850
C*.....
C*      S9E0S 0860
C*      S9E0S 0870
C*      S9E0S 0880
C*      S9E0S 0890
C*.....
C*      S9E0S 0900
C*      S9E0S 0910
C*      S9E0S 0920
C*      S9E0S 0930
C*      S9E0S 0940
C*      S9E0S 0950
C*      S9E0S 0960
C*      S9E0S 0970
C*      S9E0S 0980
C*      S9E0S 0990
C*.....
C*      S9E0S 1000
C*      S9E0S 1010
C*      S9E0S 1020
C*.....
C*      S9E0S 1030
C*      S9E0S 1040
C*      S9E0S 1050
C*      S9E0S 1060
C*      S9E0S 1070
C*      S9E0S 1080
C*      S9E0S 1090
C*      S9E0S 1100
C*      S9E0S 1110
C*.....
C*      S9E0S 1120
C*      S9E0S 1130
C*      S9E0S 1140
C*      S9E0S 1150
C*.....
C*      S9E0S 1160
C*      S9E0S 1170
C*      S9E0S 1180
C*      S9E0S 1190

```

IMPLICIT REAL(L,M)
 DATA YFS/3HYES/

TOTM(G,M)=1.0+0.5*(G-1.0)*M*M
 POPM(G,M)=TOTM(G,M)**(G/(G-1.0))

CHECK INITIAL DATA

PDPU=(2.0*GS*M1*M1+1.0-GS)/(GS+1.0)
 IF(PDPU,GT,P7P1) GO TO 105
 MWSMWP=1.0/MWPMWS
 T10T50=1.0/T50T10

ITERATE A6A5 TO FIND XP50P1=P50P1

NTYPE2=1
 NIT2=1
 A6A5=20.0
 DO 103 ITER2=1,1000

ITERATE M5 TO FIND XP7P1=P7P1

NTYPE3=1

APPENDIX D
SUBROUTINE SSEOS

CHEMICAL LASER ANALYSIS PROGRAM (CLAP)
OVERLAY PRS

PAGE D-19

NIT3=1	SSEOS 1200
M5=1.01	SSEOS 1210
DO 101 ITER3=1,1000	SSEOS 1220
C	SSEOS 1230
C	SSEOS 1240
C.....	SSEOS 1250
C*	SSEOS 1260
C* CALCULATIONS FOR SUPERSONIC-SUPERSONIC EJECTOR	SSEOS 1270
C*	SSEOS 1280
C.....	SSEOS 1290
C	SSEOS 1300
C	SSEOS 1310
A1A5=A6A5-1.0	SSEOS 1320
CALL SSF185,UP,MWSWMP,T10T50,M1,M5,A1A5,LIMIT,WSWP,GM,	SSEOS 1330
-MMMMP,T60T50,M6,XP50P1,PAF1,FAIL)	SSEOS 1340
IF(FAIL,EQ,YES) GO TO 106	SSEOS 1350
C	SSEOS 1360
C	SSEOS 1370
C.....	SSEOS 1380
C*	SSEOS 1390
C* CALCULATIONS FOR SUBSONIC DIFFUSER	SSEOS 1400
C*	SSEOS 1410
C.....	SSEOS 1420
C	SSEOS 1430
C	SSEOS 1440
CALL SDS18M,M6,A7A6,M7,P7P6,P70P60,T7T6,T70T60,ETA67,FAIL)	SSEOS 1450
IF(FAIL,EQ,YES) GO TO 107	SSEOS 1460
XP7P1=P7P6*P6P1	SSEOS 1470
C	SSEOS 1480
C	SSEOS 1490
C.....	SSEOS 1500
C*	SSEOS 1510
C* TEST FOR XP7P1=P7P1 AND INCREMENT M5	SSEOS 1520
C*	SSEOS 1530
C.....	SSEOS 1540
C	SSEOS 1550
C	SSEOS 1560
CALL ITER(M5,0.5,5.0E-06,+1.0,XP7P1,P7P1,1.0E-01,NIT3,NTYPE3,	SSEOS 1570
-XNE63,YNE63,XPOS3,YPOS3,NSIGN3,NSIGN4)	SSEOS 1580
IF(NTYPE3,EQ,3) GO TO 102	SSEOS 1590
101 CONTINUE	SSEOS 1600
GO TO 108	SSEOS 1610
C	SSEOS 1620
C	SSEOS 1630
C.....	SSEOS 1640
C*	SSEOS 1650
C* TEST FOR XP50P1=P50P1 AND INCREMENT A6A5	SSEOS 1660
C*	SSEOS 1670
C.....	SSEOS 1680
C	SSEOS 1690
C	SSEOS 1700
102 CALL ITER(A6A5,0.5,5.0E-06,-1.0,XP50P1,P50P1,1.0E-01,NIT2,NTYPE2,	SSEOS 1710
-XNE62,YNE62,XPOS2,YPOS2,NSIGN1,NSIGN2)	SSEOS 1720
IF(NTYPE2,EQ,3) GO TO 104	SSEOS 1730
103 CONTINUE	SSEOS 1740

GO TO 109	SSEOS 1750
104 WPWS=1.0/WSWP	SSEOS 1760
P5P1=XP50P1/P0PM(GP,M5)	SSEOS 1770
P50P10=XP50P1*P0PM(GS,M1)	SSEOS 1780
T5T1=T50T10*T0TM(GS,M1)/T0TM(GP,M5)	SSEOS 1790
P6P5=P6P1/P5P1	SSEOS 1800
P60P50=P6P5*P0PM(GM,M6)/P0PM(GP,M5)	SSEOS 1810
T6T5=T60T50*T0TM(GP,M5)/T0TM(GM,M6)	SSEOS 1820
RETURN	SSEOS 1830
C	SSEOS 1840
C	SSEOS 1850
C.....	SSEOS 1860
C*	SSEOS 1870
C* FAILURE INDICATORS	SSEOS 1880
C*	SSEOS 1890
C*.....	SSEOS 1900
C	SSEOS 1910
C	SSEOS 1920
105 WRITE(6,201)	SSEOS 1930
GO TO 110	SSEOS 1940
106 WRITE(6,202)	SSEOS 1950
RETURN	SSEOS 1960
107 WRITE(6,203)	SSEOS 1970
RETURN	SSEOS 1980
108 WRITE(6,204) A6A5,M5,XP7P1,P7P1	SSEOS 1990
GO TO 110	SSEOS 2000
109 WRITE(6,205) M5,A6A5,XP50P1,P50P1	SSEOS 2010
110 FAIL=YES	SSEOS 2020
C	SSEOS 2030
C	SSEOS 2040
C.....	SSEOS 2050
C*	SSEOS 2060
C* FORMAT STATEMENTS	SSEOS 2070
C*	SSEOS 2080
C*.....	SSEOS 2090
C	SSEOS 2100
C	SSEOS 2110
201 FORMAT(00,T2,*WARNING IN SUBROUTINE SSEOS*,/,T2,*THE *,	SSEOS 2120
..*NORMAL SHOCK STATIC PRESSURE RATIO FOR THE SECONDARY*,/,	SSEOS 2130
-T2,*STREAM IS GREATER THAN THE REQUESTED COMPRESSION *,	SSEOS 2140
-*RATIO*,/,T2,*M1 **E13.6,T26,*8S **E13.6,/,	SSEOS 2150
-T2,*PDP1 **E13.6,T26,*P7P1 **E13.6)	SSEOS 2160
202 FORMAT(00,T2,*PROGRAM TERMINATED IN SUBROUTINE SSEOS*,/,	SSEOS 2170
-T2,*AS CALLED FROM SUBROUTINE SSEOS*)	SSEOS 2180
203 FORMAT(00,T2,*PROGRAM TERMINATED IN SUBROUTINE SD*,/,	SSEOS 2190
-T2,*AS CALLED FROM SUBROUTINE SSEOS*)	SSEOS 2200
204 FORMAT(00,T2,*CONVERGENCE FAILURE IN SUBROUTINE SSEOS*,/,	SSEOS 2210
-T2,*FOR M5 SUCH THAT XP7P1=P7P1*,//,	SSEOS 2220
-T2,*A6A5 **E13.6,T26,*M5 **E13.6,/,	SSEOS 2230
-T2,*XP7P1 **E13.6,T26,*P7P1 **E13.6)	SSEOS 2240
205 FORMAT(00,T2,*CONVERGENCE FAILURE IN SUBROUTINE SSEOS*,/,	SSEOS 2250
-T2,*FOR A6A5 SUCH THAT XP50P1=P50P1*,//,	SSEOS 2260
-T2,*M5 **E13.6,T26,*A6A5 **E13.6,/,	SSEOS 2270
-T2,*XP50P1 **E13.6,T26,*P50P1 **E13.6)	SSEOS 2280
END	SSEOS 2290


```

SUBROUTINE SSFS(OS,OP,MWSMWP,TSOTPO,MS1,MP1,AS1AP1,LIMIT,
  -WSWP,OM,MWMMWP,TMOTPO,MM3,PMOPS1,PM3PS1,FAIL)
C
C
C.....
C*
C* SUPersonic-SUPersonic EJECTOR SUBROUTINE (SSFS)
C*
C*.....
C
C.....
C*
C* SUBROUTINE SSFS CALCULATES THE MAXIMUM COMPRESSION RATIO FOR A
C* CONSTANT-AREA, SUPersonic-SUPersonic EJECTOR, BY ONE-DIMENSIONAL
C* ANALYSIS.
C*
C* INPUT VARIABLES:
C*
C* OS      = SECONDARY GAMMA
C* OP      = PRIMARY GAMMA
C* MWSMWP  = SECONDARY-TO-PRIMARY MOLECULAR WEIGHT RATIO
C* TSOTPO  = SECONDARY-TO-PRIMARY STAGNATION TEMPERATURE RATIO
C* MS1     = SECONDARY MACH NO. AT THE MIXING TUBE ENTRANCE
C* MP1     = PRIMARY MACH NO. AT THE MIXING TUBE ENTRANCE
C* AS1AP1  = SECONDARY-TO-PRIMARY AREA RATIO
C* LIMIT   = CONTROL VARIABLE SUCH THAT:
C*           = ULPH FOR THE UPPER LIMIT POINT
C*           = MZSPH FOR THE ZUKOSKI SEPARATION POINT
C*           = UMPH FOR THE MATCHED PRESSURE POINT
C*
C* OUTPUT VARIABLES:
C*
C* WSWP    = SECONDARY-TO-PRIMARY MASS FLOW RATIO
C* OM      = MIXED STREAM GAMMA
C* MWMMWP  = MIXED STREAM-TO-PRIMARY MOLECULAR WEIGHT RATIO
C* TMOTPO  = MIXED STREAM-TO-PRIMARY STAGNATION TEMPERATURE RATIO
C* MM3     = MIXED STREAM MACH NO. AT THE MIXING TUBE EXIT
C* PMOPS1  = PRIMARY STAGNATION-TO-SECONDARY STATIC PRESSURE RATIO
C* PM3PS1  = STATIC PRESSURE COMPRESSION RATIO
C* FAIL    = ERROR FLAG
C*
C.....
C
C IMPLICIT REAL(M)
C REAL LIMIT
C DATA YES/3HYES/,SUP/3HSUP/,ULP/3HULP/,MPP/3HMPP/
C
C.....
C*
C* SPECIAL FUNCTIONS
C*
C*.....
C

```

```

C
F(IX,MXX)=1.0+IX*MXX*MXX
G(IX,MXX)=MXX*SQRT(1.0+0.5*(IX-1.0)*MXX*MXX)
H(MM,TT,GG)=SQRT(MM*GG/TT)
PP0(IX,MXX)=(1.0+0.5*(IX-1.0)*MXX*MXX)**(GX/(1.0-IX))
AAS(IX,MXX)=(2.0*(1.0+0.5*(IX-1.0)*MXX*MXX)/(IX+1.0))**((0.5*(IX+1.0)
-.01)/(IX-1.0))/MXX
C
C
C.....
C*
C*          CALCULATE CONSTANTS
C*
C.....
C
C
OS3=OS/(OS-1.0)
OP3=OP/(OP-1.0)
OSAP=OS/OP
MWSMWS=1.0/MWSMWP
PS1PS0=PP0(OS,MS1)
PP1PP0=PP0(OP,MP1)
AS1ASS=AAS(OS,MS1)
AP1APS=AAS(OP,MP1)
ASSAS1=1.0/AS1ASS
FOSMS1=F(OS,MS1)
FOPMP1=F(OP,MP1)
GOSMS1=G(OS,MS1)
GOPMP1=G(OP,MP1)
C
C
C.....
C*
C*          CHECK INITIAL DATA
C*
C.....
C
C
IF(AS1AP1,GT,0.0) GO TO 1
WRITE(6,6)AS1AP1
FAIL=YES
RETURN
1
IF(LIMIT,FQ,ULP) GO TO 2
IF(LIMIT,FQ,MPP) GO TO 4
GO TO 3
C
C
C.....
C*
C*          CALCULATE PS1PP1 FOR AN ISENTROPIC RECOMPRESSION TO
C*          SONIC CONDITIONS. MP2 IS OBTAINED FROM AP2APS.
C*
C.....
C
C
SSFS 0650
SSFS 0660
SSFS 0670
SSFS 0680
SSFS 0690
SSFS 0700
SSFS 0710
SSFS 0720
SSFS 0730
SSFS 0740
SSFS 0750
SSFS 0760
SSFS 0770
SSFS 0780
SSFS 0790
SSFS 0800
SSFS 0810
SSFS 0820
SSFS 0830
SSFS 0840
SSFS 0850
SSFS 0860
SSFS 0870
SSFS 0880
SSFS 0890
SSFS 0900
SSFS 0910
SSFS 0920
SSFS 0930
SSFS 0940
SSFS 0950
SSFS 0960
SSFS 0970
SSFS 0980
SSFS 0990
SSFS 1000
SSFS 1010
SSFS 1020
SSFS 1030
SSFS 1040
SSFS 1050
SSFS 1060
SSFS 1070
SSFS 1080
SSFS 1090
SSFS 1100
SSFS 1110
SSFS 1120
SSFS 1130
SSFS 1140
SSFS 1150
SSFS 1160
SSFS 1170
SSFS 1180
SSFS 1190

```

PAGE D-43

162

APPENDIX D
SUBROUTINE SSES

CHEMICAL LASER ANALYSIS PROGRAM (CLAP)
OVERLAY PRS

PAGE D-44

C1=TSATP0*WSWP*MMPMWS*0.53*GP3	SSES	1750
C2=WSWP*MMPMWS*0.53*GP3	SSES	1760
TH0TP0=C1/C2	SSES	1770
FFX=H(MMMMP,TH0TP0,GMGM)*(PS1PP1*AS1AP1*FGSMS1*FGPMPI)/((	SSES	1780
-(1.0*WSWP)*GGPMPI)	SSES	1790
C1=0.5*(GM-1.0)*FFX*FFX-GM*GM	SSES	1800
C2=FFX*FFX-2.0*GM	SSES	1810
C3=(-C2+SQRT(C2*C2+4.0*C1))/(2.0*C1)	SSES	1820
C4=(-C2-SQRT(C2*C2+4.0*C1))/(2.0*C1)	SSES	1830
MM3=SQRT(AMIN1(C3,C4))	SSES	1840
PM3PP1=(PS1PP1*AS1AP1*FGSMS1*FGPMPI)/((1.0*AS1AP1)*F(GM,MM3))	SSES	1850
PM3PS1=PM3PP1/PS1PP1	SSES	1860
PS1PP0=PS1PP1*PP1PP0	SSES	1870
PP0PS1=1.0/PS1PP0	SSES	1880
C	SSES	1890
C	SSES	1900
C.....	SSES	1910
C*	SSES	1920
C*	SSES	1930
C*	SSES	1940
C.....	SSES	1950
C	SSES	1960
C	SSES	1970
A	SSES	1980
FORMAT(*0*,T2,*IMPOSSIBLE VALUE...,AS1AP1 =*,E13.6)	SSES	1990
END		

Appendix E. CHEMICAL LASER ANALYSIS PROGRAM (CLAP)-OVERLAY SCS

OVFLAY(SCS,4,0)	SCS	0100
PROGRAM SCS	SCS	0110
C	SCS	0120
C	SCS	0130
C.....	SCS	0140
C*	*SCS	0150
C* SYSTEM CALCULATION OVERLAY (SCS)	*SCS	0160
C*	*SCS	0170
C.....	SCS	0180
C	SCS	0190
C.....	SCS	0200
C*	*SCS	0210
C* SUBROUTINE SCS CONTROLS THE SYSTEM CALCULATIONS FOR PROGRAM CLAP.	*SCS	0220
C*	*SCS	0230
C* INPUT VARIABLES:	*SCS	0240
C*	*SCS	0250
C* AEPNE = TOTAL AREA OF THE EJECTOR PRIMARY NOZZLE EXITS PER KMOL/S	*SCS	0260
C* OF LASER PRIMARY FLOW (S-M2/KMOL)	*SCS	0270
C* AESHRD = TOTAL AREA OF THE EJECTOR, CONSTANT-AREA, MIXING SHROUDS	*SCS	0280
C* PER KMOL/S OF LASER PRIMARY FLOW (S-M2/KMOLF)	*SCS	0290
C* BRFRAC = BANK RELIEF FRACTION	*SCS	0300
C* CANGLE = LASER CAVITY HALF-ANGLE (RAD)	*SCS	0310
C* DFORMF = CONTROL VARIABLE DESIGNATING DF OR HF LASER CHEMISTRY	*SCS	0320
C* EJECT = CONTROL VARIABLE DESIGNATING THE PRESSURE RECOVERY SYSTEM	*SCS	0330
C* EREACT = CONTROL VARIABLE DESIGNATING THE EJECTOR PRIMARY REACTANT	*SCS	0340
C* FDAA = FREE FLUORINE FLUX (KMOL/S-M2)	*SCS	0350
C* GEP = GAMMA, SPECIFIC HEAT RATIO, FOR THE EJECTOR PRIMARY	*SCS	0360
C* REACTANT	*SCS	0370
C* HBASE = HEIGHT OF A NOZZLE BASE (M)	*SCS	0380
C* HNB = HEIGHT OF A NOZZLE BANK (M)	*SCS	0390
C* K = STORAGE MODE CONTROL ARRAY	*SCS	0400
C* LCAV = LENGTH OF A LASER CAVITY (M)	*SCS	0410
C* MEPNE = MACH NO. AT THE EJECTOR PRIMARY NOZZLE EXIT	*SCS	0420
C* NBANK = NUMBER OF LASER BANKS	*SCS	0430
C* NEJECT = NUMBER OF EJECTORS PER LASER BANK	*SCS	0440
C* N1 = NUMBER OF CARBON ATOMS IN PRIMARY REACTANT 1	*SCS	0450
C* N2 = NUMBER OF HYDROGEN (DEUTERIUM) ATOMS IN PRIMARY REACTANT 1	*SCS	0460
C* N3 = NUMBER OF NITROGEN ATOMS IN PRIMARY REACTANT 4	*SCS	0470
C* N4 = NUMBER OF FLUORINE ATOMS IN PRIMARY REACTANT 4	*SCS	0480
C* POEP = EJECTOR PRIMARY STAGNATION PRESSURE (PA)	*SCS	0490
C* POLP = LASER PRIMARY STAGNATION PRESSURE (PA)	*SCS	0500
C* POLS = LASER SECONDARY STAGNATION PRESSURE (PA)	*SCS	0510
C* Q = HEAT RELEASED PER KMOL OF PRIMARY FLOW BY THE CHEMICAL	*SCS	0520
C* REACTION OF FLUORINE IN THE LASER CAVITY (J/KMOL)	*SCS	0530
C* RTIME = RUN TIME (S)	*SCS	0540
C* SCSS2 = CONTROL VARIABLE DESIGNATING WHETHER OR NOT SYSTEM	*SCS	0550
C* CALCULATIONS ARE TO BE PERFORMED	*SCS	0560
C* STMODE = REACTANT STORAGE MODE DESCRIPTOR ARRAY	*SCS	0570
C* WEPNLT = EJECTOR PRIMARY-TO-TOTAL LASER MASS FLOW RATIO	*SCS	0580
C* WFPF3 = MASS FRACTION OF LASER PRIMARY PRODUCT 3 (FREE FLUORINE)	*SCS	0590
C* WFPF1 = MASS FRACTION OF LASER PRIMARY REACTANT 1	*SCS	0600
C* WFPF2 = MASS FRACTION OF LASER PRIMARY REACTANT 2	*SCS	0610
C* WFPF3 = MASS FRACTION OF LASER PRIMARY REACTANT 3	*SCS	0620
C* WFPF4 = MASS FRACTION OF LASER PRIMARY REACTANT 4	*SCS	0630
C* WFSR1 = MASS FRACTION OF LASER SECONDARY REACTANT 1	*SCS	0640

C* WFSR2	= MASS FRACTION OF LASER SECONDARY REACTANT 2	*SCS	0650
C* WFSR3	= MASS FRACTION OF LASER SECONDARY REACTANT 3	*SCS	0660
C* WLSWLP	= LASER SECONDARY-TO-PRIMARY REACTANT MASS FLOW RATIO	*SCS	0670
C* WPNWLP	= MIRROR PURGE-TO-LASER PRIMARY REACTANT MASS FLOW RATIO	*SCS	0680
C* WPP3	= MASS FLOW RATE OF LASER PRIMARY PRODUCT 3 (FREE FLUORINE)	*SCS	0690
C*	(KG/S)	*SCS	0700
C* XFPP3	= MOLE FRACTION OF LASER PRIMARY PRODUCT 3 (FREE FLUORINE)	*SCS	0710
C*		*SCS	0720
C*	OUTPUT VARIABLES:	*SCS	0730
C*		*SCS	0740
C* FAIL	= ERROR FLAG	*SCS	0750
C* HXDEV	= HEIGHT OF THE ROX DEVICE (M)	*SCS	0760
C* LBXDEV	= LENGTH OF THE ROX DEVICE (M)	*SCS	0770
C* LLOS	= LENGTH OF THE LASER DEVICE SECTION (M)	*SCS	0780
C* LPRS	= LENGTH OF THE PRESSURE RECOVERY SYSTEM (M)	*SCS	0790
C* MAW	= TOTAL MASS OF THE AERO-WINDOWS (KG)	*SCS	0800
C* MBASE	= TOTAL MASS OF THE LASER NOZZLE BASES (KG)	*SCS	0810
C* MCAV	= TOTAL MASS OF THE LASER CAVITIES (KG)	*SCS	0820
C* MCB	= TOTAL MASS OF THE COMBUSTOR BODIES (KG)	*SCS	0830
C* MCS	= MASS OF THE COOLING SYSTEM (KG)	*SCS	0840
C* MDS	= MASS OF THE DEVICE SUPPORT (KG)	*SCS	0850
C* MEJECT	= TOTAL MASS OF THE EJECTORS (KG)	*SCS	0860
C* MELINE	= MASS OF THE EJECTOR REACTANT FEED LINES (KG)	*SCS	0870
C* MERRER	= MASS OF THE EJECTOR PRIMARY REACTANT REGULATOR (KG)	*SCS	0880
C* MERT	= MASS OF THE EJECTOR PRIMARY REACTANT TANKAGE AND FLUID	*SCS	0890
C*	(KG)	*SCS	0900
C* MINJ	= TOTAL MASS OF THE INJECTORS (KG)	*SCS	0910
C* MLDHW	= MASS OF THE LASER DEVICE HARDWARE (KG)	*SCS	0920
C* MLDS	= MASS OF THE LASER DEVICE SYSTEM (KG)	*SCS	0930
C* MLLINE	= MASS OF THE LASER REACTANT FEED LINES (KG)	*SCS	0940
C* MLRREG	= MASS OF THE LASER REACTANT REGULATOR (KG)	*SCS	0950
C* MLRT	= MASS OF THE LASER REACTANT TANKAGE AND FLUID (KG)	*SCS	0960
C* MMISC	= MASS OF MISCELLANEOUS ITEMS (KG)	*SCS	0970
C* MOPT	= TOTAL MASS OF THE LASER OPTICS (KG)	*SCS	0980
C* MPRHW	= MASS OF THE PRESSURE RECOVERY HARDWARE (KG)	*SCS	0990
C* MPRS	= MASS OF THE PRESSURE RECOVERY SYSTEM (KG)	*SCS	1000
C* MSUBD	= TOTAL MASS OF THE SUBSONIC DIFFUSERS (KG)	*SCS	1010
C* MSUPD	= TOTAL MASS OF THE SUPERSONIC DIFFUSERS (KG)	*SCS	1020
C* MTOTAL	= TOTAL SYSTEM MASS (KG)	*SCS	1030
C* VAW	= TOTAL VOLUME OF THE AERO-WINDOWS (M3)	*SCS	1040
C* VBXDEV	= VOLUME OF THE ROX DEVICE (M3)	*SCS	1050
C* VCAV	= TOTAL VOLUME OF THE LASER CAVITIES (M3)	*SCS	1060
C* VCOMB	= TOTAL VOLUME OF THE LASER COMBUSTORS (M3)	*SCS	1070
C* VCS	= VOLUME OF THE COOLING SYSTEM (M3)	*SCS	1080
C* VEJECT	= TOTAL VOLUME OF THE EJECTORS (M3)	*SCS	1090
C* VERT	= VOLUME OF THE EJECTOR PRIMARY REACTANT TANKAGE (M3)	*SCS	1100
C* VLDHW	= VOLUME OF THE LASER DEVICE HARDWARE (M3)	*SCS	1110
C* VLDS	= VOLUME OF THE LASER DEVICE SYSTEM (M3)	*SCS	1120
C* VLRT	= VOLUME OF THE LASER REACTANT TANKAGE (M3)	*SCS	1130
C* VOPT	= TOTAL VOLUME OF THE LASER OPTICS (M3)	*SCS	1140
C* VPRHW	= VOLUME OF THE PRESSURE RECOVERY HARDWARE (M3)	*SCS	1150
C* VPRS	= VOLUME OF THE PRESSURE RECOVERY SYSTEM (M3)	*SCS	1160
C* VSUBD	= TOTAL VOLUME OF THE SUBSONIC DIFFUSERS (M3)	*SCS	1170
C* VSUPD	= TOTAL VOLUME OF THE SUPERSONIC DIFFUSERS (M3)	*SCS	1180
C* VSYSTEM	= TOTAL VOLUME CONTAINING THE SYSTEM (M3)	*SCS	1190

```
C* VTOTAL = TOTAL VOLUME OCCUPIED BY THE SYSTEM (M3)          *SCS 1200
C* WRASE = WIDTH OF A NOZZLE BASE (M3)                        *SCS 1210
C* WRXDEV = WIDTH OF THE ROX DEVICE (M3)                      *SCS 1220
C* XLP = LASER PRIMARY PRODUCT MOLAR FLOW RATE (KMOLE/S)      *SCS 1230
C*                                                              *SCS 1240
C.....*SCS 1250
C                                                              *SCS 1260
C.....*SCS 1270
C*                                                              *SCS 1280
C*                                NOTATION SCHEME              *SCS 1290
C*                                *SCS 1300
C* THE STORAGE MODE DESCRIPTOR ARRAY, STMODE(I,J), STORES DATA BY *SCS 1310
C* DESCRIPTOR (ROW) AS FOLLOWS:                                *SCS 1320
C*                                *SCS 1330
C*      I DESCRIPTOR      I DESCRIPTOR                        *SCS 1340
C*      1 REACTANT        6 STORAGE TIME (DAYS)                *SCS 1350
C*      2 PHASE           7 STORAGE PRESSURE (PA)              *SCS 1360
C*      3 CONTAINER       8 STORAGE PRESSURE (PSI)             *SCS 1370
C*      4 STORAGE TEMPERATURE (K)  9 REACTANT FEED SYSTEM      *SCS 1380
C*      5 STORAGE TIME (S)  10 MATERIAL                        *SCS 1390
C*                                *SCS 1400
C* AND BY FLUID (COLUMN) AS FOLLOWS:                            *SCS 1410
C*                                *SCS 1420
C*      J                                J                        *SCS 1430
C*      1 DESCRIPTOR      6 LASER REACTANT 5                    *SCS 1440
C*      2 LASER REACTANT 1 7 AERO-WINDOW FLUID                  *SCS 1450
C*      3 LASER REACTANT 2 8 COOLING SYSTEM FLUID               *SCS 1460
C*      4 LASER REACTANT 3 9 EJECTOR REACTANT 1                 *SCS 1470
C*      5 LASER REACTANT 4 10 EJECTOR REACTANT 2                *SCS 1480
C*                                *SCS 1490
C.....*SCS 1500
C                                                              *SCS 1510
C                                                              *SCS 1520
C      IMPLICIT REAL(L,M)                                       *SCS 1530
C                                                              *SCS 1540
C      REAL NO                                                  *SCS 1550
C                                                              *SCS 1560
C      COMMON/CCS3/DFORHF                                       *SCS 1570
C                                                              *SCS 1580
C      COMMON/CCS4/FDAA                                         *SCS 1590
C                                                              *SCS 1600
C      COMMON/CCS5/N1,N2,N3,N4                                  *SCS 1610
C                                                              *SCS 1620
C      COMMON/CCS7/Q                                             *SCS 1630
C                                                              *SCS 1640
C      COMMON/CCS9/WFPP3,WFPR1,WFPR4,WFSR1                     *SCS 1650
C                                                              *SCS 1660
C      COMMON/CCS10/WFPR2,WFPR3,WFSR2,WFSR3                    *SCS 1670
C                                                              *SCS 1680
C      COMMON/CCS11/WPGWLP                                       *SCS 1690
C                                                              *SCS 1700
C      COMMON/CCS15/XFPP3                                         *SCS 1710
C                                                              *SCS 1720
C      COMMON/LDS5/BRFRAC,CANGLE,HBASE,HNB,LCAV               *SCS 1730
C                                                              *SCS 1740
```


C	COMMON/LDS6/POLP,POLS,WLSWLP	SCS	1750
C	COMMON/MAIN1/FAIL	SCS	1760
C	COMMON/PR54/AEPNE,AESHPD,MEPNE,MEPWL	SCS	1770
C	COMMON/PR55/EJECT	SCS	1780
C	COMMON/PR56/8EP,P0EP	SCS	1790
C	COMMON/SCS1/SCSS2	SCS	1800
C	COMMON/SCS2/EREACT,NRANK,NEJECT,RTIME,WPP3	SCS	1810
C	COMMON/SCS3/HBXDEV,LBXDEV,LLDS,LPRS,NAW,MBASE,MCAV,MCB,MCS,MDS, -MEJECT,MELINE,MEPREG,MERT,MINJ,MLDMDW,MLDS,MLLINE,MLRREG,MLRT, -MMISC,MOPT,MPRHDW,MPRS,MSURD,MSUPD,MTOTAL,VAN,VBXDFV,VCAV,VCOMB, -VCS,VEJECT,VERT,VLDMDW,VLDS,VLRT,VOPT,VPRHDW,VPRS,VSUBD,VSUPD, -VSYSTM,VTOTAL,WBASE,WBXDEV,XLP	SCS	1820
C	COMMON/SCS4/K(10)	SCS	1830
C	COMMON/SCS5/STMODE(10,10)	SCS	1840
C	DATA SDANGL/0.122173/,TRAN01/0.523599/,TRAN02/0.523599/	SCS	1850
C	DATA CAE/3HCAE/,DIF/3HDF/,HF/2HHF/,NO/2HNO/,SSE/3HSE/,YES/3HYES/	SCS	1860
C	*****	SCS	1870
C	*****	SCS	1880
C	*****	SCS	1890
C	*****	SCS	1900
C	*****	SCS	1910
C	*****	SCS	1920
C	*****	SCS	1930
C	*****	SCS	1940
C	*****	SCS	1950
C	*****	SCS	1960
C	*****	SCS	1970
C	*****	SCS	1980
C	*****	SCS	1990
C	*****	SCS	2000
C	*****	SCS	2010
C	*****	SCS	2020
C	*****	SCS	2030
C	*****	SCS	2040
C	*****	SCS	2050
C	*****	SCS	2060
C	*****	SCS	2070
C	*****	SCS	2080
C	*****	SCS	2090
C	*****	SCS	2100
C	*****	SCS	2110
C	*****	SCS	2120
C	*****	SCS	2130
C	*****	SCS	2140
C	*****	SCS	2150
C	*****	SCS	2160
C	*****	SCS	2170
C	*****	SCS	2180
C	*****	SCS	2190
C	*****	SCS	2200
C	*****	SCS	2210
C	*****	SCS	2220
C	*****	SCS	2230
C	*****	SCS	2240
C	*****	SCS	2250
C	*****	SCS	2260
C	*****	SCS	2270
C	*****	SCS	2280
C	*****	SCS	2290

C*	INITIALIZE THE STORAGE MODE DESCRIPTOR	*SCS	2300
C*	ARRAY AND TANK VOLUME/MASS VARIABLES	*SCS	2310
C*		*SCS	2320
C	.....	*SCS	2330
C		SCS	2340
C		SCS	2350
	DO 101 I=1,10	SCS	2360
	DO 101 J=2,10	SCS	2370
101	STMODE(I,J)=10M	SCS	2380
	MERT=0.0	SCS	2390
	MLRT=0.0	SCS	2400
	VERT=0.0	SCS	2410
	VLRT=0.0	SCS	2420
C		SCS	2430
C		SCS	2440
C	.....	*SCS	2450
C*		*SCS	2460
C*	SYSTEM SCALE-UP CALCULATIONS	*SCS	2470
C*		*SCS	2480
C	.....	*SCS	2490
C		SCS	2500
C		SCS	2510
	XLP=WPP3/(XFPP3*18.9984)	SCS	2520
C		SCS	2530
C		SCS	2540
C	.....	*SCS	2550
C*		*SCS	2560
C*	CALCULATE THE LASER PRIMARY & SECONDARY REACTANT TANK VOLUME/MASS	*SCS	2570
C*		*SCS	2580
C	.....	*SCS	2590
C		SCS	2600
C		SCS	2610
	WLP=WPP3/WFPP3	SCS	2620
	MLPR=WLP*RTIME	SCS	2630
	WLS=WLSWLP*WLP	SCS	2640
	MLSR=WLS*RTIME	SCS	2650
C		SCS	2660
	IF (DFORMF.NE.WF) GO TO 102	SCS	2670
	CALL VMD2(2,WFPR1*MLPR,POLP,MLRT,VLRT)	SCS	2680
	GO TO 105	SCS	2690
102	IF (N1.EQ.2.AND.N2.EQ.4) GO TO 103	SCS	2700
	IF (N1.EQ.0.AND.N2.EQ.2) GO TO 104	SCS	2710
103	CALL VMC2H(2,WFPR1*MLPR,POLP,MLRT,VLRT)	SCS	2720
	GO TO 105	SCS	2730
104	CALL VMH2(2,WFPR1*MLPR,POLP,MLRT,VLRT)	SCS	2740
105	NTANK=1	SCS	2750
C		SCS	2760
	MHE=WFR2*MLPR+WFSR2*MLSR	SCS	2770
	IF (K(5).LT.3.AND.WFSR2.EQ.0.0) GO TO 106	SCS	2780
	IF (MHE.FQ.0.0) GO TO 106	SCS	2790
	IF (WFR2.NE.0.0.AND.WFSR2.NE.0.0) P0=AMAX1(POLP,POLS)	SCS	2800
	IF (WFR2.NE.0.0.AND.WFSR2.EQ.0.0) P0=POLP	SCS	2810
	IF (WFR2.EQ.0.0.AND.WFSR2.NE.0.0) P0=POLS	SCS	2820
	CALL VMHE(3,MHE,P0,MLRT,VLRT)	SCS	2830
	NTANK=NTANK+1	SCS	2840

```
      MMF=0.0
C
106 IF (N3.EQ.0.0.AND.N4.FO.2) GO TO 107
      CALL VMNF3(5,MHE,WFP3*MLPR,POLP,MLRT,VLRT)
      GO TO 108
107 CALL VMF2(5,WFP3*MLPP,MHE,POLP,MLRT,VLRT)
108 N/TANK=NTANK+1
C
      IF (WFP3.EQ.0.0.AND.WFSR3.EQ.0.0) GO TO 109
      IF (WFP3.NE.0.0.AND.WFSR3.NE.0.0) P0=AMAX1(POLP,POLS)
      IF (WFP3.NE.0.0.AND.WFSR3.EQ.0.0) P0=POLP
      IF (WFP3.EQ.0.0.AND.WFSR3.NE.0.0) P0=POLS
      CALL VMN2(4,WFP3*MLPR,WFSR3*MLSR,P0,MLRT,VLRT)
      NTANK=NTANK+1
C
109 IF (DFORMF.EQ.MF) CALL VMH2(6,WFSR1*MLSR,POLS,MLRT,VLRT)
      IF (DFORMF.NE.MF) CALL VKD2(6,WFSR1*MLSR,POLS,MLRT,VLRT)
      NTANK=NTANK+1
C
      MLRPER=NTANK*(MLP+WLS)
C
C*****
C*
C*      CALCULATE THE LASER DEVICE VOLUME/MASS
C*
C*****
C
C
      ANR=XLP*XFPH3/(FOAA*NBANK)
      WNR=ANR/MNB
      ABASE=ANR/MRFRAC
      WBASE=ABASE/MRASE
      DA=HBASE+2.0*LCAV*TAN(CANGLE)
      NMAX=WBASE/DA
C
      LINJ=1.05587E-08*POLP*HBASE+1.143E-02
      MINJ=7.94690E+03*ABASE*LINJ*NBANK
      WCR=WBASE/NMAX
      MCB=1.82687E+04*(1.10519E-09*POLP*((WCB+5.08E-04)*WCB+(HBASE+
-5.08E-04)*HBASE)+7.61289E-05*(WCB*HBASE+1.016E-02))*NMAX*NBANK
      MBASE=150.808*ABASE*NBANK
      LCOMB=AMAX1(2.0*MRASF,LINJ+0.1)1600)
      VCOMR=ABASE*LCOMR*NBANK
C
      ASCAV=2.0*LCAV*WBASE/COS(CANGLE)
      TAU=AMAX1(1.27000E-03,4.77465E-03*DA)
      MCAV=7.91645E+03*TAU*ASCAV*NBANK
      VCAV=WBASE*LCAV*(HBASE+DA)*NBANK/2.0
C
      DMIR=SQRT(LCAV*LCAV+DA*DA)
      B=DMIR 2.54000E-02
      KMIR=1.03728*DMIR**2.5
      MOPT=(3.0*MMIR+276.530*B*(WBASE*B+0.609600)*(0.125*WBASE*B+
-7.62000E-02)+36.2874)*NBANK
```

```
SCS 2850
SCS 2860
SCS 2870
SCS 2880
SCS 2890
SCS 2900
SCS 2910
SCS 2920
SCS 2930
SCS 2940
SCS 2950
SCS 2960
SCS 2970
SCS 2980
SCS 2990
SCS 3000
SCS 3010
SCS 3020
SCS 3030
SCS 3040
SCS 3050
SCS 3060
SCS 3070
*SCS 3080
*SCS 3090
*SCS 3100
*SCS 3110
SCS 3120
SCS 3130
SCS 3140
SCS 3150
SCS 3160
SCS 3170
SCS 3180
SCS 3190
SCS 3200
SCS 3210
SCS 3220
SCS 3230
SCS 3240
SCS 3250
SCS 3260
SCS 3270
SCS 3280
SCS 3290
SCS 3300
SCS 3310
SCS 3320
SCS 3330
SCS 3340
SCS 3350
SCS 3360
SCS 3370
SCS 3380
SCS 3390
```

	VOPT=(0.785398*B*B*(WRASE+0.609600)+7.29450*B+2.78000E-03-	SCS	3400
	-LCAV*WRASE*(DA+WRASE)/2.0)*NBANK	SCS	3410
C		SCS	3420
	MDS=0.1*(MINJ+MCR+MRASE+MCAV+MOPT)	SCS	3430
C		SCS	3440
C		SCS	3450
C	.....	SCS	3460
C		SCS	3470
C	CALCULATE THE AERO-WINDOW VOLUME/MASS	SCS	3480
C		SCS	3490
C	.....	SCS	3500
C		SCS	3510
C		SCS	3520
	WPURGE=WPGLP*WLP	SCS	3530
	WAW=3.32520*MRASE*NBANK	SCS	3540
	WAWL=1.57480E-02*MRASE*NRANK	SCS	3550
	MAWF=(WAW+WPURGE)*RTIME	SCS	3560
	CALL VMAN(7,MAWF,RTIME,MLRT,VLRT)	SCS	3570
	NTANK=NTANK+1	SCS	3580
	MAW=413.501*MBASE*NRANK	SCS	3590
	VAW=0.309974*MBASE*NRANK	SCS	3600
C		SCS	3610
C		SCS	3620
C	.....	SCS	3630
C		SCS	3640
C	CALCULATE THE COOLING SYSTEM VOLUME/MASS	SCS	3650
C		SCS	3660
C	.....	SCS	3670
C		SCS	3680
C		SCS	3690
	WCS=3.9A076E-07*Q*XLP	SCS	3700
	IF(K(10),PQ,5) WCS=3.0*WCS	SCS	3710
	WCSF=WCS*RTIME	SCS	3720
	CALL VMCS(8,WCSF,RTIME,WCS,VCS)	SCS	3730
	NTANK=NTANK+1	SCS	3740
C		SCS	3750
	LLINE=NTANK*(1.73205*(VLRT+VCS)**(1.0/3.0)*NBANK*	SCS	3760
	-SQRT(MRASE*MBASE+MBASE*NBANK*(LCOMB+LCAV)**2))	SCS	3770
	MLLINE=0.226239*LLINE	SCS	3780
C		SCS	3790
C		SCS	3800
C	.....	SCS	3810
C		SCS	3820
C	CALCULATE THE SUPERSONIC/SUBSONIC DIFFUSER VOLUME/MASS	SCS	3830
C		SCS	3840
C	.....	SCS	3850
C		SCS	3860
C		SCS	3870
	IF(EJECT,EQ,NO) GO TO 115	SCS	3880
	IF(EJECT,EQ,SSE) GO TO 110	SCS	3890
	LSUPD=9.0*DA	SCS	3900
	ASSUPD=LSUPD*(2.0*MBASE*(NMAX+1)*DA)	SCS	3910
	MSUPD=7.91645E+03*TAU*ASSUPD*NBANK	SCS	3920
	VSUPD=DA*MBASE*LSUPD*NBANK	SCS	3930
C		SCS	3940

```

LSURD=3.0*DA
DR=DA*2.0*LSURD*TAN(SDANGL)
ASSURD=LSURD*(2.0*WBASE/COS(SDANGL)+(NMAX+1)*(DA+DR)/2.0)
TAU=AMAX1(1.27000E-03,4.77465E-03*DB)
MSURD=7.91445E+03*TAU*ASSURD*NBANK
VSURD=WBASE*LSURD*(DA+DB)*NBANK/2.0
C
C
C*****SCS 3950
C*****SCS 3960
C*****SCS 3970
C*****SCS 3980
C*****SCS 3990
C*****SCS 4000
C*****SCS 4010
C*****SCS 4020
C*****SCS 4030
C*****SCS 4040
C*
C* CALCULATE THE EJECTOR PRIMARY REACTANT TANK VOLUME/MASS
C*
C*****SCS 4050
C*****SCS 4060
C*****SCS 4070
C*****SCS 4080
C*****SCS 4090
C*****SCS 4100
110 IF (EJECT.EQ.DIF) GO TO 115
WLT=WLP+WLS+WAWL+WPURGE
WEP=WEPWLT*WLT
MEPR=WEP*RTIME
IF (FRACT.EQ.10MN2H4 ) GO TO 111
IF (FRACT.EQ.10H1RFNA/MMH ) GO TO 112
111 CALL VMN2H4(9,MEPR,P0EP,RTIME,MERT,VERT)
NTANK=1
MERREG=1.5*WEP
GO TO 113
112 CALL VMMH(9,0.65*MEPR,P0EP,RTIME,MERT,VERT)
CALL VM1RFNA(10,0.35*MEPR,P0EP,RTIME,MERT,VFRT)
NTANK=2
MERREG=2.5*WEP
C
C
C*****SCS 4250
C*****SCS 4260
C*****SCS 4270
C*
C* CALCULATE THE SUBSONIC/SUPERSONIC EJECTOR VOLUME/MASS
C*
C*****SCS 4280
C*****SCS 4290
C*****SCS 4300
C*****SCS 4310
C*****SCS 4320
113 IF (EJECT.EQ.SSE) GO TO 114
NMAX=WBASE/DB
IF (NEJECT.EQ.0.OR.NEJECT.GT.NMAX) NEJECT=NMAX
WTR=WBASE/NEJECT
DC=SQRT(WTR*DB)
LTR1=(DC-DB)/(2.0*TAN(TRAN31))
THETA=ATAN((WTR-DC)/(2.0*LTR1))
DD=1.12838*DC
LTR2=(DD-DC)/(2.0*TAN(TRAN32))
ASTR=LTR1*((WTR+DC)/COS(TRAN31))+(DB+DC)/COS(THETA))+LTR2*(2.0*DC-
-1.57080*DD)
TAU=AMAX1(1.27000E-03,3.75000E-03*DD)
NTR=7.91445E+03*TAU*ASTR*NEJECT*NBANK
VTR=DC*DC*(LTR1+LTR2)*NEJECT*NBANK
C
C
ACONE=AEPNE*XLP/(NBANK*NEJECT)
AE=AESHRD*XLP/(NBANK*NEJECT)
C*****SCS 4470
C*****SCS 4480
C*****SCS 4490

```

173

ASTAR=LCONE/AASH(REF,MEPNE)	SCS	5050
DSTAR=(DE-SQRT(DE*DE-1.27324*ASTAR))/2.0	SCS	5060
LCONE=((DE-DD)/2.0-DSTAR)/0.267949	SCS	5070
ASCONF=3.14159*(DE*LCONE+(DD*DE-2.0*DSTAR)*SQRT(LCONE*LCONE-	SCS	5080
-(DE-2.0*DSTAR-DD)**2)/2.0)	SCS	5090
MCONE=10.0539*ASCONF*NFJECT*NRANK	SCS	5100
C	SCS	5110
DPLEN=3.56825*SQRT(ASTAR)	SCS	5120
C=AMAX1(DE-DPLEN,DA-DPLEN)	SCS	5130
ASPLEN=9.86960*C*DPLEN	SCS	5140
TAU=2.07197E-08*POFP*DPLEN	SCS	5150
MPLFN=7.91645E+03*TAU*ASPLEN*NFJECT*NRANK	SCS	5160
C	SCS	5170
DF=DE*(1.0+R.0*TAN(SDANGL))	SCS	5180
ASSHRD=3.14159*(7.5*DF*DE+(DE*DF)*SQRT(4.0*DE*DE+(DE-DE)*	SCS	5190
-(DE-DE))/4.0)	SCS	5200
TAU=AMAX1(1.27000E-03+3.21429E-03*DF)	SCS	5210
MSHRD=7.91645E+03*TAU*ASSHRD*NFJECT*NRANK	SCS	5220
C	SCS	5230
LEJECT=18.5*DF	SCS	5240
MFJECT=MTR*MCONE*MPLFN*MSHRD	SCS	5250
VEJECT=3.14159*DE*(3.625*DE*DE+(DE*DE*DE*DF*DF*DF)/3.0)*NFJECT*	SCS	5260
NRANK	SCS	5270
C	SCS	5280
LLINE=1.73205*NTANK*(VFRY)**(1.0/3.0)*NRANK*(7.0*DF*NFJECT*WBASE)	SCS	5290
MELINE=0.226239*LLINE	SCS	5300
C	SCS	5310
C	SCS	5320
C*****	SCS	5330
C*	SCS	5340
C*	SCS	5350
C*	SCS	5360
C*****	SCS	5370
C	SCS	5380
C	SCS	5390
115 ML=MDW*MINJ+MCE+MRASE*MAV+MCS*MOPT*MDS+MLRREG*MLLINE	SCS	5400
VLQMDW=VCOMR*VCAV*VAH*VCS*VOPT	SCS	5410
MLDS=MLQMDW*MLRT	SCS	5420
VLDS=VLQMDW*VLRT	SCS	5430
LLDS=VLCOMR*LCAV	SCS	5440
C	SCS	5450
IF(EJECT.EQ.DIF) GO TO 116	SCS	5460
IF(EJECT.EQ.CAE) GO TO 117	SCS	5470
IF(EJECT.EQ.SSE) GO TO 118	SCS	5480
MPR3=0.0	SCS	5490
VPR3=0.0	SCS	5500
LPR3=0.0	SCS	5510
MRXDEV=.5*DA*NRANK	SCS	5520
GO TO 119	SCS	5530
C	SCS	5540
116 MPRS=MSUPD*MSUBD	SCS	5550
VPRS=VSUPD*VSUBD	SCS	5560
LPRS=LSUPD*LSUBD	SCS	5570
MPXDEV=.5*DB*NRANK	SCS	5580
C	SCS	5590

APPENDIX F
PROGRAM SCS

CHEMICAL LASER ANALYSIS PROGRAM (CLAP)
OVERLAY SCS

PAGE E-11

C		SCS	5600
117	MPRHDW=MSUPD+MSURD+MFJECT+MERREG+MELINE	SCS	5610
	VPRHDW=VSUPD+VSURD+VFJFCT	SCS	5620
	MPRS=MPRHDW+MERT	SCS	5630
	VPRS=VPRHDW+VERT	SCS	5640
	LPRS=LSUPD+LSURD+LEJECT	SCS	5650
	MBXDEV=1.5*DL*NBANK	SCS	5660
	GO TO 119	SCS	5670
C		SCS	5680
118	MPRHDW=MFJECT+MERREG+MELINE	SCS	5690
	MPRS=MPRHDW+MERT	SCS	5700
	VPRS=VEJECT+VERT	SCS	5710
	LPRS=LEJECT	SCS	5720
	MBXDEV=1.5*DE*NRANK	SCS	5730
C		SCS	5740
119	MMISC=AMIN1(362.874,0.1*(MLDS+MPRS))	SCS	5750
	MTOTAL=MLDS+MPRS+MMISC	SCS	5760
	VTOTAL=VLDS+VPRS	SCS	5770
	VSYSTEM=2.0*VTOTAL	SCS	5780
	LBXDEV=LLDS*LPRS	SCS	5790
	WBXDEV=1.1*WBASE	SCS	5800
	VBXDEV=LBXDEV*WBXDEV*MBXDEV	SCS	5810
C		SCS	5820
C		SCS	5830
C	.....	SCS	5840
C*		*SCS	5850
C*	OUTPUT RESULTS	*SCS	5860
C*		*SCS	5870
C	.....	SCS	5880
C		SCS	5890
C		SCS	5900
	CALL OUTSCS	SCS	5910
	GO TO 202	SCS	5920
C		SCS	5930
C		SCS	5940
C	.....	SCS	5950
C*		*SCS	5960
C*	FAILURE INDICATORS	*SCS	5970
C*		*SCS	5980
C	.....	SCS	5990
C		SCS	6000
C		SCS	6010
120	WRITE(6,201)	SCS	6020
C		SCS	6030
C		SCS	6040
C	.....	SCS	6050
C*		*SCS	6060
C*	FORMAT STATEMENTS	*SCS	6070
C*		*SCS	6080
C	.....	SCS	6090
C		SCS	6100
C		SCS	6110
201	FORMAT(*0*.T2,*SUBROUTINE INSCS WAS CALLED FROM SUBROUTINE SCS*)	SCS	6120
202	END	SCS	6130


```
SURROUTINE INSCS
C
C
C.....
C* INPUT SURROUTINE (INSCS)
C*.....
C
C.....
C* SUBROUTINE INSCS CONTROLS THE INPUT OF INITIAL DATA FOR THE SYSTEM
C* CALCULATION SECTION.
C*
C* INPUT VARIABLES:
C*
C* EJECT   = PRESSURE RECOVERY SECTION CONTROL VARIABLE
C* N1      = NUMBER OF CARBON ATOMS IN PRIMARY REACTANT 1
C* N2      = NUMBER OF HYDROGEN (DEUTERIUM) ATOMS IN PRIMARY
C*          REACTANT 1
C* N3      = NUMBER OF NITROGEN ATOMS IN PRIMARY REACTANT 4
C* N4      = NUMBER OF FLUORINE ATOMS IN PRIMARY REACTANT 4
C* SCSS1   = CONTROL VARIABLE
C* SCSS3   = CONTROL VARIABLE
C* SCSS4   = CONTROL VARIABLE
C* STAW    = STORAGE MODE DESCRIPTOR DATA ARRAY FOR N2-AW
C* STCS    = STORAGE MODE DESCRIPTOR DATA ARRAY FOR H2O-CS
C* STC2H4  = STORAGE MODE DESCRIPTOR DATA ARRAY FOR C2H4
C* STD2    = STORAGE MODE DESCRIPTOR DATA ARRAY FOR D2
C* STF2    = STORAGE MODE DESCRIPTOR DATA ARRAY FOR F2
C* STHE    = STORAGE MODE DESCRIPTOR DATA ARRAY FOR HE
C* STM2    = STORAGE MODE DESCRIPTOR DATA ARRAY FOR H2
C* STIRFNA = STORAGE MODE DESCRIPTOR DATA ARRAY FOR IRFNA
C* STMHM   = STORAGE MODE DESCRIPTOR DATA ARRAY FOR MMH
C* STNF3   = STORAGE MODE DESCRIPTOR DATA ARRAY FOR NF3
C* STN2    = STORAGE MODE DESCRIPTOR DATA ARRAY FOR N2
C* STN2H4  = STORAGE MODE DESCRIPTOR DATA ARRAY FOR N2H4
C* WFR2    = MASS FRACTION OF HE
C* WFR3    = MASS FRACTION OF N2
C* WFSR2   = MASS FRACTION OF HE
C* WFSR3   = MASS FRACTION OF N2
C*
C* INPUT/OUTPUT VARIABLES:
C*
C* EREACT  = ALPHANUMERIC SYMBOL FOR THE EJECTOR PRIMARY REACTANT
C* FAIL    = ERROR FLAG
C* K       = STORAGE MODE CONTROL ARRAY
C* NBRANK  = NUMBER OF LASER BANKS
C* NEJECT  = NUMBER OF EJECTORS PER BANK
C*         = 0. FOR THE MAXIMUM ALLOWABLE
C* RTIME   = RUN TIME (S)
C* SCSS2   = CONTROL VARIABLE
C* SETSCS  = CONTROL VARIABLE
C* WPP3    = FREE FLUORINE MASS FLOW RATE (KG/S)
C*
INSCS 0100
INSCS 0110
INSCS 0120
INSCS 0130
*INSCS 0140
*INSCS 0150
*INSCS 0160
INSCS 0170
INSCS 0180
INSCS 0190
*INSCS 0200
*INSCS 0210
*INSCS 0220
*INSCS 0230
*INSCS 0240
*INSCS 0250
*INSCS 0260
*INSCS 0270
*INSCS 0280
*INSCS 0290
*INSCS 0300
*INSCS 0310
*INSCS 0320
*INSCS 0330
*INSCS 0340
*INSCS 0350
*INSCS 0360
*INSCS 0370
*INSCS 0380
*INSCS 0390
*INSCS 0400
*INSCS 0410
*INSCS 0420
*INSCS 0430
*INSCS 0440
*INSCS 0450
*INSCS 0460
*INSCS 0470
*INSCS 0480
*INSCS 0490
*INSCS 0500
*INSCS 0510
*INSCS 0520
*INSCS 0530
*INSCS 0540
*INSCS 0550
*INSCS 0560
*INSCS 0570
*INSCS 0580
*INSCS 0590
*INSCS 0600
*INSCS 0610
*INSCS 0620
*INSCS 0630
*INSCS 0640
```


C*****	INSCS	1200
C*	*INSCS	1210
C*	*INSCS	1220
C*	*INSCS	1230
C*****	INSCS	1240
C	INSCS	1250
C	INSCS	1260
IF (SETSCS.EQ.NO) GO TO 102	INSCS	1270
EREACT=10H1RFNA/MMH	INSCS	1280
K(2)=1	INSCS	1290
K(3)=1	INSCS	1300
K(4)=1	INSCS	1310
K(5)=1	INSCS	1320
K(6)=1	INSCS	1330
K(7)=1	INSCS	1340
K(8)=1	INSCS	1350
K(9)=1	INSCS	1360
K(10)=1	INSCS	1370
NBANK=1	INSCS	1380
NEJECT=1	INSCS	1390
RTIME=60.0	INSCS	1400
SCSS2=YES	INSCS	1410
DO 101 I=1,10	INSCS	1420
101 STMDE(I,)=DESCR(I)	INSCS	1430
WPP3=1.69645	INSCS	1440
SETSCS=NO	INSCS	1450
C	INSCS	1460
C	INSCS	1470
C*****	INSCS	1480
C*	*INSCS	1490
C*	*INSCS	1500
C*	*INSCS	1510
C*****	INSCS	1520
C	INSCS	1530
C	INSCS	1540
102 WRITE(6,310)	INSCS	1550
READ(5,304)SCSS1	INSCS	1560
IF (SCSS1.EQ.NO) RETURN	INSCS	1570
WRITE(6,311)	INSCS	1580
READ(5,304)SCSS2	INSCS	1590
IF (SCSS2.EQ.NO) RETURN	INSCS	1600
WRITE(6,312)	INSCS	1610
READ(5,304)SCSS3	INSCS	1620
IF (SCSS3.EQ.NO) GO TO 103	INSCS	1630
REWIND 4	INSCS	1640
READ(4)EREACT,(K(I),I=2,10),NBANK,NEJECT,RTIME,SCSS2,WPP3	INSCS	1650
RETURN	INSCS	1660
103 WRITE(6,313)	INSCS	1670
IF (EJECT.NE.CAE.AND.EJECT.NE.SSE) WRITE(6,314)NBANK,RTIME,WPP3	INSCS	1680
IF (EJECT.EQ.CAF.OR.EJECT.EQ.SSE) WRITE(6,315)NBANK,NEJECT,RTIME,	INSCS	1690
-WPP3	INSCS	1700
READ(5,NLSCS)	INSCS	1710
WRITE(6,316)	INSCS	1720
READ(5,304)SCSS4	INSCS	1730
IF (SCSS4.EQ.NO) GO TO 118	INSCS	1740

C		INSCS	1750
C		INSCS	1760
C	.....	INSCS	1770
C*		INSCS	1780
C*	LASER PRIMARY & SECONDARY REACTANT STORAGE MODE SELECTION	INSCS	1790
C*		INSCS	1800
C	.....	INSCS	1810
C		INSCS	1820
C		INSCS	1830
	WRITE(6,317)	INSCS	1840
	IF(DFORMF.EQ.DF) GO TO 105	INSCS	1850
	IF(N1.EQ.0.AND.N2.EQ.2) GO TO 104	INSCS	1860
	GO TO 119	INSCS	1870
104	WRITE(6,320)STD2(1,1)	INSCS	1880
	WRITE(6,308)(TITLE(L),L=1,5),(STMODE(I,1),(STD2(I,L),L=1,4),	INSCS	1890
	-I=2,10)	INSCS	1900
	GO TO 108	INSCS	1910
105	IF(N1.EQ.2.AND.N2.EQ.4) GO TO 106	INSCS	1920
	IF(N1.EQ.0.AND.N2.EQ.2) GO TO 107	INSCS	1930
	GO TO 120	INSCS	1940
106	WRITE(6,320)STC2H4(1,1)	INSCS	1950
	WRITE(6,307)(TITLE(L),L=1,3),(STMODE(I,1),(SYC2H4(I,L),L=1,2),	INSCS	1960
	-I=2,10)	INSCS	1970
	GO TO 108	INSCS	1980
107	WRITE(6,320)STH2(1,1)	INSCS	1990
	WRITE(6,308)(TITLE(L),L=1,5),(STMODE(I,1),(STH2(I,L),L=1,4),	INSCS	2000
	-I=2,10)	INSCS	2010
108	READ(5,303)K(2)	INSCS	2020
	IF(N3.EQ.1.AND.N4.EQ.3) GO TO 109	INSCS	2030
	IF(N3.EQ.0.AND.N4.EQ.2) GO TO 110	INSCS	2040
	GO TO 121	INSCS	2050
109	WRITE(6,320)STNF3(1,1)	INSCS	2060
	WRITE(6,308)(TITLE(L),L=1,5),(STMODE(I,1),(STNF3(I,L),L=1,4),	INSCS	2070
	-I=2,10)	INSCS	2080
	GO TO 111	INSCS	2090
110	WRITE(6,320)STF2(1,1)	INSCS	2100
	WRITE(6,308)(TITLE(L),L=1,5),(STMODE(I,1),(STF2(I,L),L=1,4),	INSCS	2110
	-I=2,10)	INSCS	2120
111	READ(5,303)K(5)	INSCS	2130
	IF(K(5).LT.3.AND.WFSR2.EQ.0.0) GO TO 112	INSCS	2140
	IF(WFPR2.EQ.0.0.AND.WFSR2.EQ.0.0) GO TO 112	INSCS	2150
	WRITE(6,320)STHE(1,1)	INSCS	2160
	WRITE(6,308)(TITLE(L),L=1,5),(STMODE(I,1),(STHE(I,L),L=1,4),	INSCS	2170
	-I=2,10)	INSCS	2180
	READ(5,303)K(3)	INSCS	2190
112	IF(WFPR3.EQ.0.0.AND.WFSR3.EQ.0.0) GO TO 113	INSCS	2200
	WRITE(6,320)STN2(1,1)	INSCS	2210
	WRITE(6,308)(TITLE(L),L=1,5),(STMODE(I,1),(STN2(I,L),L=1,4),	INSCS	2220
	-I=2,10)	INSCS	2230
	WRITE(6,309)(TITLE(L),L=6,10),(STMODE(I,1),(STN2(I,L),L=5,8),	INSCS	2240
	-I=2,10)	INSCS	2250
	READ(5,303)K(4)	INSCS	2260
113	IF(DFORMF.EQ.DF) GO TO 114	INSCS	2270
	WRITE(6,320)STH2(1,1)	INSCS	2280
	WRITE(6,308)(TITLE(L),L=1,5),(STMODE(I,1),(STH2(I,L),L=1,4),	INSCS	2290

```
-I=2,10)                                INSCS 2300
GO TO 115                                INSCS 2310
114 WRITE(6,320)STD2(1,1)                 INSCS 2320
WRITE(6,308)(TITLE(L),L=1,5),(STMODE(I,1),(STD2(I,L),L=1,4), INSCS 2330
-I=2,10)                                INSCS 2340
115 READ(5,303)K(6)                      INSCS 2350
C                                         INSCS 2360
C                                         INSCS 2370
C.....INSCS 2380
C*                                         INSCS 2390
C* AERO-WINDOW FLUID STORAGE MODE SELECTION INSCS 2400
C*                                         INSCS 2410
C.....INSCS 2420
C                                         INSCS 2430
C                                         INSCS 2440
C                                         INSCS 2450
WRITE(6,318)                             INSCS 2460
WRITE(6,320)STAW(1,1)                   INSCS 2470
WRITE(6,308)(TITLE(L),L=1,5),(STMODE(I,1),(STAW(I,L),L=1,4), INSCS 2480
-I=2,10)                                INSCS 2490
READ(5,303)K(7)                         INSCS 2500
C                                         INSCS 2510
C.....INSCS 2520
C*                                         INSCS 2530
C* COOLING SYSTEM FLUID STORAGE MODE SELECTION INSCS 2540
C*                                         INSCS 2550
C.....INSCS 2560
C                                         INSCS 2570
C                                         INSCS 2580
C                                         INSCS 2590
WRITE(6,319)                             INSCS 2600
WRITE(6,320)STCS(1,1)                   INSCS 2610
WRITE(6,301)                             INSCS 2620
WRITE(6,308)(TITLE(L),L=1,5),(STMODE(I,1),(STCS(I,L),L=1,4), INSCS 2630
-I=2,10)                                INSCS 2640
WRITE(6,302)                             INSCS 2650
WRITE(6,306)(TITLE(L),L=6,7),(STMODE(I,1),STCS(I,5),I=2,10) INSCS 2660
READ(5,303)K(8)                         INSCS 2670
C                                         INSCS 2680
C.....INSCS 2690
C*                                         INSCS 2700
C* EJECTOR PRIMARY REACTANT STORAGE MODE SELECTION INSCS 2710
C*                                         INSCS 2720
C.....INSCS 2730
C                                         INSCS 2740
C                                         INSCS 2750
C                                         INSCS 2760
IF(EJECT.NE.CAE.AND.FJECT.NE.SSE) GO TO 11A INSCS 2770
WRITE(6,321)                             INSCS 2780
READ(5,305)EREACT                       INSCS 2790
IF(EREACT.EQ.10HN2H4 ) GO TO 116        INSCS 2800
IF(EREACT.EQ.10H1RFNA/MMH ) GO TO 117   INSCS 2810
GO TO 122                                INSCS 2820
116 WRITE(6,320)STN2H4(1,1)              INSCS 2830
WRITE(6,308)(TITLE(L),L=1,5),(STMODE(I,1),(STN2H4(I,L),L=1,4), INSCS 2840
-I=2,10)
```

	READ(5,303)K(9)	INSCS 2850
	RETURN	INSCS 2860
117	WRITE(6,320)STMMH(1,1)	INSCS 2870
	WRITE(6,308)(TITLE(L),L=1,5),(STMODE(I,1),(STMMH(I,L),L=1,4),	INSCS 2880
	-I=2,10)	INSCS 2890
	READ(5,303)K(9)	INSCS 2900
	WRITE(6,320)STIRFNA(1,1)	INSCS 2910
	WRITE(6,308)(TITLE(L),L=1,5),(STMODE(I,1),(STIRFNA(I,L),L=1,4),	INSCS 2920
	-I=2,10)	INSCS 2930
	READ(5,303)K(10)	INSCS 2940
118	REWIND 4	INSCS 2950
	WRITE(4)EREACT,(K(I),I=2,10),NBANK,NEJECT,RTIME,SCSS2,WPP3	INSCS 2960
	RETURN	INSCS 2970
C		INSCS 2980
C		INSCS 2990
C	.....	INSCS 3000
C*		*INSCS 3010
C*	FAILURE INDICATORS	*INSCS 3020
C*		*INSCS 3030
C	.....	INSCS 3040
C		INSCS 3050
C		INSCS 3060
119	WRITE(6,201)N1,N2	INSCS 3070
	GO TO 123	INSCS 3080
120	WRITE(6,202)N1,N2	INSCS 3090
	GO TO 123	INSCS 3100
121	WRITE(6,203)N3,N4	INSCS 3110
	GO TO 123	INSCS 3120
122	WRITE(6,204)EREACT	INSCS 3130
123	FAIL=YES	INSCS 3140
C		INSCS 3150
C		INSCS 3160
C	.....	INSCS 3170
C*		*INSCS 3180
C*	FORMAT STATEMENTS	*INSCS 3190
C*		*INSCS 3200
C	.....	INSCS 3210
C		INSCS 3220
C		INSCS 3230
201	FORMAT(*1*,T2,*NO TANK VOLUME/MASS SUBROUTINE EXITS FOR C*,I1,*D*,	INSCS 3240
	-I1,/,T2,*PROGRAM TERMINATED IN SUBROUTINE INSCS*)	INSCS 3250
202	FORMAT(*1*,T2,*NO TANK VOLUME/MASS SUBROUTINE EXITS FOR C*,I1,*H*,	INSCS 3260
	-I1,/,T2,*PROGRAM TERMINATED IN SUBROUTINE INSCS*)	INSCS 3270
203	FORMAT(*1*,T2,*NO TANK VOLUME/MASS SUBROUTINE EXITS FOR N*,I1,*F*,	INSCS 3280
	-I1,/,T2,*PROGRAM TERMINATED IN SUBROUTINE INSCS*)	INSCS 3290
204	FORMAT(*1*,T2,*NO TANK VOLUME/MASS SUBROUTINE EXITS FOR *,A10,/,	INSCS 3300
	-T2,*PROGRAM TERMINATED IN SUBROUTINE INSCS*)	INSCS 3310
301	FORMAT(*Q*)	INSCS 3320
302	FORMAT(*R*)	INSCS 3330
303	FORMAT(I1)	INSCS 3340
304	FORMAT(A3)	INSCS 3350
305	FORMAT(A10)	INSCS 3360
306	FORMAT(*1*,9(T2,2A12,/,T2,2A12)	INSCS 3370
307	FORMAT(* *,9(T2,3A12,/,T2,3A12)	INSCS 3380
308	FORMAT(* *,9(T2,5A12,/,T2,5A12)	INSCS 3390

```

309 FORMAT(10,9(T2,5A12,/,),T2,5A12) INSCS 3400
310 FORMAT(10,T2,ARE NEW SYSTEM CALCULATION INPUTS REQUIRED?,/) INSCS 3410
311 FORMAT(10,T2,ARE SYSTEM CALCULATIONS DESIRED?,/) INSCS 3420
312 FORMAT(100,T2,SHOULD INPUT DATA BE READ FROM TAPE4?,/) INSCS 3430
313 FORMAT(10,T2,INPUT DATA FOR THE SYSTEM CALCULATION SECTION BY MAIN INSCS 3440
-MELIST,/,T2,CURRENT VALUES ARE:*) INSCS 3450
314 FORMAT(10,T2,SNLSCS,T26,NBANK **I13,T50,RTIME **E13.6, INSCS 3460
-/,T2,WPP3 **E13.6,* $,/) INSCS 3470
315 FORMAT(10,T2,SNLSCS,T26,NBANK **I13,T50,NFJFCT **I13,/, INSCS 3480
-T2,RTIME **E13.6,T26,WPP3 **E13.6,* $,/) INSCS 3490
316 FORMAT(10,T2,ARE NEW REACTANT STORAGE MODES REQUIRED?,/) INSCS 3500
317 FORMAT(10,////,T2,LASER PRIMARY & SECONDARY REACTANT STORAGE INSCS 3510
-INPUT SECTION*) INSCS 3520
318 FORMAT(10,////,T2,AERO-WINDOW FLUID STORAGE INPUT SECTION*) INSCS 3530
319 FORMAT(10,////,T2,COOLING SYSTEM FLUID STORAGE INPUT SECTION*) INSCS 3540
320 FORMAT(10,T2,A6,MAY BE STORED ANY OF THE FOLLOWING WAYS, INPUT INSCS 3550
-K,*) INSCS 3560
321 FORMAT(10,T2,INPUT THE EJECTOR PRIMARY REACTANT FROM THE FOLLOW INSCS 3570
-NO LIST:,,/T2,***N?MAN FOR A MONOPROPELLANT DRIVER,/,T2, INSCS 3580
-***INFNA/MMH FOR A BIPROPELLANT DRIVER,/) INSCS 3590
END INSCS 3600

```



```

C*                                *OUTSCS 0650
C*.....OUTSCS 0660
C                                OUTSCS 0670
C                                OUTS S 0680
C                                OUTSCS 0690
      WRITE(20,205)XLP
      WRITE(20,206)MINJ,MCB,MBASE,VCOMB,MCAV,VCAV,MAW,VAV,MCS,VCS,MOPT,
-VOPT,MDS,MLRRE6,MLLINE,MLDNDW,VLDNDW,MLRT,VLRT,MLDS,VLDS
      IF(EJECT.EQ.NO) 80 TO 104
      IF(EJECT.EQ.CAE) 80 TO 101
      IF(EJECT.EQ.SSE) 80 TO 102
      WRITE(20,207)MSUPD,VSUPD,MSUBD,VSUBD,MPRS,VPRS
      80 TO 103
101  WRITE(20,208)MSUPD,VSUPD,MSUBD,VSUBD,MEJECT,VEJECT,MEERRE6,MELINE,
-MPRNDW,VPRNDW,MERT,VERT,MPRS,VPRS
      80 TO 103
102  WRITE(20,209)MEJECT,VEJECT,MEERRE6,MELINE,MPRNDW,MERT,VERT,MPRS,
-VPRS
103  WRITE(20,210)MLDS,VLDS,MPRS,VPRS,MNISC,MTOTAL,VTOTAL,VSYSN,WBASE,
-LLDS,LPRS,LBXDEV,WBXDEV,MBXDEV,VBXDEV
      RETURN
104  WRITE(20,211)MLDS,VLDS,MNISC,MTOTAL,VTOTAL,VSYSN,WBASE,LLDS,
-LBXDEV,WBXDEV,MBXDEV,VBXDEV
C                                OUTSCS 0670
C                                OUTSCS 0680
C*.....OUTSCS 0690
C*                                *OUTSCS 0900
C*                                *OUTSCS 0910
C*                                *OUTSCS 0920
C*.....OUTSCS 0930
C                                OUTSCS 0940
C                                OUTSCS 0950
201  FORMAT(01,T53,*SYSTEM CALCULATION SECTION*,//,T60,*INITIAL DATA*,
-)
202  FORMAT(00,T32,*NBANK **I13,T66,*RTIME **E13.6,* S*/.
-T32,*WPP3 **E13.6,* K6/S*)
203  FORMAT(00,T32,*EREACT **A13,T66,*NBANK **I13,/.
-T32,*MEJECT **I13,T66,*RTIME **E13.6,* S*/.
-T32,*WPP3 **E13.6,* K6/S*)
204  FORMAT(00,T55,*REACTANT STORAGE METHOD*,//,10(T32,A11,/.
-10(//,T32,SA11))
205  FORMAT(00,T59,*RESULTANT DATA*,//,T55,*SYSTEM SCALE-UP FACTOR*,
-//,T32,*XLP **E13.6,* KMOL/S*)
206  FORMAT(00,T51,*LASER DEVICE SYSTEM VOLUME/MASS*,//,
-T32,*MINJ **E13.6,* K6*/.T32,*MCB **E13.6,* K6*/.
-T32,*MBASE **E13.6,* K6*,T66,*VCOMB **E13.6,* M3*/.
-T32,*MCAV **E13.6,* K6*,T66,*VCAV **E13.6,* M3*/.
-T32,*MAW **E13.6,* K6*,T66,*VAV **E13.6,* M3*/.
-T32,*MCS **E13.6,* K6*,T66,*VCS **E13.6,* M3*/.
-T32,*MOPT **E13.6,* K6*,T66,*VOPT **E13.6,* M3*/.
-T32,*MDS **E13.6,* K6*/.T32,*MLRRE6 **E13.6,* K6*/.
-T32,*MLLINE **E13.6,* K6*/.T43,*-----*
-T77,*-----*/.T32,*MLDNDW **E13.6,* K6*,
-T66,*VLDNDW **E13.6,* M3*/.T32,*MLRT **E13.6,* K6*,
-T66,*VLRT **E13.6,* M3*/.T43,*-----*
-T77,*-----*/.T32,*MLDS **E13.6,* K6*,

```

	-T66,*VLDS **E13.6,* M3*)	OUTSCS 1200
207	FORMAT(*1*,T48,*PRESSURE RECOVERY SYSTEM VOLUME/MASS*,//,	OUTSCS 1210
	-T32,*MSUPD **E13.6,* KG*,T66,*VSUPD **E13.6,* M3*,//,	OUTSCS 1220
	-T32,*MSURD **E13.6,* KG*,T66,*VSUBD **E13.6,* M3*,//,	OUTSCS 1230
	-T43,*-----*T77,*-----*//,	OUTSCS 1240
	-T32,*MPRS **E13.6,* KG*,T66,*VPRS **E13.6,* M3*)	OUTSCS 1250
208	FORMAT(*1*,T48,*PRESSURE RECOVERY SYSTEM VOLUME/MASS*,//,	OUTSCS 1260
	-T32,*MSUPD **E13.6,* KG*,T66,*VSUPD **E13.6,* M3*,//,	OUTSCS 1270
	-T32,*MSUBD **E13.6,* KG*,T66,*VSUBD **E13.6,* M3*,//,	OUTSCS 1280
	-T32,*MEJECT **E13.6,* KG*,T66,*VEJECT **E13.6,* M3*,//,	OUTSCS 1290
	-T32,*MERREG **E13.6,* KG*,//T32,*MELINE **E13.6,* KG*,//,	OUTSCS 1300
	-T43,*-----*T77,*-----*//,	OUTSCS 1310
	-T32,*MPRMDW **E13.6,* KG*,T66,*VPRMDW **E13.6,* M3*,//,	OUTSCS 1320
	-T32,*MFRT **E13.6,* KG*,T66,*VERT **E13.6,* M3*,//,	OUTSCS 1330
	-T43,*-----*T77,*-----*//,	OUTSCS 1340
	-T32,*MPRS **E13.6,* KG*,T66,*VPRS **E13.6,* M3*)	OUTSCS 1350
209	FORMAT(*1*,T48,*PRESSURE RECOVERY SYSTEM VOLUME/MASS*,//,	OUTSCS 1360
	-T32,*MEJECT **E13.6,* KG*,T66,*VEJECT **E13.6,* M3*,//,	OUTSCS 1370
	-T32,*MERREG **E13.6,* KG*,//T32,*MELINE **E13.6,* KG*,//,	OUTSCS 1380
	-T43,*-----*//T32,*MPRMDW **E13.6,* KG*,//,	OUTSCS 1390
	-T32,*MFRT **E13.6,* KG*,T66,*VERT **E13.6,* M3*,//,	OUTSCS 1400
	-T43,*-----*T77,*-----*//,	OUTSCS 1410
	-T32,*MPRS **E13.6,* KG*,T66,*VPRS **E13.6,* M3*)	OUTSCS 1420
210	FORMAT(*0*,T53,*SYSTEM VOLUME/MASS SUMMARY*,//,	OUTSCS 1430
	-T32,*MLDS **E13.6,* KG*,T66,*VLDS **E13.6,* M3*,//,	OUTSCS 1440
	-T32,*MPRS **E13.6,* KG*,T66,*VPRS **E13.6,* M3*,//,	OUTSCS 1450
	-T32,*MMISC **E13.6,* KG*,//T43,*-----*//,	OUTSCS 1460
	-T77,*-----*//T32,*MTOTAL **E13.6,* KG*,	OUTSCS 1470
	-T66,*VTOTAL **E13.6,* M3*,//T66,*VSYSTEM **E13.6,* M3*,//,	OUTSCS 1480
	-T32,*WBASE **E13.6,* M*,T66,*LLDS **E13.6,* M*,//,	OUTSCS 1490
	-T32,*LPRS **E13.6,* M*,//T32,*LBXDEV **E13.6,* M*,	OUTSCS 1500
	-T66,*WBXDEV **E13.6,* M*,//T32,*HBXDEV **E13.6,* M*,	OUTSCS 1510
	-T66,*VRXDEV **E13.6,* M3*)	OUTSCS 1520
211	FORMAT(*1*,T53,*SYSTEM VOLUME/MASS SUMMARY*,//,	OUTSCS 1530
	-T32,*MLDS **E13.6,* KG*,T66,*VLDS **E13.6,* M3*,//,	OUTSCS 1540
	-T32,*MMISC **E13.6,* KG*,//T43,*-----*//,	OUTSCS 1550
	-T77,*-----*//T32,*MTOTAL **E13.6,* KG*,	OUTSCS 1560
	-T66,*VTOTAL **E13.6,* M3*,//T66,*VSYSTEM **E13.6,* M3*,//,	OUTSCS 1570
	-T32,*WBASE **E13.6,* M*,T66,*LLDS **E13.6,* M*,//,	OUTSCS 1580
	-T32,*LBXDEV **E13.6,* M*,T66,*VRXDEV **E13.6,* M*,//,	OUTSCS 1590
	-T32,*HBXDEV **E13.6,* M*,T66,*VBXDEV **E13.6,* M3*)	OUTSCS 1600
	END	OUTSCS 1610

```

SUBROUTINE VMAW(J,MN2,RTIME,MTANK,VTANK)
C
C
C.....
C*
C*      AERO-WINDOW TANK VOLUME/MASS SUBROUTINE (VMAW)
C*
C*.....
C
C.....
C*
C*      SUBROUTINE VMAW CALCULATES THE N2 TANK VOLUME/MASS FOR THE
C*      AERO-WINDOW.
C*
C*      N2 FOR THE AERO-WINDOW MAY BE STORED ANY OF FOUR WAYS:
C*
C*      K          1          2          3          4
C*      PHASE      GAS          GAS          LIQ          LIQ
C*      CONT       SPH          CYL          SPH          SPH
C*      STMP       300.0 K      300.0 K      77.5 K      77.5 K
C*      STIME      INFINITE     INFINITE     8.6E+05 S    1.6E+07 S
C*                                   (10 DAY)    (180 DAY)
C*      SPRES      4.1E+07 PA    4.1E+07 PA    1.5E+06 PA    1.5E+06 PA
C*                                   (6000 PSI)   (220 PSI)
C*      RFSYS      BLD          BLD          HPS          HPS
C*      MATER      TI           TI           SS           SS
C*
C*      INPUT VARIABLES:
C*
C*      J          = STORAGE MODE CONTROL VARIABLE
C*      K          = STORAGE MODE CONTROL ARRAY
C*      MN2        = TOTAL DELIVERED MASS OF N2 (KG)
C*      RTIME      = RUN TIME (S)
C*
C*      OUTPUT VARIABLES:
C*
C*      MTANK      = TANK MASS (KG)
C*      STAW       = STORAGE MODE DESCRIPTOR DATA ARRAY
C*      STMODE     = STORAGE MODE DESCRIPTOR ARRAY
C*      VTANK      = TANK VOLUME (M3)
C*
C*.....
C
C      IMPLICIT REAL(M)
C
C      COMMON/SCS4/K(10)
C
C      COMMON/SCS5/STMODE(10,10)
C
C      COMMON/SCS6/STAW(10,4)
C
C      DATA ((STAW(I,K),K=1,4),I=1,10)/
C      -10MN2-AW ,10MN2-AW ,10MN2-AW ,10MN2-AW ,
C      -10MRAS ,10MRAS ,10MLIQ ,10MLIQ ,
C
C.....

```

```

VMAW 0100
VMAW 0110
VMAW 0120
VMAW 0130
VMAW 0140
VMAW 0150
VMAW 0160
VMAW 0170
VMAW 0180
VMAW 0190
VMAW 0200
VMAW 0210
VMAW 0220
VMAW 0230
VMAW 0240
VMAW 0250
VMAW 0260
VMAW 0270
VMAW 0280
VMAW 0290
VMAW 0300
VMAW 0310
VMAW 0320
VMAW 0330
VMAW 0340
VMAW 0350
VMAW 0360
VMAW 0370
VMAW 0380
VMAW 0390
VMAW 0400
VMAW 0410
VMAW 0420
VMAW 0430
VMAW 0440
VMAW 0450
VMAW 0460
VMAW 0470
VMAW 0480
VMAW 0490
VMAW 0500
VMAW 0510
VMAW 0520
VMAW 0530
VMAW 0540
VMAW 0550
VMAW 0560
VMAW 0570
VMAW 0580
VMAW 0590
VMAW 0600
VMAW 0610
VMAW 0620
VMAW 0630
VMAW 0640

```

-10MSPH	.10MSPH	.10MSPH	.10MSPH	VMAW	0650
-10M300.0 K	.10M300.0 K	.10M77.5 K	.10M77.5 K	VMAW	0660
-10MINFINITE	.10MINFINITE	.10M1.6E+05 S	.10M1.6E+07 S	VMAW	0670
-10M	.10M	.10M(10 DAY)	.10M(100 DAY)	VMAW	0680
-10M4.1E+07 PA	.10M4.1E+07 PA	.10M1.5E+06 PA	.10M1.5E+06 PA	VMAW	0690
-10M(6000 PSI)	.10M(6000 PSI)	.10M(220 PSI)	.10M(220 PSI)	VMAW	0700
-10MBLD	.10MBLD	.10MMP5	.10MMP5	VMAW	0710
-10MTI	.10MTI	.10MSS	.10MSS	VMAW	0720
C				VMAW	0730
C				VMAW	0740
C				VMAW	0750
C				VMAW	0760
C	SET STORAGE MODE DESCRIPTOR ARRAY			VMAW	0770
C				VMAW	0780
C				VMAW	0790
C				VMAW	0800
C				VMAW	0810
C	DO 101 I=1,10			VMAW	0820
101	STMODE(I,J)=STAW(I,K,J)			VMAW	0830
C				VMAW	0840
C				VMAW	0850
C				VMAW	0860
C				VMAW	0870
C	CALCULATE TANK VOLUME/MASS			VMAW	0880
C				VMAW	0890
C				VMAW	0900
C				VMAW	0910
C				VMAW	0920
C	80 TO (102,103,104,105),K(J)			VMAW	0930
C				VMAW	0940
C				VMAW	0950
C				VMAW	0960
C				VMAW	0970
C	GAS STORAGE (300 K)			VMAW	0980
C				VMAW	0990
C				VMAW	1000
C				VMAW	1010
C				VMAW	1020
102	MTANK=MTANK+3.26960*MN2			VMAW	1030
-	+0.284938*MN2** (2.0/3.0)			VMAW	1040
-	+30.8400*MN2/RTIME			VMAW	1050
-	VTANK=VTANK+3.32512E-03*MN2			VMAW	1060
-	+1.45542E-02*MN2/RTIME			VMAW	1070
-	RETURN			VMAW	1080
103	MTANK=MTANK+3.90631*MN2			VMAW	1090
-	+0.629548*MN2** (2.0/3.0)			VMAW	1100
-	+30.8400*MN2/RTIME			VMAW	1110
-	VTANK=VTANK+3.32512E-03*MN2			VMAW	1120
-	+1.45542E-02*MN2/RTIME			VMAW	1130
-	RETURN			VMAW	1140
C				VMAW	1150
C				VMAW	1160
C				VMAW	1170
C				VMAW	1180
C	4PS LIQUID STORAGE (77.5 K)			VMAW	1190

C*		*VMAW	1200
C*****		*VMAW	1210
C		VMAW	1220
C		VMAW	1230
104	MVT=1.22861*MN2	VMAW	1240
-	+0.882613*MN2** (2.0/3.0)	VMAW	1250
-	+0.127222*MN2** (1.0/3.0)	VMAW	1260
-	+50.6600*MN2/RTIME	VMAW	1270
	MMT=1.19593*MN2	VMAW	1280
-	+1.13820*MN2** (2.0/3.0)	VMAW	1290
-	+0.127222*MN2** (1.0/3.0)	VMAW	1300
-	+50.6600*MN2/RTIME	VMAW	1310
	MTANK=MTANK+AMAX1 (MVT,MMT)	VMAW	1320
	VTANK=VTANK+1.49639E-03*MN2	VMAW	1330
-	+9.95326E-04*MN2** (2.0/3.0)	VMAW	1340
-	+2.20679E-04*MN2** (1.0/3.0)	VMAW	1350
-	+3.16948E-02*MN2/RTIME	VMAW	1360
	RETURN	VMAW	1370
105	MVT=1.20968*MN2	VMAW	1380
-	+1.99684*MN2** (2.0/3.0)	VMAW	1390
-	+2.07277*MN2** (1.0/3.0)	VMAW	1400
-	+50.6600*MN2/RTIME	VMAW	1410
	MMT=1.17700*MN2	VMAW	1420
-	+2.25223*MN2** (2.0/3.0)	VMAW	1430
-	+2.07277*MN2** (1.0/3.0)	VMAW	1440
-	+50.6600*MN2/RTIME	VMAW	1450
	MTANK=MTANK+AMAX1 (MVT,MMT)	VMAW	1460
	VTANK=VTANK+1.49639E-03*MN2	VMAW	1470
-	+4.97663E-03*MN2** (2.0/3.0)	VMAW	1480
-	+5.51700E-03*MN2** (1.0/3.0)	VMAW	1490
-	+3.16948E-02*MN2/RTIME	VMAW	1500
	END	VMAW	1510

```

      SUBROUTINE VMCS(J,MH2O,RTIME,MCS,VCS)
      VMCS 0100
      C VMCS 0110
      C VMCS 0120
      C .....VMCS 0130
      C .....VMCS 0140
      C COOLING SYSTEM VOLUME/MASS SUBROUTINE (VMCS)
      C .....VMCS 0150
      C .....VMCS 0160
      C .....VMCS 0170
      C VMCS 0180
      C .....VMCS 0190
      C .....VMCS 0200
      C SURROUTINE VMCS CALCULATED THE VOLUME/MASS FOR THE COOLING SYSTEM
      C INCLUDING HARDWARE AND H2O STORAGE TANK.
      C .....VMCS 0210
      C .....VMCS 0220
      C .....VMCS 0230
      C H2O FOR THE COOLING SYSTEM MAY BE STORED ANY OF FIVE WAYS:
      C .....VMCS 0240
      C .....VMCS 0250
      C K 1 2 3 4
      C PHASE LIQ LIQ LIQ LIQ
      C CONT SPH CYL SPH CYL
      C STEMP 300.0 K 300.0 K 300.0 K 300.0 K
      C STIME INFINITE INFINITE INFINITE INFINITE
      C SPRFS 2.8E+06 PA 2.8E+06 PA 1 ATM 1 ATM
      C (400 PSI) (400 PSI)
      C RFSYS PGS PGS PGS PGS
      C WATER TI TI AL AL
      C .....VMCS 0350
      C K 5
      C PHASE LIQ
      C CONT SPH
      C STEMP 368-388 K
      C STIME INFINITE
      C SPRES 1 ATM
      C RFSYS RFP
      C WATER AL
      C .....VMCS 0430
      C .....VMCS 0440
      C INPUT VARIABLES:
      C .....VMCS 0450
      C .....VMCS 0460
      C J = STORAGE MODE CONTROL VARIABLE
      C K = STORAGE MODE CONTROL ARRAY
      C MH2O = TOTAL DELIVERED MASS OF H2O (KG)
      C RTIME = RUN TIME (S)
      C .....VMCS 0500
      C .....VMCS 0510
      C OUTPUT VARIABLES:
      C .....VMCS 0520
      C .....VMCS 0530
      C MCS = COOLING SYSTEM MASS (KG)
      C STCS = STORAGE MODE DESCRIPTOR DATA ARRAY
      C STNGDE = STORAGE MODE DESCRIPTOR ARRAY
      C VCS = COOLING SYSTEM VOLUME (M3)
      C .....VMCS 0580
      C .....VMCS 0590
      C .....VMCS 0600
      C .....VMCS 0610
      C IMPLICIT REAL(M)
      C .....VMCS 0620
      C .....VMCS 0630
      C COMMON/SC54/K(10)
      C .....VMCS 0640

```

C		VMCS	0650
	COMMON/SCS5/SYMODE(10,10)	VMCS	0660
C		VMCS	0670
	COMMON/SCS7/STCS(10,5)	VMCS	0680
C		VMCS	0690
	DATA ((STCS(I,K),K=1,4),I=1,10)/	VMCS	0700
	-10MM20-CS .10MM20-CS .10MM20-CS .10MM20-CS .	VMCS	0710
	-10MLIQ .10MLIQ .10MLIQ .10MLIQ .	VMCS	0720
	-10MSPH .10MSPH .10MSPH .10MSPH .	VMCS	0730
	-10M300.0 K .10M300.0 K .10M300.0 K .10M300.0 K .	VMCS	0740
	-10MINFINITE .10MINFINITE .10MINFINITE .10MINFINITE .	VMCS	0750
	-10M .10M .10M .10M .	VMCS	0760
	-10MP.8E+06 PA.10M2.8E+06 PA.10M1 ATM .10M1 ATM .	VMCS	0770
	-10M(400 PSI) .10M(400 PSI) .10M .10M .	VMCS	0780
	-10MPGS .10MPGS .10MPGS .10MPGS .	VMCS	0790
	-10MTI .10MTI .10HAL .10HAL /	VMCS	0800
	DATA (STCS(I,3),I=1,10)/	VMCS	0810
	-10MM20-CS .	VMCS	0820
	-10MLIQ .	VMCS	0830
	-10MSPH .	VMCS	0840
	-10M360-360 K .	VMCS	0850
	-10MINFINITE .	VMCS	0860
	-10M .	VMCS	0870
	-10M1 ATM .	VMCS	0880
	-10M .	VMCS	0890
	-10MREF .	VMCS	0900
	-10HAL /	VMCS	0910
C		VMCS	0920
C		VMCS	0930
C	.....	VMCS	0940
C*		VMCS	0950
C*	SET STORAGE MODE DESCRIPTOR ARRAY	VMCS	0960
C*		VMCS	0970
C	.....	VMCS	0980
C		VMCS	0990
C		VMCS	1000
	DO 101 I=1,10	VMCS	1010
101	STMODE(I,J)=STCS(I,K(J))	VMCS	1020
C		VMCS	1030
C		VMCS	1040
C	.....	VMCS	1050
C*		VMCS	1060
C*	CALCULATE COOLING SYSTEM VOLUME/MASS	VMCS	1070
C*		VMCS	1080
C	.....	VMCS	1090
C		VMCS	1100
C		VMCS	1110
	GO TO (102,103,104,105,106),K(J)	VMCS	1120
C		VMCS	1130
C		VMCS	1140
C	.....	VMCS	1150
C*		VMCS	1160
C*	P95 LIQUID STORAGE (300.0 K)	VMCS	1170
C*		VMCS	1180
C	.....	VMCS	1190

APPENDIX F
SUBROUTINE VMCS

CHEMICAL LASER ANALYSIS PROGRAM (CLAP)
OVERLAY SCS

PAGE E-27

C		VMCS	1200
C		VMCS	1210
102	MVT=1.31266*MM20	VMCS	1220
-	+0.144270*MM20** (2.0/3.0)	VMCS	1230
-	MMT=1.26542*MM20	VMCS	1240
-	+0.268637*MM20** (2.0/3.0)	VMCS	1250
-	MCS=AMAX1(MVT,MMT)	VMCS	1260
-	VCS=1.34760E-03*MM20	VMCS	1270
-	RETURN	VMCS	1280
103	MVT=1.30400*MM20	VMCS	1290
-	+0.278414*MM20** (2.0/3.0)	VMCS	1300
-	MMT=1.24362*MM20	VMCS	1310
-	+0.553176*MM20** (2.0/3.0)	VMCS	1320
-	MCS=AMAX1(MVT,MMT)	VMCS	1330
-	VCS=1.34760E-03*MM20	VMCS	1340
-	RETURN	VMCS	1350
C		VMCS	1360
C		VMCS	1370
C	.....	VMCS	1380
C		VMCS	1390
C	PFS LIQUID STORAGE (300.0 K)	VMCS	1400
C		VMCS	1410
C	.....	VMCS	1420
C		VMCS	1430
C		VMCS	1440
104	MCS=1.19153*MM20	VMCS	1450
-	+0.346386*MM20** (2.0/3.0)	VMCS	1460
-	+3.62274*(MM20/RTIME)** (2.0/3.0)	VMCS	1470
-	+2.08062*(MM20/RTIME)** (1.0/3.0)	VMCS	1480
-	VCS=1.22931E-03*MM20	VMCS	1490
-	+2.28810E-03*(MM20/RTIME)** (2.0/3.0)	VMCS	1500
-	+1.31411E-03*(MM20/RTIME)** (1.0/3.0)	VMCS	1510
-	RETURN	VMCS	1520
105	MCS=1.16953*MM20	VMCS	1530
-	+0.745310*MM20** (2.0/3.0)	VMCS	1540
-	+3.62274*(MM20/RTIME)** (2.0/3.0)	VMCS	1550
-	+2.08062*(MM20/RTIME)** (1.0/3.0)	VMCS	1560
-	VCS=1.22931E-03*MM20	VMCS	1570
-	+2.28810E-03*(MM20/RTIME)** (2.0/3.0)	VMCS	1580
-	+1.31411E-03*(MM20/RTIME)** (1.0/3.0)	VMCS	1590
-	RETURN	VMCS	1600
C		VMCS	1610
C		VMCS	1620
C	.....	VMCS	1630
C		VMCS	1640
C	RFP LIQUID STORAGE (368-388 K)	VMCS	1650
C		VMCS	1660
C	.....	VMCS	1670
C		VMCS	1680
C		VMCS	1690
106	MCS=46.0	VMCS	1700
-	+2.06716E-02*MM20	VMCS	1710
-	+22.3800*MM20/RTIME	VMCS	1720
-	+26.3317*(MM20/RTIME)** (2.0/3.0)	VMCS	1730
-	+2.49379*(MM20/RTIME)** (1.0/3.0)	VMCS	1740

APPENDIX F
SURROUTINE VMCS

CHEMICAL LASER ANALYSIS PROGRAM (CLAP)
OVERLAY SCS

PAGE E-28

```

VCS=4.50098E-02
-   +2.11566E-04*MM20
-   +2.3445AE-02*MM20/RTIME
-   +2.87723E-02*(MM20/RTIME)**(2.0/3.0)
-   +1.57507E-03*(MM20/RTIME)**(1.0/3.0)
RETURN
END

```

```

VMCS 1750
VMCS 1760
VMCS 1770
VMCS 1780
VMCS 1790
VMCS 1800
VMCS 1810

```

```

SUBROUTINE VMC2H4(J,MC2H4,P0,MTANK,VTANK)
C
C
C.....
C*
C*          C2H4 TANK VOLUME/MASS SUBROUTINE (VMC2H4)
C*
C*.....
C
C.....
C*
C* SURROUTINE VMC2H4 CALCULATES THE TANK VOLUME/MASS FOR THE STORAGE
C* OF C2H4.
C*
C* C2H4 MAY BE STORED ANY OF TWO WAYS:
C*
C*      K      1      2
C* PHASE      GAS      GAS
C* CONT       SPM      CYL
C* STMP       300.0 K   300.0 K
C* STIME      INFINITE INFINITE
C* SPRES      4.1E+07 PA 4.1E+07 PA
C*            (6000 PSI) (6000 PSI)
C* RFSYS      RLD      RLD
C* WATER      TI       TI
C*
C* INPUT VARIABLES:
C*
C* J      = STORAGE MODE CONTROL VARIABLE
C* K      = STORAGE MODE CONTROL ARRAY
C* MC2H4  = TOTAL DELIVERED MASS OF C2H4 (KG)
C* P0     = COMBUSTOR OR NOZZLE STAGNATION PRESSURE (PA)
C*
C* OUTPUT VARIABLES:
C*
C* MTANK  = TANK MASS (KG)
C* STC2H4 = STORAGE MODE DESCRIPTOR DATA ARRAY
C* STMODE = STORAGE MODE DESCRIPTOR ARRAY
C* VTANK  = TANK VOLUME (M3)
C*
C.....
C
C      IMPLICIT REAL(M)
C
C      COMMON/SCS4/K(10)
C
C      COMMON/SCS5/STMODE(10,10)
C
C      COMMON/SCS6/STC2H4(10,2)
C
C      DATA ((STC2H4(I,K),K=1,2),I=1,10)/
C      -10MC2H4, 10MC2H4, .
C      -10MGAS, 10MGAS, .
C      -10MSPM, 10MCYL, .

```

```

VMC2H4 0100
VMC2H4 0110
VMC2H4 0120
VMC2H4 0130
VMC2H4 0140
VMC2H4 0150
VMC2H4 0160
VMC2H4 0170
VMC2H4 0180
VMC2H4 0190
VMC2H4 0200
VMC2H4 0210
VMC2H4 0220
VMC2H4 0230
VMC2H4 0240
VMC2H4 0250
VMC2H4 0260
VMC2H4 0270
VMC2H4 0280
VMC2H4 0290
VMC2H4 0300
VMC2H4 0310
VMC2H4 0320
VMC2H4 0330
VMC2H4 0340
VMC2H4 0350
VMC2H4 0360
VMC2H4 0370
VMC2H4 0380
VMC2H4 0390
VMC2H4 0400
VMC2H4 0410
VMC2H4 0420
VMC2H4 0430
VMC2H4 0440
VMC2H4 0450
VMC2H4 0460
VMC2H4 0470
VMC2H4 0480
VMC2H4 0490
VMC2H4 0500
VMC2H4 0510
VMC2H4 0520
VMC2H4 0530
VMC2H4 0540
VMC2H4 0550
VMC2H4 0560
VMC2H4 0570
VMC2H4 0580
VMC2H4 0590
VMC2H4 0600
VMC2H4 0610
VMC2H4 0620
VMC2H4 0630
VMC2H4 0640

```

APPENDIX F
SUBROUTINE VMC2H4

CHEMICAL LASER ANALYSIS PROGRAM (CLAP)
OVERLAY SC5

PAGE 2-39

```

-10M300.0 K      :10M300.0 K      .
-10MINFINITE     :10MINFINITE     .
-10M              :10M              .
-10M4.1E+07 PA.  :10M4.1E+07 PA.  .
-10M(6000 PSI).  :10M(6000 PSI).  .
-10MBLD          :10MBLD          .
-10MTI           :10MTI           /
C
C
C.....
C*
C*          SET STORAGE MODE DESCRIPTOR ARRAY
C*
C*.....
C
C
C      DO 101 I=1,10
101  STMODE(I,J)=STC2H4(I,K(J))
C
C
C.....
C*
C*          CALCULATE TANK VOLUME/MASS
C*
C*.....
C
C      AF=1.0/(1.0-(3.02162E-08*P0)**(1.0/1.23910))
GO TO (102,103),K(J)
102  MTANK=MTANK+2.46738*AF*MC2H4
      +0.219165*(AF*MC2H4)**(2.0/3.0)
      VTANK=VTANK+2.24304E-03*AF*MC2H4
      RETURN
103  MTANK=MTANK+2.89199*AF*MC2H4
      +0.484226*(AF*MC2H4)**(2.0/3.0)
      VTANK=VTANK+2.24304E-03*AF*MC2H4
      END
VNC2H4 0650
VNC2H4 0660
VNC2H4 0670
VNC2H4 0680
VNC2H4 0690
VNC2H4 0700
VNC2H4 0710
VNC2H4 0720
VNC2H4 0730
VNC2H4 0740
VNC2H4 0750
VNC2H4 0760
VNC2H4 0770
VNC2H4 0780
VNC2H4 0790
VNC2H4 0800
VNC2H4 0810
VNC2H4 0820
VNC2H4 0830
VNC2H4 0840
VNC2H4 0850
VNC2H4 0860
VNC2H4 0870
VNC2H4 0880
VNC2H4 0890
VNC2H4 0900
VNC2H4 0910
VNC2H4 0920
VNC2H4 0930
VNC2H4 0940
VNC2H4 0950
VNC2H4 0960
VNC2H4 0970
VNC2H4 0980
VNC2H4 0990
VNC2H4 1000
VNC2H4 1010

```

```

SUBROUTINE VMD2(J,P02,F0,M,TANK,VYANK)
C
C
C.....
C*
C*          D2 TANK VOLUME/MASS SUBROUTINE (VMD2)
C*
C.....
C          VMD2
C.....
C*
C* SURROUTINE VMD2 CALCULATES THE TANK VOLUME/MASS FOR THE STORAGE
C* OF D2.
C*
C* D2 MAY BE STORED ANY OF FOUR WAYS:
C*
C*      K      1      2      3      4
C* PHASE      GAS      GAS      GAS      GAS
C* CONT       SPH      CYL      SPH      SPH
C* STMP       300.0 K   300.0 K   77.5 K   77.5 K
C* STIME      INFINITE INFINITE  8.6E+05 S  1.6E+07 S
C*           (10 DAY)  (180 DAY)
C* SPRFS      4.1E+07 PA 4.1E+07 PA 4.1E+07 PA 4.1E+07 PA
C*           (6000 PSI) (6000 PSI) (6000 PSI) (6000 PSI)
C* RFSYS      BLD      BLD      BLD      BLD
C* WATER      TI       TI       SS       SS
C*
C* INPUT VARIABLES:
C*
C* J      = STORAGE MODE CONTROL VARIABLE
C* K      = STORAGE MODE CONTROL ARRAY
C* MD2    = TOTAL DELIVERED MASS OF D2 (KG)
C* P0     = COMBUSTOR OR NOZZLE STAGNATION PRESSURE (PA)
C*
C* OUTPUT VARIABLES:
C*
C* MTANK   = TANK MASS (KG)
C* STD2    = STORAGE MODE DESCRIPTOR DATA ARRAY
C* STMODE  = STORAGE MODE DESCRIPTOR ARRAY
C* VTANK   = TANK VOLUME (M3)
C*
C.....
C
C      IMPLICIT REAL (M)
C
C      COMMON/SCS4/K(10)
C
C      COMMON/SCS5/STMODE(10,10)
C
C      COMMON/SCS9/STD2(10,4)
C
C      DATA ((STD2(I,K),K=1,4),I=1,10)/
C      -10MD2      +10MD2      +10MD2      +10MD2      +
C      -10MBAS     +10MBAS     +10MBAS     +10MBAS     +

```

```

      .10MSPH      .10MCTL      .10MSPH      .10MSPH      .
      -10M300.0 K  .10M300.0 K  .10M77.5 K  .10M77.5 K  .
      -10MINFINITE .10MINFINITE .10M1.6E+07 S .10M1.6E+07 S .
      -10M      .10M      .10M(10 DAY) .10M(100 DAY) .
      -10M4.1E+07 PA .10M4.1E+07 PA .10M4.1E+07 PA .10M4.1E+07 PA .
      -10M16000 PSI .10M16000 PSI .10M16000 PSI .10M16000 PSI .
      -10MBLD      .10MBLD      .10MBLD      .10MBLD      .
      -10MTI      .10MTI      .10MSS      .10MSS      /
C
C
C.....
C*
C*          SET STORAGE MODE OF DESCRIPTOR ARRAY
C*
C.....
C
C
C      DO 1,1 I=1,10
101  STMOF(I,J)=STOZ(I,K(J))
C
C
C.....
C*
C*          CALCULATE TANK VOLUME/MASS
C*
C.....
C
C
C      GO TO (102,102,104,105),K(IJ)
C
C
C.....
C*
C*          GAS STORAGE (300 K)
C*
C.....
C
C
C      AF=1.0/(1.0-(3.02162E-08*P0)**(1.0/1.39822))
      GO TO (103,104),K(IJ)
103  MTANK=MTANK+13.4155*AF*MD2
      +0.349597*(AF*MD2)**(2.0/3.0)
      VTANK=VTANK+2.02297E-02*AF*MD2
      RETURN
104  MTANK=MTANK+17.4102*AF*MD2
      +2.09806*(AF*MD2)**(2.0/3.0)
      VTANK=VTANK+2.02297E-02*AF*MD2
      RETURN
C
C
C.....
C*
C*          GAS STORAGE (77.5 K)
C*
C.....

```

APPENDIX F
SUBROUTINE VM02

CHEMICAL LASER ANALYSIS PROGRAM (CLAP)
OVERLAY SCS

PAGE E-33

C		VM02	1200
C		VM02	1210
105	AF=1.0/(1.0-(3.02162E-04*PO))**((1.0/1.37800))	VM02	1220
	GO TO (106,107),K(J)-2	VM02	1230
106	MTANK=MTANK+4.66774*AF*MD2	VM02	1240
-	+2.53700*(AF*MD2)**(2.0/3.0)	VM02	1250
	VTANK=VTANK+6.56745E-03*AF*MD2	VM02	1260
-	+2.62703E-03*(AF*MD2)**(2.0/3.0)	VM02	1270
-	+3.50275E-04*(AF*MD2)**(1.0/3.0)	VM02	1280
	RETURN	VM02	1290
107	MTANK=MTANK+4.38071*AF*MD2	VM02	1300
-	+5.61743*(AF*MD2)**(2.0/3.0)	VM02	1310
-	+3.44660*(AF*MD2)**(1.0/3.0)	VM02	1320
	VTANK=VTANK+6.56745E-03*AF*MD2	VM02	1330
-	+1.31342E-02*(AF*MD2)**(2.0/3.0)	VM02	1340
-	+4.75602E-03*(AF*MD2)**(1.0/3.0)	VM02	1350
	END	VM02	1360

```

      SUBROUTINE VMF2(J,MF2,MHF,P0,MTANK,VTANK)
      VMF2 0100
C
      VMF2 0110
C
      VMF2 0120
C.....VMF2 0130
C*
      *VMF2 0140
C*
      F2 TANK VOLUME/MASS SUBROUTINE (VMF2)
      *VMF2 0150
C*
      *VMF2 0160
C.....VMF2 0170
C
      VMF2 0180
C.....VMF2 0190
C*
      *VMF2 0200
C*
      SUBROUTINE VMF2 CALCULATES THE TANK VOLUME/MASS FOR THE STORAGE
      *VMF2 0210
C*
      OF F2.
      *VMF2 0220
C*
      *VMF2 0230
C*
      F2 MAY BE STORED ANY OF FOUR WAYS: HOWEVER, WHEN STORED AS A GAS,
      *VMF2 0240
C*
      F2 IS STORED WITH HE AS A GAS MIXTURE AT A PARTIAL PRESSURE
      *VMF2 0250
C*
      PF2 = 6.89476E+06 PA (1000 PSIA) PROVIDED HE IS PRESENT IN THE
      *VMF2 0260
C*
      SYSTEM:
      *VMF2 0270
C*
      *VMF2 0280
C*
      K      1      2      3      4
      *VMF2 0290
C*
      P USF   GAS      LIO      LIO
      *VMF2 0300
C*
      CONT    SPH      CYL      SPH
      *VMF2 0310
C*
      STEMP   300.0 K   300.0 K   77.5 K   77.5 K
      *VMF2 0320
C*
      STIME   INFINITE INFINITE  1.6E+04 S  1.6E+07 S
      *VMF2 0330
C*
      *VMF2 0340
C*
      SPRFS   6.0E+06 PA  6.0E+06 PA  1.25*P0  1.25*P0
      *VMF2 0350
C*
      *VMF2 0360
C*
      (1000 PSI) (1000 PSI)
      *VMF2 0370
C*
      RFSYS   RLD      RLD      PGS      PGS
      *VMF2 0380
C*
      WATER   SS       SS       SS       SS
      *VMF2 0390
C*
      *VMF2 0400
C*
      INPUT VARIABLES:
      *VMF2 0410
C*
      *VMF2 0420
C*
      J      = STORAGE MODE CONTROL VARIABLE
      *VMF2 0430
C*
      K      = STORAGE MODE CONTROL ARRAY
      *VMF2 0440
C*
      MF2    = TOTAL DELIVERED MASS OF F2 (KG)
      *VMF2 0450
C*
      MHF    = TOTAL DELIVERED MASS OF HE (KG)
      *VMF2 0460
C*
      P0     = COMBUSTOR OR NOZZLE STAGNATION PRESSURE (PA)
      *VMF2 0470
C*
      *VMF2 0480
C*
      *VMF2 0490
C*
      OUTPUT VARIABLES:
      *VMF2 0500
C*
      *VMF2 0510
C*
      MTANK  = TANK MASS (KG)
      *VMF2 0520
C*
      STF2   = STORAGE MODE DESCRIPTOR DATA ARRAY
      *VMF2 0530
C*
      STMODE  = STORAGE MODE DESCRIPTOR ARRAY
      *VMF2 0540
C*
      VTANK  = TANK VOLUME (M3)
      *VMF2 0550
C.....
C
      VMF2 0560
C
      VMF2 0570
C
      IMPLICIT REAL(M)
      VMF2 0580
C
      COMMON/SCS4/K(10)
      VMF2 0590
C
      COMMON/SCS5/STMODE(10,10)
      VMF2 0600
C
      COMMON/SCS10/STF2(10,4)
      VMF2 0610
C
      VMF2 0620
      VMF2 0630
      VMF2 0640

```

Line	Code	Statement	Variable	Value
C		DATA ((STF2(I,K),K=1,4),I=1,10)/		
		-10MF2 .10MF2 .10MF2 .10MF2		VMF2 0650
		-10MGAS .10MGAS .10MLIQ .10MLIQ		VMF2 0660
		-10MSPH .10MSPH .10MSPH .10MSPH		VMF2 0670
		-10M300.0 K .10M300.0 K .10M77.5 K .10M77.5 K		VMF2 0680
		-10MINFINITE .10MINFINITE .10M8.6E+05 S .10M1.6E+07 S		VMF2 0690
		-10M .10M .10M(10 DAY) .10M(100 DAY)		VMF2 0700
		-10M6.9E+06 PA .10M6.9E+06 PA .10M1.25*P0 .10M1.25*P0		VMF2 0710
		-10M(1000 PSI) .10M(1000 PSI) .10M .10M		VMF2 0720
		-10MBLD .10MBLD .10MPOS .10MPOS		VMF2 0730
		-10MSS .10MSS .10MSS .10MSS		VMF2 0740
C				VMF2 0750
C				VMF2 0760
C				VMF2 0770
C				VMF2 0780
C				VMF2 0790
C				VMF2 0800
C		SET STORAGE MODE DESCRIPTOR ARRAY		VMF2 0810
C				VMF2 0820
C				VMF2 0830
C				VMF2 0840
C				VMF2 0850
C		DO 101 I=1,10		VMF2 0860
101		STMODE(I,J)=STF2(I,K(J))		VMF2 0870
C				VMF2 0880
C				VMF2 0890
C				VMF2 0900
C				VMF2 0910
C				VMF2 0920
C				VMF2 0930
C				VMF2 0940
C				VMF2 0950
C				VMF2 0960
C		GO TO (102,102,105,105),K(J)		VMF2 0970
C				VMF2 0980
C				VMF2 0990
C				VMF2 1000
C				VMF2 1010
C				VMF2 1020
C				VMF2 1030
C				VMF2 1040
C				VMF2 1050
C				VMF2 1060
102		IF(MME,NE,0,0) STMODE(1,J)=10MF2/ME		VMF2 1070
		XFF2=1.0/(1.0+(37.9968*MME)/(4.0026*MF2))		VMF2 1080
		XFME=1.0-XFF2		VMF2 1090
		PS=6.89476E+06/XFF2		VMF2 1100
		PME=PS-6.89476E+06		VMF2 1110
		MW=37.9968*(MME/MF2+1.0)/(XFME/XFF2+1.0)		VMF2 1120
		O=(2.50092*XFME/XFF2+4.16146)/(1.50092*XFME/XFF2+3.16146)		VMF2 1130
		ZME=4.61576E-09*PME+1.00053		VMF2 1140
		Z=0.980995*XFF2+ZME*XFME		VMF2 1150
		AF=1.0/(1.0-(1.25*P0/PS))* (1.0/O)		VMF2 1160
		NTOTAL=MME*MF2		VMF2 1170
		IF(PS,GT,4.13685E+07) WRITE(6,201)(PS,II=1,4)		VMF2 1180
		GO TO(103,104),K(J)		VMF2 1190


```
103  MTANK=MTANK+1.10210*(1.0+67.5353*Z/MW)*AF*MTOTAL
      - +2.47854E+05*(7*AF*MTOTAL/(PS*MW))**(2.0/3.0)
      VTANK=VTANK+2.69759E+06*Z*AF*MTOTAL/(PS*MW)
      RETURN
104  MTANK=MTANK+1.08150*(1.0+91.2639*Z/MW)*AF*MTOTAL
      - +5.47613E+05*(Z*AF*MTOTAL/(PS*MW))**(2.0/3.0)
      VTANK=VTANK+2.69759E+06*Z*AF*MTOTAL/(PS*MW)
      RETURN
C
C
C*****
C*
C*          PGS LIQUID STORAGE (77.5 K)
C*
C*****
C
C
105  AF=1.0/(1.0-(3.17270E-08*P0)**(1.0/1.61019))
      Z=1.74986E-08*1.25*P0+0.999271
      MPGS=7.08056E-03*MF2/(1.22656E+05*Z/P0-6.76795E-03*AF)
      GO TO (106,107),K(J)-2
106  MTPGS=4.71181*AF*MPGS
      - +2.67404*(AF*MPGS)**(2.0/3.0)
      - +0.217186*(AF*MPGS)**(1.0/3.0)
      VTPGS=7.10635E-03*AF*MPGS
      - +2.76884E-03*(AF*MPGS)**(2.0/3.0)
      - +3.59605E-04*(AF*MPGS)**(1.0/3.0)
      MVT=1.18685*MF2
      - +1.68221E-08*P0*MF2
      - +0.571231*MF2**(2.0/3.0)
      - +0.102337*MF2**(1.0/3.0)
      MMT=1.18685*MF2
      - +0.736480*MF2**(2.0/3.0)
      - +0.102337*MF2**(1.0/3.0)
      MTANK=MTANK+AMAX1(MVT,MMT)*MTPGS
      VTANK=VTANK+7.78861E-04*MF2
      - +6.44034E-04*MF2**(2.0/3.0)
      - +1.77514E-04*MF2**(1.0/3.0)
      - +VTPGS
      RETURN
107  MTPGS=4.61764*AF*MPGS
      - +5.92067*(AF*MPGS)**(2.0/3.0)
      - +3.53850*(AF*MPGS)**(1.0/3.0)
      VTPGS=7.10635E-03*AF*MPGS
      - +1.38442E-02*(AF*MPGS)**(2.0/3.0)
      - +8.99017E-03*(AF*MPGS)**(1.0/3.0)
      MVT=1.17700*MF2
      - +1.68221E-08*P0*MF2
      - +1.29207*MF2**(2.0/3.0)
      - +1.66733*MF2**(1.0/3.0)
      MMT=1.17700*MF2
      - +1.45732*MF2**(2.0/3.0)
      - +1.66733*MF2**(1.0/3.0)
      MTANK=MTANK+AMAX1(MVT,MMT)*MTPGS
      VTANK=VTANK+7.78861E-04*MF2
```

```
VMF2 1200
VMF2 1210
VMF2 1220
VMF2 1230
VMF2 1240
VMF2 1250
VMF2 1260
VMF2 1270
VMF2 1280
VMF2 1290
VMF2 1300
*VMF2 1310
*VMF2 1320
*VMF2 1330
*VMF2 1340
VMF2 1350
VMF2 1360
VMF2 1370
VMF2 1380
VMF2 1390
VMF2 1400
VMF2 1410
VMF2 1420
VMF2 1430
VMF2 1440
VMF2 1450
VMF2 1460
VMF2 1470
VMF2 1480
VMF2 1490
VMF2 1500
VMF2 1510
VMF2 1520
VMF2 1530
VMF2 1540
VMF2 1550
VMF2 1560
VMF2 1570
VMF2 1580
VMF2 1590
VMF2 1600
VMF2 1610
VMF2 1620
VMF2 1630
VMF2 1640
VMF2 1650
VMF2 1660
VMF2 1670
VMF2 1680
VMF2 1690
VMF2 1700
VMF2 1710
VMF2 1720
VMF2 1730
VMF2 1740
```

-	+3.22017E-03*MF2** (2.0/3.0)	VMF2	1750
-	+4.43787E-03*MF2** (1.0/3.0)	VMF2	1760
-	+VTTP85	VMF2	1770
RETURN		VMF2	1780
C		VMF2	1790
C		VMF2	1800
C	.....	VMF2	1810
C*		VMF2	1820
C*	FORMAT STATEMENTS	VMF2	1830
C		VMF2	1840
C	.....	VMF2	1850
C		VMF2	1860
C		VMF2	1870
201	FORMAT(*1*.T2,*WARNING: STORAGE PRESSURE FOR P2/HE EXCEEDS 4.13685	VMF2	1880
	-E.07 PA (6000 PSIA)*.9(/.T2,*PS =*.E13.6,* PA*))	VMF2	1890
	END	VMF2	1900

```

      SUBROUTINE VMHE(J,MHE,P0,MTANK,VTANK)
      C
      C
      C.....VMHE 0100
      C
      C
      C.....VMHE 0110
      C
      C.....VMHE 0120
      C.....VMHE 0130
      C.....VMHE 0140
      C
      C      HE TANK VOLUME/MASS SUBROUTINE (VMHE)
      C.....VMHE 0150
      C.....VMHE 0160
      C.....VMHE 0170
      C.....VMHE 0180
      C.....VMHE 0190
      C.....VMHE 0200
      C
      C      SUBROUTINE VMHE CALCULATES THE TANK VOLUME/MASS FOR THE STORAGE
      C      OF HE.
      C.....VMHE 0210
      C.....VMHE 0220
      C.....VMHE 0230
      C
      C      HE MAY BE STORED ANY OF FOUR WAYS:
      C.....VMHE 0240
      C.....VMHE 0250
      C.....VMHE 0260
      C
      C      K      1      2      3      4
      C      PHASE  GAS      GAS      GAS      GAS
      C      CONT   SPH      CYL      SPH      SPH
      C      STMP    300.0 K    300.0 K    77.5 K    77.5 K
      C      STIME   INFINITE  INFINITE  8.6E+05 S  1.6E+07 S
      C              (10 DAY)  (180 DAY)
      C      SPRES   4.1E+07 PA  4.1E+07 PA  4.1E+07 PA  4.1E+07 PA
      C              (6000 PSI) (6000 PSI) (6000 PSI) (6000 PSI)
      C      RFSYS   RLD      RLD      BLD      RLD
      C      MATFR   TI       TI       SS       SS
      C.....VMHE 0300
      C.....VMHE 0310
      C.....VMHE 0320
      C.....VMHE 0330
      C.....VMHE 0340
      C.....VMHE 0350
      C.....VMHE 0360
      C
      C      INPUT VARIABLES:
      C.....VMHE 0370
      C.....VMHE 0380
      C.....VMHE 0390
      C.....VMHE 0400
      C.....VMHE 0410
      C.....VMHE 0420
      C.....VMHE 0430
      C.....VMHE 0440
      C.....VMHE 0450
      C.....VMHE 0460
      C.....VMHE 0470
      C.....VMHE 0480
      C.....VMHE 0490
      C.....VMHE 0500
      C.....VMHE 0510
      C.....VMHE 0520
      C.....VMHE 0530
      C.....VMHE 0540
      C.....VMHE 0550
      C.....VMHE 0560
      C.....VMHE 0570
      C.....VMHE 0580
      C.....VMHE 0590
      C.....VMHE 0600
      C.....VMHE 0610
      C.....VMHE 0620
      C.....VMHE 0630
      C.....VMHE 0640
      C
      C      IMPLICIT REAL(M)
      C
      C      COMMON/SCS4/K(10)
      C
      C      COMMON/SCS5/STMODE(10,10)
      C
      C      COMMON/SCS11/STHE(10,4)
      C
      C      DATA ((STHE(I,K),K=1,4),I=1,10)/
      C      -10MHE ,10MHE ,10MHE ,10MHE ,
      C      -10MGAS ,10MGAS ,10MGAS ,10MGAS ,

```

```
      -10MSEH      .10MCYL      .10MSPH      .10MSPH      .
      -10M300.0 K  .10M300.0 K  .10M77.5 K  .10M77.5 K  .
      -10MINFINITE .10MINFINITE .10M4.6E+05 S .10M1.6E+07 S .
      -10M      .10M      .10M(10 DAY) .10M(180 DAY) .
      -10M4.1E+07 PA.10M4.1E+07 PA.10M4.1E+07 PA.10M4.1E+07 PA.
      -10M(6000 PSI).10M(6000 PSI).10M(6000 PSI).10M(6000 PSI).
      -10MRLD      .10MRLD      .10MRLD      .10MRLD      .
      -10MTI      .10MTI      .10MSS      .10MSS      /
      VMHE 0650
      C      VMHE 0660
      C      VMHE 0670
      C.....VMHE 0680
      C*      VMHE 0690
      C*      SET STORAGE MODE DESCRIPTOR ARRAY      VMHE 0700
      C*      VMHE 0710
      C*      VMHE 0720
      C.....VMHE 0730
      C      VMHE 0740
      C      VMHE 0750
      C*      VMHE 0760
      C*      DO 101 I=1,10
      C      STMODE(I,J)=STME(I,K(J))      VMHE 0770
      C      VMHE 0780
      C.....VMHE 0790
      C      VMHE 0800
      C      VMHE 0810
      C      VMHE 0820
      C      VMHE 0830
      C      VMHE 0840
      C      VMHE 0850
      C.....VMHE 0860
      C*      VMHE 0870
      C*      CALCULATE TANK VOLUME/MASS      VMHE 0880
      C*      VMHE 0890
      C.....VMHE 0900
      C      VMHE 0910
      C      VMHE 0920
      C      GO TO (102,102,105,105),K(J)      VMHE 0930
      C      VMHE 0940
      C      VMHE 0950
      C.....VMHE 0960
      C*      VMHE 0970
      C*      GAS STORAGE (300 M)      VMHE 0980
      C*      VMHE 0990
      C.....VMHE 1000
      C      VMHE 1010
      C      VMHE 1020
      C      VMHE 1030
      C      VMHE 1040
      C      VMHE 1050
      C      VMHE 1060
      C      VMHE 1070
      C      VMHE 1080
      C      VMHE 1090
      C      VMHE 1100
      C      VMHE 1110
      C      VMHE 1120
      C      VMHE 1130
      C      VMHE 1140
      C.....VMHE 1150
      C*      VMHE 1160
      C*      GAS STORAGE (77.5 K)      VMHE 1170
      C*      VMHE 1180
      C.....VMHE 1190
```

APPENDIX F
SUBROUTINE VMHF

CHEMICAL LASER ANALYSIS PROGRAM (CLAP)
OVERLAY SCS

PAGE E-40

C		VMHE	1200
C		VMHE	1210
105	AF=1.0/(1.0-(3.07162F-0A*P0)**(1.0/1.61016))	VMHE	1220
	GO TO (106,107),K(J)-2	VMHE	1230
106	MTANK=MTANK+4.85317*AF*VMHF	VMHE	1240
-	+2.72725*(AF*VMHE)**(2.0/3.0)	VMHE	1250
-	+0.219336*(AF*VMHE)**(1.0/3.0)	VMHE	1260
	VTANK=VTANK+7.31954E-03*AF*VMHE	VMHE	1270
-	+2.82395E-03*(AF*VMHE)**(2.0/3.0)	VMHE	1280
-	+3.63166E-04*(AF*VMHE)**(1.0/3.0)	VMHE	1290
	RETURN	VMHE	1300
107	MTANK=MTANK+4.75617*AF*VMHF	VMHE	1310
-	+6.03850*(AF*VMHE)**(2.0/3.0)	VMHE	1320
-	+3.57353*(AF*VMHE)**(1.0/3.0)	VMHE	1330
	VTANK=VTANK+7.31954E-03*AF*VMHE	VMHE	1340
-	+1.41197E-02*(AF*VMHE)**(2.0/3.0)	VMHE	1350
-	+9.07919E-03*(AF*VMHE)**(1.0/3.0)	VMHE	1360
	END	VMHE	1370

205

-10HSPH	.10HCYL	.10HSPH	.10HSPH		VMH2	0650
-10H300.0 K	.10H300.0 K	.10H77.5 K	.10H77.5 K		VMH2	0660
-10MINFINITE	.10MINFINITE	.10H.6E+05 S	.10H.6E+07 S		VMH2	0670
-10H	.10H	.10H(10 DAY)	.10H(180 DAY)		VMH2	0680
-10H4.1E+07 PA	.10H4.1E+07 PA	.10H4.1E+07 PA	.10H4.1E+07 PA		VMH2	0690
-10H(6000 PSI)	.10H(6000 PSI)	.10H(6000 PSI)	.10H(6000 PSI)		VMH2	0700
-10HBLD	.10HBLD	.10HBLD	.10HBLD		VMH2	0710
-10HCSS	.10HCSS	.10HSS	.10HSS	/	VMH2	0720
C					VMH2	0730
C					VMH2	0740
C					VMH2	0750
C					VMH2	0760
C	SET STORAGE MODE DESCRIPTOR ARRAY				VMH2	0770
C					VMH2	0780
C					VMH2	0790
C					VMH2	0800
C					VMH2	0810
	DO 101 I=1,10				VMH2	0820
101	STMODE(I,J)=STM2(I,K(J))				VMH2	0830
C					VMH2	0840
C					VMH2	0850
C					VMH2	0860
C					VMH2	0870
C	CALCULATE TANK VOLUME/MASS				VMH2	0880
C					VMH2	0890
C					VMH2	0900
C					VMH2	0910
C					VMH2	0920
	GO TO (102,102,105,105),K(J)				VMH2	0930
C					VMH2	0940
C					VMH2	0950
C					VMH2	0960
C					VMH2	0970
C	GAS STORAGE (300 K)				VMH2	0980
C					VMH2	0990
C					VMH2	1000
C					VMH2	1010
C					VMH2	1020
102	AF=1.0/(1.0-(3.02162E-08*P0)**(1.0/1.36381))				VMH2	1030
	GO TO (103,104),K(J)				VMH2	1040
103	MTANK=MTANK+25.9560*AF*MH2				VMH2	1050
	+1.51665*(AF*MH2)**(2.0/3.0)				VMH2	1060
	VTANK=VTANK+4.08327E-02*AF*MH2				VMH2	1070
	RETURN				VMH2	1080
104	MTANK=MTANK+34.0401*AF*MH2				VMH2	1090
	+3.35091*(AF*MH2)**(2.0/3.0)				VMH2	1100
	VTANK=VTANK+4.08327E-02*AF*MH2				VMH2	1110
	RETURN				VMH2	1120
C					VMH2	1130
C					VMH2	1140
C					VMH2	1150
C					VMH2	1160
C	GAS STORAGE (77.5 K)				VMH2	1170
C					VMH2	1180
C					VMH2	1190

APPENDIX E
SUBROUTINE VMH2

CHEMICAL LASER ANALYSIS PROGRAM (CLAP)
OVERLAY SC5

PAGE E-43

```

C
C
105  AF=1.0/(1.0-(3.07167E-09*P0)**(1.0/1.44641))
      GO TO (106,107),K(J)-2
106  MTANK=MTANK+7.74831*AF*MMH2
      -      +3.99336*(AF*MMH2)**(2.0/3.0)
      -      +0.265409*(AF*MMH2)**(1.0/3.0)
      VTANK=VTANK+1.29689E-02*AF*MMH2
      -      +4.13494E-03*(AF*MMH2)**(2.0/3.0)
      -      +4.39452E-04*(AF*MMH2)**(1.0/3.0)
      RETURN
107  MTANK=MTANK+7.57645*AF*MMH2
      -      +8.84183*(AF*MMH2)**(2.0/3.0)
      -      +4.32419*(AF*MMH2)**(1.0/3.0)
      VTANK=VTANK+1.29689E-02*AF*MMH2
      -      +2.06747E-02*(AF*MMH2)**(2.0/3.0)
      -      +1.09864E-02*(AF*MMH2)**(1.0/3.0)
      END

```

```

VMH2  1200
VMH2  1210
VMH2  1220
VMH2  1230
VMH2  1240
VMH2  1250
VMH2  1260
VMH2  1270
VMH2  1280
VMH2  1290
VMH2  1300
VMH2  1310
VMH2  1320
VMH2  1330
VMH2  1340
VMH2  1350
VMH2  1360
VMH2  1370

```



```

SUBROUTINE VMIRFNA(J,MIRFNA,P0,RTIME,MTANK,VTANK)
C
C
C.....
C*
C*      IRFNA TANK VOLUME/MASS SUBROUTINE (VMIRFNA)
C*
C*.....
C
C.....
C* SUBROUTINE VMIRFNA CALCULATES THE TANK VOLUME/MASS FOR THE STORAGE
C* OF INHIBITED RED FUMING NITRIC ACID (M1.4803N1.6435O4.631AF0.03).
C*
C* IRFNA MAY BE STORED ANY OF FOUR WAYS:
C*
C*      K      1      2      3      4
C*      PHASE  LIQ    LIQ    LIQ    LIQ
C*      CONT   SPH    CYL    SPH    CYL
C*      STEMP   300.0 K  300.0 K  300.0 K  300.0 K
C*      STIME   INFINITE INFINITE INFINITE INFINITE
C*      SPRFS   1.25*P0 1.25*P0 1 ATM    1 ATM
C*      RFSYS   PGS     PGS     PGS     PGS
C*      MATER   AL      AL      AL      AL
C*
C* INPUT VARIABLES:
C*
C* J      = STORAGE MODE CONTROL VARIABLE
C* K      = STORAGE MODE CONTROL ARRAY
C* MIRFNA = TOTAL DELIVERED MASS OF IRFNA (KG)
C* P0     = COMBUSTOR OR NOZZLE STAGNATION PRESSURE (PA)
C* RTIME  = RUN TIME (S)
C*
C* OUTPUT VARIABLES:
C*
C* MTANK  = TANK MASS (KG)
C* STIRFNA = STORAGE MODE DESCRIPTOR DATA ARRAY
C* STMODE  = STORAGE MODE DESCRIPTOR ARRAY
C* VTANK  = TANK VOLUME (M3)
C*.....
C
C      IMPLICIT REAL(M)
C
C      COMMON/SCS4/K(10)
C
C      COMMON/SCS5/STMODE(10,10)
C
C      COMMON/SCS13/STIRFNA(10,4)
C
C      DATA ((STIRFNA(I,K),K=1,4),I=1,10)/
-10MIRFNA  ,10MIRFNA  ,10MIRFNA  ,10MIRFNA  ,
-10MLIQ    ,10MLIQ    ,10MLIQ    ,10MLIQ    ,
-10MSPH    ,10MSPH    ,10MSPH    ,10MSPH    ,

```

APPENDIX E
SUBROUTINE VMIRFNA

CHEMICAL LASER ANALYSIS PROGRAM (CLAP)
OVERLAY SC5

PAGE E-49

```

      -10M300.0 K      .10M300.0 K      .10M300.0 K      .10M300.0 K      .
      -10MINFINITE    .10MINFINITE    .10MINFINITE    .10MINFINITE    .
      -10M             .10             .10M             .10M             .
      -10M1.25*P0      .10M1.25*P0      .10M1 ATM       .10M1 ATM       .
      -10M             .10M             .10M             .10M             .
      -10MP3S          .10MP3S          .10MP3S          .10MP3S          .
      -10HAL           .10HAL           .10HAL           .10HAL           /
      VMIRFNA0650
      VMIRFNA0660
      VMIRFNA0670
      VMIRFNA0680
      VMIRFNA0690
      VMIRFNA0700
      VMIRFNA0710
      VMIRFNA0720
      VMIRFNA0730
      VMIRFNA0740
      VMIRFNA0750
      VMIRFNA0760
      VMIRFNA0770
      VMIRFNA0780
      VMIRFNA0790
      VMIRFNA0800
      VMIRFNA0810
      VMIRFNA0820
      VMIRFNA0830
      VMIRFNA0840
      VMIRFNA0850
      VMIRFNA0860
      VMIRFNA0870
      VMIRFNA0880
      VMIRFNA0890
      VMIRFNA0900
      VMIRFNA0910
      VMIRFNA0920
      VMIRFNA0930
      VMIRFNA0940
      VMIRFNA0950
      VMIRFNA0960
      VMIRFNA0970
      VMIRFNA0980
      VMIRFNA0990
      VMIRFNA1000
      VMIRFNA1010
      VMIRFNA1020
      VMIRFNA1030
      VMIRFNA1040
      VMIRFNA1050
      VMIRFNA1060
      VMIRFNA1070
      VMIRFNA1080
      VMIRFNA1090
      VMIRFNA1100
      VMIRFNA1110
      VMIRFNA1120
      VMIRFNA1130
      VMIRFNA1140
      VMIRFNA1150
      VMIRFNA1160
      VMIRFNA1170
      VMIRFNA1180
      VMIRFNA1190

      C
      C
      C.....
      C*
      C*          SET STORAGE MODE DESCRIPTOR ARRAY
      C*
      C*.....
      C
      C
      C      DO 101 I=1,10
      101  STMODE(I,J)=STIRFNA(I,K(J))
      C
      C
      C.....
      C*
      C*          CALCULATE TANK VOLUME/MASS
      C*
      C*.....
      C
      C
      C      GO TO (102,102,105,106),K(J)
      C
      C
      C.....
      C*
      C*          P3S LIQUID STORAGE (300 K)
      C*
      C*.....
      C
      C
      102  AF=1.0/1.0-(3.17270E-08*P0)**(1.0/1.66498)
      Z=4.73641E-09*1.25*P0+1.00003
      MP3S=6.90088E-04*VMIRFNA/(4.74797E+05*Z/PC-1.79146E-02*AF)
      MTTP3S=12.5194*AF*MP3S
      +0.904642*(AF*MP3S)**(2.0/3.0)
      VTTP3S=1.28103E-02*AF*MP3S
      GO TO (103,104),K(J)
      103  MVT=1.17700*VMIRFNA
      - 3.05493E-08*P0*VMIRFNA
      - 8.10866E-07*VMIRFNA*(2.0/3.0)
      HMT=1.17700*VMIRFNA
      - 8.10866E-07*VMIRFNA*(2.0/3.0)
      MTANK=MTANK+AMAL*(MVT,HMT)*MTTP3S
      VTANK=VTANK+7.54097E-04*VMIRFNA+VTTP3S
      RET IRN
      104  MVT=1.15500*VMIRFNA
      - 6.70330E-09*P0*VMIRFNA
      - 0.179154*VMIRFNA*(2.0/3.0)

```

```

      MMT=1.15500*MIRFNA
      *0.432704*MIRFNA** (2.0/3.0)
      MTANK=MTANK+AMAX1(MVT,MMT)*MTTPGS
      VTANK=VTANK+7.59097E-04*MIRFNA*VTTPGS
      RETURN

C
C
C.....VMIRFNA1270
C*
C*          PFS LIQUID STORAGE (300 K)
C*
C.....VMIRFNA1310
C
C
105  MTANK=MTANK+1.17700*MIRFNA
      -      *0.253226*MIRFNA** (2.0/3.0)
      -      *4.11538E-09*P0*MIRFNA
      -      *1.56269E-04*(P0*MIRFNA/RTIME)** (2.0/3.0)
      -      *1.36650E-02*(P0*MIRFNA/RTIME)** (1.0/3.0)
      VTANK=VTANK+7.59097E-04*MIRFNA
      -      *4.21192E-12*P0*MIRFNA
      -      *9.86986E-08*(P0*MIRFNA/RTIME)** (2.0/3.0)
      -      *8.63079E-06*(P0*MIRFNA/RTIME)** (1.0/3.0)
      RETURN
106  MTANK=MTANK+1.15500*MIRFNA
      -      *0.559482*MIRFNA** (2.0/3.0)
      -      *4.11538E-09*P0*MIRFNA
      -      *1.56269E-04*(P0*MIRFNA/RTIME)** (2.0/3.0)
      -      *1.36650E-02*(P0*MIRFNA/RTIME)** (1.0/3.0)
      VTANK=VTANK+7.59097E-04*MIRFNA
      -      *4.21192E-12*P0*MIRFNA
      -      *9.86986E-08*(P0*MIRFNA/RTIME)** (2.0/3.0)
      -      *8.63079E-06*(P0*MIRFNA/RTIME)** (1.0/3.0)
      END

```

```

VMIRFNA1200
VMIRFNA1210
VMIRFNA1220
VMIRFNA1230
VMIRFNA1240
VMIRFNA1250
VMIRFNA1260
VMIRFNA1270
VMIRFNA1280
VMIRFNA1290
VMIRFNA1300
VMIRFNA1310
VMIRFNA1320
VMIRFNA1330
VMIRFNA1340
VMIRFNA1350
VMIRFNA1360
VMIRFNA1370
VMIRFNA1380
VMIRFNA1390
VMIRFNA1400
VMIRFNA1410
VMIRFNA1420
VMIRFNA1430
VMIRFNA1440
VMIRFNA1450
VMIRFNA1460
VMIRFNA1470
VMIRFNA1480
VMIRFNA1490
VMIRFNA1500
VMIRFNA1510
VMIRFNA1520
VMIRFNA1530

```

```

SUBROUTINE VMMMH(J,MMMH,P0,RTIME,MTANK,VTANK)
C
C
C.....
C*
C*          MMH TANK VOLUME/MASS  SUBROUTINE (VMMMH)
C*
C*.....
C
C.....
C* SUBROUTINE VMMMH CALCULATES THE TANK VOLUME/MASS FOR THE STORAGE
C* OF MONOMETHYL HYDRAZINE (CH6N2).
C*
C* MMH MAY BE STORED ANY OF FOUR WAYS:
C*
C*      #      1      2      3      4
C*      PHASE  LIQ    LIQ    LIQ    LIQ
C*      CONT   SPH    CYL    SPH    CYL
C*      STMP   300.0 K 300.0 K 300.0 K 300.0 K
C*      STIME  INFINITE INFINITE INFINITE INFINITE
C*      SPRES  1.25*P0 1.25*P0 1 ATM    1 ATM
C*      RFSYS  PGS     PGS     PFS     PFS
C*      MATER  TI      TI      AL      AL
C*
C* INPUT VARIABLES:
C*
C* J      = STORAGE MODE CONTROL VARIABLE
C* K      = STORAGE MODE CONTROL ARRAY
C* MMMH   = TOTAL DELIVERED MASS OF MMH (KG)
C* P0     = COMBUSTOR OR NOZZLE STAGNATION PRESSURE (PA)
C* RTIME  = RUN TIME (S)
C*
C* OUTPUT VARIABLES:
C*
C* MTANK  = TANK MASS (KG)
C* STMMH  = STORAGE MODE DESCRIPTOR DATA ARRAY
C* STMODE = STORAGE MODE DESCRIPTOR ARRAY
C* VTANK  = TANK VOLUME (M3)
C*
C.....
C
C      IMPLICIT REAL(M)
C
C      COMMON/SCS4/K(10)
C
C      COMMON/SCS5/STMODE(10,10)
C
C      COMMON/SCS14/STMMH(10,4)
C
C      DATA ((STMMH(I,K),K=1,4),I=1,10)/
-10HMMH ,10HMMH ,10HMMH ,10HMMH ,
-10HLIQ ,10HLIQ ,10HLIQ ,10HLIQ ,
-10HSPH ,10HSPH ,10HSPH ,10HSPH ,

```

VMMMH 0100
VMMMH 0110
VMMMH 0120
VMMMH 0130
VMMMH 0140
VMMMH 0150
VMMMH 0160
VMMMH 0170
VMMMH 0180
VMMMH 0190
VMMMH 0200
VMMMH 0210
VMMMH 0220
VMMMH 0230
VMMMH 0240
VMMMH 0250
VMMMH 0260
VMMMH 0270
VMMMH 0280
VMMMH 0290
VMMMH 0300
VMMMH 0310
VMMMH 0320
VMMMH 0330
VMMMH 0340
VMMMH 0350
VMMMH 0360
VMMMH 0370
VMMMH 0380
VMMMH 0390
VMMMH 0400
VMMMH 0410
VMMMH 0420
VMMMH 0430
VMMMH 0440
VMMMH 0450
VMMMH 0460
VMMMH 0470
VMMMH 0480
VMMMH 0490
VMMMH 0500
VMMMH 0510
VMMMH 0520
VMMMH 0530
VMMMH 0540
VMMMH 0550
VMMMH 0560
VMMMH 0570
VMMMH 0580
VMMMH 0590
VMMMH 0600
VMMMH 0610
VMMMH 0620
VMMMH 0630
VMMMH 0640

```
      -10M300.0 K      .10M300.0 K      .10M300.0 K      .10M300.0 K      .      VMMH 0650
      -10MINFINITE     .10MINFINITE     .10MINFINITE     .10MINFINITE     .      VMMH 0660
      -10M              .10M              .10M              .10M              .      VMMH 0670
      -10M1.25*P0       .10M1.25*P0       .10M1 ATM        .10M1 ATM        .      VMMH 0680
      -10M              .10M              .10M              .10M              .      VMMH 0690
      -10MPGS           .10MPGS           .10MPFS           .10MPFS           .      VMMH 0700
      -10MTI            .10MTI            .10MAL            .10MAL            /      VMMH 0710
C                                          VMMH 0720
C                                          VMMH 0730
C.....VMMH 0740
C*                                          VMMH 0750
C*      SET STORAGE MODE DESCRIPTOR ARRAY      VMMH 0760
C*                                          VMMH 0770
C.....VMMH 0780
C                                          VMMH 0790
C                                          VMMH 0800
C      DO 101 I=1,10      VMMH 0810
101  STMODE(I,J)=STMMH(I,K(J))      VMMH 0820
C                                          VMMH 0830
C                                          VMMH 0840
C.....VMMH 0850
C*                                          VMMH 0860
C*      CALCULATE TANK VOLUME/MASS      VMMH 0870
C*                                          VMMH 0880
C.....VMMH 0890
C                                          VMMH 0900
C                                          VMMH 0910
C      GO TO (102,102,105,106),K(J)      VMMH 0920
C                                          VMMH 0930
C                                          VMMH 0940
C.....VMMH 0950
C*                                          VMMH 0960
C*      PGS LIQUID STORAGE (300 K)      VMMH 0970
C*                                          VMMH 0980
C.....VMMH 0990
C                                          VMMH 1000
C                                          VMMH 1010
102  AF=1.0/(1.0-(3.17270E-08*P0)**(1.0/1.6649A))      VMMH 1020
      Z=4.736A1E-09*1.25*P0+1.00003      VMMH 1030
      MPGS=1.25858E-03*MMH/(4.74797E+05*Z/P0-1.79146E-02*AF)      VMMH 1040
      MTPGS=12.5194*AF*MPGS      VMMH 1050
      - 0.904642*(AF*MPGS)**(2.0/3.0)      VMMH 1060
      VTPGS=1.86103E-02*AF*MPGS      VMMH 1070
      GO TO (103,104),K(J)      VMMH 1080
103  MVT=1.17700*MMH      VMMH 1090
      - 2.43051E-08*P0*MMH      VMMH 1100
      - 0.121041      H**(2.0/3.0)      VMMH 1110
      MMT=1.17700*H      VMMH 1120
      - 0.256759*MMH**(2.0/3.0)      VMMH 1130
      MTANK=MTANK+AMAX1(MVT,MMT)*MTPGS      VMMH 1140
      VTANK=VTANK+1.38444E-03*MMH*VTPGS      VMMH 1150
      RETURN      VMMH 1160
104  MVT=1.15500*MMH      VMMH 1170
      - 3.22308E-08*P0*MMH      VMMH 1180
      - 0.267430*MMH**(2.0/3.0)      VMMH 1190
```

MMT=1.15500*MMH	VMMH	1200
- *0.567288*MMH** (2.0/3.0)	VMMH	1210
MTANK=MTANK*AMAX1(MVT,MMT)*MTTPGS	VMMH	1220
VTANK=VTANK*1.38444E-03*MMH*VTTPGS	VMMH	1230
RETURN	VMMH	1240
C	VMMH	1250
C	VMMH	1260
C.....	VMMH	1270
C*	VMMH	1280
C* PFS LIQUID STORAGE (300 K)	VMMH	1290
C*	VMMH	1300
C.....	VMMH	1310
C	VMMH	1320
C	VMMH	1330
105 MTANK=MTANK*1.17700*MMH	VMMH	1340
- *0.378001*MMH** (2.0/3.0)	VMMH	1350
- *7.50561E-09*P0*MMH	VMMH	1360
- *2.33269E-04*(P0*MMH/RTIME)** (2.0/3.0)	VMMH	1370
- *1.66956E-02*(P0*MMH/RTIME)** (1.0/3.0)	VMMH	1380
VTANK=VTANK*1.38444E-03*MMH	VMMH	1390
- *7.68168E-12*P0*MMH	VMMH	1400
- *1.47331E-07*(P0*MMH/RTIME)** (2.0/3.0)	VMMH	1410
- *1.05449E-05*(P0*MMH/RTIME)** (1.0/3.0)	VMMH	1420
RETURN	VMMH	1430
06 MTANK=MTANK*1.15500*MMH	VMMH	1440
- *0.835161*MMH** (2.0/3.0)	VMMH	1450
- *7.50561E-09*P0*MMH	VMMH	1460
- *2.33269E-04*(P0*MMH/RTIME)** (2.0/3.0)	VMMH	1470
- *1.66956E-02*(P0*MMH/RTIME)** (1.0/3.0)	VMMH	1480
VTANK=VTANK*1.38444E-03*MMH	VMMH	1490
- *7.68168E-12*P0*MMH	VMMH	1500
- *1.47331E-07*(P0*MMH/RTIME)** (2.0/3.0)	VMMH	1510
- *1.05449E-05*(P0*MMH/RTIME)** (1.0/3.0)	VMMH	1520
END	VMMH	1530

```

      SUBROUTINE VMNF3(J,MHF,MNF3,P0,MTANK,VTANK)
      VMNF3 0100
C
      VMNF3 0110
C
      VMNF3 0120
C*****
      VMNF3 0130
C*
      VMNF3 0140
C*          NF3 TANK VOLUME/MASS SUBROUTINE (VMNF3)
      VMNF3 0150
C*
      VMNF3 0160
C*****
      VMNF3 0170
C
      VMNF3 0180
C*****
      VMNF3 0190
C*
      VMNF3 0200
C* SURROUTINE VMNF3 CALCULATES THE TANK VOLUME/MASS FOR THE STORAGE
      VMNF3 0210
C* OF NF3.
      VMNF3 0220
C*
      VMNF3 0230
C* NF3 MAY BE STORED ANY OF FOUR WAYS; HOWEVER, WHEN STORED AS A GAS,
      VMNF3 0240
C* NF3 IS STORED WITH HE AS A GAS MIXTURE AT A PARTIAL PRESSURE
      VMNF3 0250
C* PNF3 = 1.24106E+07 PA (1800 PSIA) PROVIDED HE IS PRESENT IN THE
      VMNF3 0260
C* SYSTEM:
      VMNF3 0270
C*
      VMNF3 0280
C*
      VMNF3 0290
C* K          1          2          3          4
      VMNF3 0300
C* PHASE      GAS        GAS        LIQ        LIQ
      VMNF3 0310
C* CONT       SPH        CYL        SPH        SPH
      VMNF3 0320
C* STMP       300.0 K    300.0 K    77.5 K    77.5 K
      VMNF3 0330
C* STIME      INFINITE   INFINITE   8.6E+05 S  1.6E+07 S
      VMNF3 0340
C*
      VMNF3 0350
C* SPRFS      1.2E+07 PA  1.2E+07 PA  1.25*P0   1.25*P0
      VMNF3 0360
C*
      VMNF3 0370
C* RFSYS      BLD        BLD        PGS        PGS
      VMNF3 0380
C* MATER      SS         SS         SS         SS
      VMNF3 0390
C*
      VMNF3 0400
C* INPUT VARIABLES:
      VMNF3 0410
C*
      VMNF3 0420
C* J          = STORAGE MODE CONTROL VARIABLE
      VMNF3 0430
C* K          = STORAGE MODE CONTROL ARRAY
      VMNF3 0440
C* MHF        = TOTAL DELIVERED MASS OF HE (KG)
      VMNF3 0450
C* MNF3       = TOTAL DELIVERED MASS OF NF3 (KG)
      VMNF3 0460
C* P0         = COMBUSTOR OR NOZZLE STAGNATION PRESSURE (PA)
      VMNF3 0470
C*
      VMNF3 0480
C* OUTPUT VARIABLES:
      VMNF3 0490
C*
      VMNF3 0500
C* MTANK      = TANK MASS (KG)
      VMNF3 0510
C* STMODE     = STORAGE MODE DESCRIPTOR ARRAY
      VMNF3 0520
C* STNF3      = STORAGE MODE DESCRIPTOR DATA ARRAY
      VMNF3 0530
C* VTANK      = TANK VOLUME (M3)
      VMNF3 0540
C*****
      VMNF3 0550
C
      VMNF3 0560
C
      VMNF3 0570
C
      VMNF3 0580
C
      VMNF3 0590
C
      VMNF3 0600
C
      VMNF3 0610
C
      VMNF3 0620
C
      VMNF3 0630
C
      VMNF3 0640
      COMMON/SCS4/K(10)
      COMMON/SCS5/STMODE(10,10)
      COMMON/SCS15/STNF3(10,4)

```

```

C
DATA ((STNF3(I,K),K=1,4),I=1,10)/
-10MNF3      ,10MNF3      ,10MNF3      ,10MNF3      ,
-10MGAS      ,10MGAS      ,10MLIQ      ,10MLIQ      ,
-10MSPH      ,10MSPH      ,10MSPH      ,10MSPH      ,
-10M300.0 K  ,10M300.0 K  ,10M77.5 K   ,10M77.5 K   ,
-10MINFINITE ,10MINFINITE ,10M8.6E+05 S ,10M1.6E+07 S ,
-10M        ,10M        ,10M(10 DAY) ,10M(10 DAY) ,
-10M1.2E+07 PA,10M1.2E+07 PA,10M1.25*P0 ,10M1.25*P0 ,
-10M(1800 PSI),10M(1800 PSI),10M        ,10M        ,
-10MRLD      ,10MRLD      ,10MPOS      ,10MPOS      ,
-10MSS       ,10MSS       ,10MSS       ,10MSS       /

C
C
C.....
C*
C*          SET STORAGE MODE DESCRIPTOR ARRAY
C*
C.....
C
C
C      DO 101 I=1,10
101  STMODE(I,J)=STNF3(I,K(J))
C
C
C.....
C*
C*          CALCULATE TANK VOLUME/MASS
C*
C.....
C
C      GO TO (102,102,105,105),K(J)
C
C
C.....
C*
C*          GAS STORAGE (300 K)
C*
C.....
C
C
102  IF(MHE,NE,0.0) STMODE(1,J)=10MNF3/ME
      XFNF3=1.0/(1.0+(71.0019*MHE)/(4.0926*MNF3))
      XFHE=1.0-XFNF3
      PS=1.24106E+07/XFNF3
      PHE=PS-1.24106E+07
      MW=71.0019*(MHE/MNF3+1.0)/(XFHE/XFNF3+1.0)
      G=(2.50092*XFHE/XFNF3+6.44455)/(1.50092*XFHE/XFNF3+5.44455)
      ZHE=4.61576E-09*PHE+1.00053
      Z=0.65*XFNF3+ZHE*XFHE
      AF=1.0/(1.0-(1.25*P0/PS)**(1.0/6))
      MTOY=L*MHE*MNF3
      IF(PS,GT,4.13685E+07) WRITE(6,201)(PS,I=1,9)
      GO TO(103,104),K(J)

```


APPENDIX F
SUBROUTINE VMNF3

CHEMICAL LASER ANALYSIS PROGRAM (CLAP)
OVERLAY SC5

PAGE E-52

103	MTANK=MTANK+1.10210*(1.0+67.9353*Z/MW)*AF*MTOTAL	VMNF3	1200
-	+2.47854E+05*(Z*AF*MTOTAL/(PS*MW))**(2.0/3.0)	VMNF3	1210
	VTANK=VTANK+2.69759E+06*Z*AF*MTOTAL/(PS*MW)	VMNF3	1220
	RETURN	VMNF3	1230
104	MTANK=MTANK+1.08150*(1.0+91.2639*Z/MW)*AF*MTOTAL	VMNF3	1240
-	+5.47613E+05*(Z*AF*MTOTAL/(PS*MW))**(2.0/3.0)	VMNF3	1250
	VTANK=VTANK+2.69759E+06*Z*AF*MTOTAL/(PS*MW)	VMNF3	1260
	RETURN	VMNF3	1270
C		VMNF3	1280
C		VMNF3	1290
C	*****	VMNF3	1300
C*		VMNF3	1310
C*	PGS LIQUID STORAGE (77.5 K)	VMNF3	1320
C*		VMNF3	1330
C	*****	VMNF3	1340
C		VMNF3	1350
C		VMNF3	1360
105	AF=1.0/(1.0-(3.17270E-08*P0)**(1.0/1.61019))	VMNF3	1370
	Z=1.74986E-08*1.25*P0*0.999271	VMNF3	1380
	MPGS=7.19015E-03*MNFB/(1.22656E+05*Z/P0-6.76795E-03*AF)	VMNF3	1390
	GO TO (106,107),K(J)-2	VMNF3	1400
106	MTTPGS=4.71181*AF*MPGS	VMNF3	1410
-	+2.67404*(AF*MPGS)**(2.0/3.0)	VMNF3	1420
-	+0.217186*(AF*MPGS)**(1.0/3.0)	VMNF3	1430
	VTPGS=7.10635E-03*AF*MPGS	VMNF3	1440
-	+2.76884E-03*(AF*MPGS)**(2.0/3.0)	VMNF3	1450
-	+3.57605E-04*(AF*MPGS)**(1.0/3.0)	VMNF3	1460
	MVT=1.18700*MNFB	VMNF3	1470
-	+1.70825E-08*P0*MNFB	VMNF3	1480
-	+0.577111*MNFB**2.0/3.0	VMNF3	1490
-	+0.102863*MNFB**1.0/3.0	VMNF3	1500
	MMT=1.18700*MNFB	VMNF3	1510
-	+0.744061*MNFB**2.0/3.0	VMNF3	1520
-	+0.102863*MNFB**1.0/3.0	VMNF3	1530
	MTANK=MTANK+AMAX1(MVT,MMT)*MTTPGS	VMNF3	1540
	VTANK=VTANK+7.90917E-04*MNFB	VMNF3	1550
-	+6.50663E-04*MNFB**2.0/3.0	VMNF3	1560
-	+1.78425E-04*MNFB**1.0/3.0	VMNF3	1570
-	+VTPGS	VMNF3	1580
	RETURN	VMNF3	1590
107	MTTPGS=4.61764*AF*MPGS	VMNF3	1600
-	+5.92067*(AF*MPGS)**(2.0/3.0)	VMNF3	1610
-	+3.53850*(AF*MPGS)**(1.0/3.0)	VMNF3	1620
	VTPGS=7.10635E-03*AF*MPGS	VMNF3	1630
-	+1.38442E-02*(AF*MPGS)**(2.0/3.0)	VMNF3	1640
-	+8.99017E-03*(AF*MPGS)**(1.0/3.0)	VMNF3	1650
	MVT=1.17700*MNFB	VMNF3	1660
-	+1.70825E-08*P0*MNFB	VMNF3	1670
-	+1.30537*MNFB**2.0/3.0	VMNF3	1680
-	+1.67589*MNFB**1.0/3.0	VMNF3	1690
	MMT=1.17700*MNFB	VMNF3	1700
-	+1.47232*MNFB**2.0/3.0	VMNF3	1710
-	+1.67589*MNFB**1.0/3.0	VMNF3	1720
	MTANK=MTANK+AMAX1(MVT,MMT)*MTTPGS	VMNF3	1730
	VTANK=VTANK+7.90917E-04*MNFB	VMNF3	1740

APPENDIX F
SUBROUTINE VMNF3

CHEMICAL LASER ANALYSIS PROGRAM (CLAP)
OVERLAY SC5

PAGE E-53

-	+3.25331E-03*VMNF3*(2.0/3.0)	VMNF3	1750
-	+4.46065E-03*VMNF3*(1.0/3.0)	VMNF3	1760
-	+VTTPG5	VMNF3	1770
	RETURN	VMNF3	1780
C		VMNF3	1790
C		VMNF3	1800
C	.....	VMNF3	1810
C		VMNF3	1820
C	FORMAT STATEMENTS	VMNF3	1830
C		VMNF3	1840
C	.....	VMNF3	1850
C		VMNF3	1860
C		VMNF3	1870
701	FORMAT(*1*,T2,*WARNING: STORAGE PRESSURE FOR NF3/HF EXCEEDS 4.136	VMNF3	1880
	-9E+07 PA (6000 PSIA)*.9(/,T2,*PS **E13.6,* PA*)	VMNF3	1890
	END	VMNF3	1900

```

SUBROUTINE VMN2(J,MN2,P0,RTIME,MTANK,VTANK)
C
C
C.....
C*
C*          N2 TANK VOLUME/MASS SUBROUTINE (VMN2)
C*
C.....
C
C.....
C*
C* SUBROUTINE VMN2 CALCULATES THE TANK VOLUME/MASS FOR THE STORAGE
C* OF N2.
C*
C* N2 MAY BE STORED ANY OF EIGHT WAYS:
C*
C*   K      1      2      3      4
C* PHASE    GAS    GAS    LIQ    LIQ
C* CONT     SPH    CYL    SPH    SPH
C* STMP     300.0 K 300.0 K 77.5 K 77.5 K
C* STIME     INFINITE INFINITE 8.6E+05 S 1.6E+07 S
C*           (10 DAY) (180 DAY)
C* SPRES     4.1E+07 PA 4.1E+07 PA 1.25*P0 1.25*P0
C*           (6000 PSI) (6000 PSI)
C* RFSYS     BLD    BLD    PPS    PPS
C* MATER     TI     TI     SS     SS
C*
C*   K      5      6      7      8
C* PHASE     LIQ    LIQ    LIQ    LIQ
C* CONT     SPH    SPH    SPH    SPH
C* STMP     77.5 K 77.5 K 77.5 K 77.5 K
C* STIME     8.6E+05 S 1.6E+07 S 8.6E+05 S 1.6E+07 S
C*           (10 DAY) (180 DAY) (10 DAY) (180 DAY)
C* SPRES     1 ATM  1 ATM  1.25*P0 1.25*P0
C* RFSYS     PPS    PPS    HPS    HPS
C* MATER     AL     AL     SS     SS
C*
C* INPUT VARIABLES:
C*
C* J      = STORAGE MODE CONTROL VARIABLE
C* K      = STORAGE MODE CONTROL ARRAY
C* MN2    = TOTAL DELIVERED MASS OF N2 (KG)
C* P0     = COMBUSTOR OR NOZZLE STAGNATION PRESSURE (PA)
C* RTIME  = RUN TIME (S)
C*
C* OUTPUT VARIABLES:
C*
C* MTANK  = TANK MASS (KG)
C* STMODE = STORAGE MODE DESCRIPTOR ARRAY
C* STN2   = STORAGE MODE DESCRIPTOR DATA ARRAY
C* VTANK  = TANK VOLUME (M3)
C.....
C
C
C

```

```

VMN2 0100
VMN2 0110
VMN2 0120
VMN2 0130
*VMN2 0140
*VMN2 0150
*VMN2 0160
*VMN2 0170
*VMN2 0180
*VMN2 0190
*VMN2 0200
*VMN2 0210
*VMN2 0220
*VMN2 0230
*VMN2 0240
*VMN2 0250
*VMN2 0260
*VMN2 0270
*VMN2 0280
*VMN2 0290
*VMN2 0300
*VMN2 0310
*VMN2 0320
*VMN2 0330
*VMN2 0340
*VMN2 0350
*VMN2 0360
*VMN2 0370
*VMN2 0380
*VMN2 0390
*VMN2 0400
*VMN2 0410
*VMN2 0420
*VMN2 0430
*VMN2 0440
*VMN2 0450
*VMN2 0460
*VMN2 0470
*VMN2 0480
*VMN2 0490
*VMN2 0500
*VMN2 0510
*VMN2 0520
*VMN2 0530
*VMN2 0540
*VMN2 0550
*VMN2 0560
*VMN2 0570
*VMN2 0580
*VMN2 0590
*VMN2 0600
*VMN2 0610
*VMN2 0620
*VMN2 0630
*VMN2 0640

```

IMPLICIT REAL(M)	VMN2	0650
C	VMN2	0660
COMMON/SCS4/K(10)	VMN2	0670
C	VMN2	0680
COMMON/SCS5/STMODE(10,10)	VMN2	0690
C	VMN2	0700
COMMON/SCS16/STN2(10,8)	VMN2	0710
C	VMN2	0720
DATA ((STN2(I,K),K=1,4),I=1,10)/	VMN2	0730
-10HN2 ,10HN2 ,10HN2 ,10HN2 ,	VMN2	0740
-10HGAS ,10HGAS ,10HLIQ ,10HLIQ ,	VMN2	0750
-10HSPH ,10HCYL ,10HSPH ,10HSPH ,	VMN2	0760
-10H300.0 K ,10H300.0 K ,10H77.5 K ,10H77.5 K ,	VMN2	0770
-10MINFINITE ,10MINFINITE ,10H8.6E+05 S ,10H1.6E+07 S ,	VMN2	0780
-10H ,10H ,10H(10 DAY) ,10H(180 DAY) ,	VMN2	0790
-10H6.1E+07 PA,10H4.1E+07 PA,10H1.25*P0 ,10H1.25*P0 ,	VMN2	0800
-10H(6000 PSI),10H(6000 PSI),10H ,10H ,	VMN2	0810
-10HRLD ,10HRLD ,10HPPS ,10HPPS ,	VMN2	0820
-10HTI ,10HTI ,10HSS ,10HSS /	VMN2	0830
DATA ((STN2(I,K),K=5,8),I=1,10)/	VMN2	0840
-10HN2 ,10HN2 ,10HN2 ,10HN2 ,	VMN2	0850
-10HLIQ ,10HLIQ ,10HLIQ ,10HLIQ ,	VMN2	0860
-10HSPH ,10HSPH ,10HSPH ,10HSPH ,	VMN2	0870
-10H77.5 K ,10H77.5 K ,10H77.5 K ,10H77.5 K ,	VMN2	0880
-10H8.6E+05 S ,10H1.6E+07 S ,10H8.6E+05 S ,10H1.6E+07 S ,	VMN2	0890
-10H(10 DAY) ,10H(180 DAY) ,10H(10 DAY) ,10H(180 DAY) ,	VMN2	0900
-10H1 ATM ,10H1 ATM ,10H1.25*P0 ,10H1.25*P0 ,	VMN2	0910
-10H ,10H ,10H ,10H ,	VMN2	0920
-10HPPS ,10HPPS ,10HPPS ,10HPPS ,	VMN2	0930
-10HAL ,10HAL ,10HSS ,10HSS /	VMN2	0940
C	VMN2	0950
C	VMN2	0960
C*****	VMN2	0970
C*	VMN2	0980
C* SET STORAGE MODE DESCRIPTOR ARRAY	VMN2	0990
C*	VMN2	1000
C*****	VMN2	1010
C	VMN2	1020
C	VMN2	1030
DO 101 I=1,10	VMN2	1040
101 STMODE(I,J)=STN2(I,K(J))	VMN2	1050
C	VMN2	1060
C	VMN2	1070
C*****	VMN2	1080
C*	VMN2	1090
C* CALCULATE TANK VOLUME/MASS	VMN2	1100
C*	VMN2	1110
C*****	VMN2	1120
C	VMN2	1130
C	VMN2	1140
GO TO (102,102,105,105,108,109,110,110),K(J)	VMN2	1150
C	VMN2	1160
C	VMN2	1170
C*****	VMN2	1180
C*	VMN2	1190

C*	GAS STORAGE (300 K)	*VMN2	1200
C*		*VMN2	1210
C*****		*VMN2	1220
C		VMN2	1230
C		VMN2	1240
102	AF=1.0/(1.0-(3.02162E-08*P0)**(1.0/1.27725))	VMN2	1250
	GO TO (103,104),K(J)	VMN2	1260
103	MTANK=MTANK+2.89274*AF*MN2	VMN2	1270
-	+0.262599*(AF*MN2)**(2.0/3.0)	VMN2	1280
	VTANK=VTANK+2.94186E-03*AF*MN2	VMN2	1290
	RETURN	VMN2	1300
104	MTANK=MTANK+3.45605*AF*MN2	VMN2	1310
-	+0.580192*(AF*MN2)**(2.0/3.0)	VMN2	1320
	VTANK=VTANK+2.94186E-03*AF*MN2	VMN2	1330
	RETURN	VMN2	1340
C		VMN2	1350
C		VMN2	1360
C*****		*VMN2	1370
C*		*VMN2	1380
C*	PGS LIQUID STORAGE (77.5 K)	*VMN2	1390
C*		*VMN2	1400
C*****		*VMN2	1410
C		VMN2	1420
C		VMN2	1430
105	AF=1.0/(1.0-(3.17270E-08*P0)**(1.0/1.61019))	VMN2	1440
	Z=1.74986E-08*1.25*P0+0.999271	VMN2	1450
	MPGS=1.36036E-02*MN2/(1.22656E+03*Z/P0-6.76795E-03*AF)	VMN2	1460
	GO TO (105,107),K(J)-2	VMN2	1470
106	MTTPGS=4.71181*AF*MPGS	VMN2	1480
-	+2.67404*(AF*MPGS)**(2.0/3.0)	VMN2	1490
-	+0.217186*(AF*MPGS)**(1.0/3.0)	VMN2	1500
	VTPGS=7.10635E-03*AF*MPGS	VMN2	1510
-	+2.76884E-03*(AF*MPGS)**(2.0/3.0)	VMN2	1520
-	+3.59605E-04*(AF*MPGS)**(1.0/3.0)	VMN2	1530
	MVT=1.19593*MN2	VMN2	1540
-	+2.15464E-08*P0*MN2	VMN2	1550
-	+0.802813*MN2***(2.0/3.0)	VMN2	1560
-	+0.127222*MN2***(1.0/3.0)	VMN2	1570
	MMT=1.19593*MN2	VMN2	1580
-	+1.13820*MN2***(2.0/3.0)	VMN2	1590
-	+0.127222*MN2***(1.0/3.0)	VMN2	1600
	MTANK=MTANK+AMAX1(MVT,MMT)*MTTPGS	VMN2	1610
	VTANK=VTANK+1.49639E-03*MN2	VMN2	1620
-	+9.95326E-04*MN2***(2.0/3.0)	VMN2	1630
-	+2.20679E-04*MN2***(1.0/3.0)	VMN2	1640
-	+VTPGS	VMN2	1650
	RETURN	VMN2	1660
107	MTTPGS=4.61764*AF*MPGS	VMN2	1670
-	+5.92067*(AF*MPGS)**(2.0/3.0)	VMN2	1680
-	+3.53850*(AF*MPGS)**(1.0/3.0)	VMN2	1690
	VTPGS=7.10635E-03*AF*MPGS	VMN2	1700
-	+1.38442E-02*(AF*MPGS)**(2.0/3.0)	VMN2	1710
-	+8.99017E-03*(AF*MPGS)**(1.0/3.0)	VMN2	1720
	MVT=1.17700*MN2	VMN2	1730
-	+2.15464E-08*P0*MN2	VMN2	1740

-	+1.99684*MM2** (2.0/3.0)	VMN2	1750
-	+2.07277*MM2** (1.0/3.0)	VMN2	1760
	MMT=1.17700*MM2	VMN2	1770
-	+2.25223*MM2** (2.0/3.0)	VMN2	1780
-	+2.07277*MM2** (1.0/3.0)	VMN2	1790
	MTANK=MTANK+AMAX1 (MVT,MMT)*MTTP65	VMN2	1800
	VTANK=VTANK+1.49639E-03*MM2	VMN2	1810
-	+4.97663E-03*MM2** (2.0/3.0)	VMN2	1820
-	+5.51700E-03*MM2** (1.0/3.0)	VMN2	1830
-	*VTTP65	VMN2	1840
	RETURN	VMN2	1850
C		VMN2	1860
C		VMN2	1870
C	.....	VMN2	1880
C*		*VMN2	1890
C*	PFS LIQUID STORAGE (77.5 K)	*VMN2	1900
C*		*VMN2	1910
C	.....	VMN2	1920
C		VMN2	1930
C		VMN2	1940
108	MTANK=MTANK+1.19593*MM2	VMN2	1950
-	+1.15344*MM2** (2.0/3.0)	VMN2	1960
-	+0.127222*MM2** (1.0/3.0)	VMN2	1970
-	+8.11256E-09*P0*MM2	VMN2	1980
-	+2.45681E-04*(P0*MM2/RTIME)** (2.0/3.0)	VMN2	1990
-	+1.71340E-02*(P0*MM2/RTIME)** (1.0/3.0)	VMN2	2000
	VTANK=VTANK+1.49639E-03*MM2	VMN2	2010
-	+9.95326E-04*MM2** (2.0/3.0)	VMN2	2020
-	+2.70679E-04*MM2** (1.0/3.0)	VMN2	2030
-	+8.30287E-12*P0*MM2	VMN2	2040
-	+1.55171E-07*(P0*MM2/RTIME)** (2.0/3.0)	VMN2	2050
-	+1.08218E-05*(P0*MM2/RTIME)** (1.0/3.0)	VMN2	2060
	RETURN	VMN2	2070
109	MTANK=MTANK+1.17700*MM2	VMN2	2080
-	+2.26748*MM2** (2.0/3.0)	VMN2	2090
-	+2.07277*MM2** (1.0/3.0)	VMN2	2100
-	+8.11256E-09*P0*MM2	VMN2	2110
-	+2.45681E-04*(P0*MM2/RTIME)** (2.0/3.0)	VMN2	2120
-	+1.71340E-02*(P0*MM2/RTIME)** (1.0/3.0)	VMN2	2130
	VTANK=VTANK+1.49639E-03*MM2	VMN2	2140
-	+4.97663E-03*MM2** (2.0/3.0)	VMN2	2150
-	+5.51700E-03*MM2** (1.0/3.0)	VMN2	2160
-	+8.30287E-12*P0*MM2	VMN2	2170
-	+1.55171E-07*(P0*MM2/RTIME)** (2.0/3.0)	VMN2	2180
-	+1.08218E-05*(P0*MM2/RTIME)** (1.0/3.0)	VMN2	2190
	RETURN	VMN2	2200
C		VMN2	2210
C		VMN2	2220
C	.....	VMN2	2230
C*		*VMN2	2240
C*	MPS LIQUID STORAGE (77.5 K)	*VMN2	2250
C*		*VMN2	2260
C	.....	VMN2	2270
C		VMN2	2280
C		VMN2	2290

APPENDIX F
SUBROUTINE VMN2

CHEMICAL LASER ANALYSIS PROGRAM (CLAP)
OVERLAY SCS

PAGE E-58

110	MTTHPS=2.90075E-04*P0*MN2/RTIME	VMN2	2300
	VTTHPS=6.90262E-04*P0*MN2/RTIME	VMN2	2310
	GO TO (111,112),K(J)-6	VMN2	2320
111	MVT=1.19593*MN2	VMN2	2330
-	+2.15464E-04*P0*MN2	VMN2	2340
-	+0.002013*MN2** (2.0/3.0)	VMN2	2350
-	+0.127222*MN2** (1.0/3.0)	VMN2	2360
	MNT=1.19593*MN2	VMN2	2370
-	+1.13020*MN2** (2.0/3.0)	VMN2	2380
-	+0.127222*MN2** (1.0/3.0)	VMN2	2390
	MTANK=MTANK+AMAX1(MVT,MNT)*MTTHPS	VMN2	2400
	VTANK=VTANK+1.49639E-03*MN2	VMN2	2410
-	+9.95326E-04*MN2** (2.0/3.0)	VMN2	2420
-	+2.20679E-04*MN2** (1.0/3.0)	VMN2	2430
-	+VTTHPS	VMN2	2440
	RETURN	VMN2	2450
112	MVT=1.17700*MN2	VMN2	2460
-	+2.15464E-04*P0*MN2	VMN2	2470
-	+1.99686*MN2** (2.0/3.0)	VMN2	2480
-	+2.07277*MN2** (1.0/3.0)	VMN2	2490
	MNT=1.17700*MN2	VMN2	2500
-	+2.25223*MN2** (2.0/3.0)	VMN2	2510
-	+2.07277*MN2** (1.0/3.0)	VMN2	2520
	MTANK=MTANK+AMAX1(MVT,MNT)*MTTHPS	VMN2	2530
	VTANK=VTANK+1.49639E-03*MN2	VMN2	2540
-	+4.97663E-03*MN2** (2.0/3.0)	VMN2	2550
-	+5.51700E-03*MN2** (1.0/3.0)	VMN2	2560
-	+VTTHPS	VMN2	2570
	END	VMN2	2580

```

C SURROUTINE VMN2H4(J,MN2H4,P0,RTIME,MTANK,VTANK) VMN2H4 0100
C VMN2H4 0110
C VMN2H4 0120
C ..... VMN2H4 0130
C VMN2H4 0140
C N2H4 TANK VOLUME/MASS SURROUTINE (VMN2H4) VMN2H4 0150
C VMN2H4 0160
C ..... VMN2H4 0170
C VMN2H4 0180
C ..... VMN2H4 0190
C VMN2H4 0200
C SURROUTINE VMN2H4 CALCULATES THE TANK VOLUME/MASS FOR THE STORAGE VMN2H4 0210
C OF MONOPROPELLANT HYDRAZINE (N2H4). VMN2H4 0220
C VMN2H4 0230
C N2H4 MAY BE STORED ANY OF FOUR WAYS: VMN2H4 0240
C VMN2H4 0250
C K 1 2 3 4 VMN2H4 0260
C PHASE LIQ LIQ LIQ LIQ VMN2H4 0270
C CONT SPH CYL SPH CYL VMN2H4 0280
C STMP 300.0 K 300.0 K 300.0 K 300.0 K VMN2H4 0290
C STIME INFINITE INFINITE INFINITE INFINITE VMN2H4 0300
C SPRES 1.25*P0 1.25*P0 1 ATM 1 ATM VMN2H4 0310
C PFSYS PGS PGS PFS PFS VMN2H4 0320
C MATR TI TI AL AL VMN2H4 0330
C VMN2H4 0340
C INPUT VARIABLES: VMN2H4 0350
C VMN2H4 0360
C J = STORAGE MODE CONTROL VARIABLE VMN2H4 0370
C K = STORAGE MODE CONTROL ARRAY VMN2H4 0380
C MN2H4 = TOTAL DELIVERED MASS OF N2H4 (KG) VMN2H4 0390
C P0 = COMBUSTOR OR NOZZLE STAGNATION PRESSURE (PA) VMN2H4 0400
C RTIME = RUN TIME (S) VMN2H4 0410
C VMN2H4 0420
C OUTPUT VARIABLES: VMN2H4 0430
C VMN2H4 0440
C MTANK = TANK MASS (KG) VMN2H4 0450
C STN2H4 = STORAGE MODE DESCRIPTOR DATA ARRAY VMN2H4 0460
C VTANK = TANK VOLUME (M3) VMN2H4 0470
C VMN2H4 0480
C ..... VMN2H4 0490
C VMN2H4 0500
C VMN2H4 0510
C IMPLICIT REAL(M) VMN2H4 0520
C VMN2H4 0530
C COMMON/SCS4/K(10) VMN2H4 0540
C VMN2H4 0550
C COMMON/SCS5/STMODE(10,10) VMN2H4 0560
C VMN2H4 0570
C COMMON/SCS17/STN2H4(10,4) VMN2H4 0580
C VMN2H4 0590
C DATA ((STN2H4(I,K),K=1,4),I=1,10)/ VMN2H4 0600
C -10MN2H4 ,10M2H4 ,10MN2H4 ,10MN2H4 , VMN2H4 0610
C -10MLIQ ,10MLIQ ,10MLIQ ,10MLIQ , VMN2H4 0620
C -10MSPH ,10MCYL ,10MSPH ,10MCYL , VMN2H4 0630
C -10M300.0 K ,10M300.0 K ,10M300.0 K ,10M300.0 K , VMN2H4 0640

```



```
      -10MINFINITE  .10MINFINITE  .10MINFINITE  .10MINFINITE  .      VMN2H4 0650
      -10M          .10M          .10M          .10M          .      VMN2H4 0660
      -10M1.25*P0   .10M1.25*P0   .10M1 ATM      .10M1 ATM      .      VMN2H4 0670
      -10M          .10M          .10M          .10M          .      VMN2H4 0680
      -10MPOS       .10MPOS       .10MPFS        .10MPFS        .      VMN2H4 0690
      -10MTI        .10MTI        .10MAL        .10MAL        /      VMN2H4 0700
C
C
C.....VMN2H4 0710
C.....VMN2H4 0720
C.....VMN2H4 0730
C*
C*          SET STORAGE MODE DESCRIPTOR ARRAY      *VMN2H4 0740
C*
C*.....VMN2H4 0750
C*.....VMN2H4 0760
C*.....VMN2H4 0770
C.....VMN2H4 0780
C.....VMN2H4 0790
C.....VMN2H4 0800
101  DO 101 I=1,10
      STMODE(I,J)=STN2H4(I,K(J))
C
C.....VMN2H4 0810
C.....VMN2H4 0820
C.....VMN2H4 0830
C.....VMN2H4 0840
C*
C*          CALCULATE TANK VOLUME/MASS      *VMN2H4 0850
C*
C*.....VMN2H4 0860
C*.....VMN2H4 0870
C*.....VMN2H4 0880
C.....VMN2H4 0890
C.....VMN2H4 0900
C.....VMN2H4 0910
C.....VMN2H4 0920
C.....VMN2H4 0930
C.....VMN2H4 0940
C*
C*          POS LIQUID STORAGE (300 K)      *VMN2H4 0950
C*
C*.....VMN2H4 0960
C*.....VMN2H4 0970
C*.....VMN2H4 0980
C.....VMN2H4 0990
C.....VMN2H4 1000
102  AF=1.0/(1.0-(3.17270E-08*P0)**(1.0/1.6649R))
      Z=4.73A61E-09*1.25*P0+1.00003
      MP0S=1.09122E-02*MN2H4/(4.74797E-05*Z/P0-1.79166E-02*AF)
      MTTP0S=12.5194*AF*MP0S
      - 0.904642*(AF*MP0S)**(2.0/3.0)
      VTTP0S=1.88103E-02*AF*MP0S
      GO TO (103,104),K(J)
103  MVT=1.17700*MN2H4
      - 2.10730E-08*P0*MN2H4
      - 0.110058*MN2H4** (2.0/3.0)
      MMT=1.17700*MN2H4
      - 0.233460*MN2H4** (2.0/3.0)
      MTANK=MTANK+AMAX1(MVT,MMT)*MTTP0S
      VTANK=VTANK+1.20034E-03*MN2H4*VTTP0S
      RETURN
104  MVT=1.15500*MN2H4
      - 2.79448E-08*P0*MN2H4
      - 0.243163*MN2H4** (2.0/3.0)
      MMT=1.15500*MN2H4
      VMN2H4 1150
      VMN2H4 1160
      VMN2H4 1170
      VMN2H4 1180
      VMN2H4 1190
```

-	+0.515R11*MN2H4** (2.0/3.0)	VMN2H4	1200
	MTANK=MTANK+AMAX1(MVT,MHT)+MTTPGS	VMN2H4	1210
	VTANK=VTANK+1.20034E-03*MN2H4+VTTPGS	VMN2H4	1220
	RETURN	VMN2H4	1230
C		VMN2H4	1240
C		VMN2H4	1250
C	.....	VMN2H4	1260
C		VMN2H4	1270
C	PFS LIQUID STORAGE (300 K)	VMN2H4	1280
C		VMN2H4	1290
C	.....	VMN2H4	1300
C		VMN2H4	1310
C		VMN2H4	1320
105	MTANK=MTANK+1.17700*MN2H4	VMN2H4	1330
-	+0.343700*MN2H4** (2.0/3.0)	VMN2H4	1340
-	+6.50752E-09*P0*MN2H4	VMN2H4	1350
-	+2.12101E-04*(P0*MN2H4/RTIME)** (2.0/3.0)	VMN2H4	1360
-	+1.59201E-02*(P0*MN2H4/RTIME)** (1.0/3.0)	VMN2H4	1370
	VTANK=VTANK+1.20034E-03*MN2H4	VMN2H4	1380
-	+6.66019E-12*P0*MN2H4	VMN2H4	1390
-	+1.33962E-07*(P0*MN2H4/RTIME)** (2.0/3.0)	VMN2H4	1400
-	+1.00551E-05*(P0*MN2H4/RTIME)** (1.0/3.0)	VMN2H4	1410
	RETURN	VMN2H4	1420
106	MTANK=MTANK+1.15500*MN2H4	VMN2H4	1430
-	+0.759376*MN2H4** (2.0/3.0)	VMN2H4	1440
-	+6.50752E-09*P0*MN2H4	VMN2H4	1450
-	+2.12101E-04*(P0*MN2H4/RTIME)** (2.0/3.0)	VMN2H4	1460
-	+1.59201E-02*(P0*MN2H4/RTIME)** (1.0/3.0)	VMN2H4	1470
	VTANK=VTANK+1.20034E-03*MN2H4	VMN2H4	1480
-	+6.66019E-12*P0*MN2H4	VMN2H4	1490
-	+1.33962E-07*(P0*MN2H4/RTIME)** (2.0/3.0)	VMN2H4	1500
-	+1.00551E-05*(P0*MN2H4/RTIME)** (1.0/3.0)	VMN2H4	1510
	END	VMN2H4	1520

Appendix F. NOMENCLATURE-OVERLAY MAIN

NOMENCLATURE FOR PROGRAM MAIN

AEXP ▀ DUMMY NAMELIST VARIABLE
ALPHA ▀ DUMMY NAMELIST VARIABLE
A3A7 ▀ DUMMY NAMELIST VARIABLE
A7A6 ▀ DUMMY NAMELIST VARIABLE
RRFRAC ▀ DUMMY NAMELIST VARIABLE
CANOLE ▀ DUMMY NAMELIST VARIABLE
CCS ▀ ALPHANUMERIC SYMBOL DESIGNATING THE COMBUSTION CHEMISTRY
 SECTION
CCS1 ▀ DUMMY BLOCK COMMON VARIABLE
CCS9 ▀ DUMMY BLOCK COMMON VARIABLE
CCS10 ▀ DUMMY BLOCK COMMON VARIABLE
CCS13 ▀ DUMMY BLOCK COMMON VARIABLE
CCS14 ▀ DUMMY BLOCK COMMON VARIABLE
CCS15 ▀ DUMMY BLOCK COMMON VARIABLE
CCS16 ▀ DUMMY BLOCK COMMON VARIABLE
CHOKED ▀ ALPHANUMERIC SYMBOL DESIGNATING CHOKED FLOW
D1 ▀ DUMMY NAMELIST VARIABLE
D15 ▀ DUMMY NAMELIST VARIABLE
D3 ▀ DUMMY NAMELIST VARIABLE
D35 ▀ DUMMY NAMELIST VARIABLE
ETA12 ▀ DUMMY NAMELIST VARIABLE
FAIL ▀ ERROR FLAG
FLOW ▀ CHOKED/SEPARATED/SUBSONIC/SUPERSONIC FLOW FLAG
OS ▀ DUMMY NAMELIST VARIABLE
MNB ▀ DUMMY NAMELIST VARIABLE
LCAV ▀ DUMMY NAMELIST VARIABLE
LDS ▀ ALPHANUMERIC SYMBOL DESIGNATING THE LASER DEVICE SECTION
LDS1 ▀ DUMMY BLOCK COMMON VARIABLE
LPNO2 ▀ DUMMY NAMELIST VARIABLE
LSNO2 ▀ DUMMY NAMELIST VARIABLE
MWS ▀ DUMMY NAMELIST VARIABLE
NBANK ▀ DUMMY NAMELIST VARIABLE
NEJECT ▀ DUMMY NAMELIST VARIABLE
NO ▀ ALPHANUMERIC SYMBOL DESIGNATING A NEGATIVE RESPONSE
NSPNO2 ▀ DUMMY NAMELIST VARIABLE
N1 ▀ DUMMY NAMELIST VARIABLE
N2 ▀ DUMMY NAMELIST VARIABLE
N3 ▀ DUMMY NAMELIST VARIABLE
N4 ▀ DUMMY NAMELIST VARIABLE
PKFRAC ▀ DUMMY NAMELIST VARIABLE
PRS ▀ ALPHANUMERIC SYMBOL DESIGNATING THE PRESSURE RECOVERY SECTION
PRS1 ▀ DUMMY BLOCK COMMON VARIABLE
P10 ▀ DUMMY NAMELIST VARIABLE
P50 ▀ DUMMY NAMELIST VARIABLE
P7 ▀ DUMMY NAMELIST VARIABLE
RECALL ▀ ALPHANUMERIC SYMBOL FOR AN OVERLAY RECALL OPTION
RTIME ▀ DUMMY NAMELIST VARIABLE
RUN ▀ CONTROL VARIABLE TO STOP OR RESTART THE PROGRAM
SCS ▀ ALPHANUMERIC SYMBOL DESIGNATING THE SYSTEM CALCULATION SECTION
SCS4 ▀ DUMMY BLOCK COMMON VARIABLE
SETCCS ▀ CONTROL VARIABLE TO SET DEFAULT VALUES IN SUBROUTINE INCCS
SETLDS ▀ CONTROL VARIABLE TO SET DEFAULT VALUES IN SUBROUTINE INLDS

SETPRS	■ CONTROL VARIABLE TO SET DEFAULT VALUES IN SUBROUTINE INPRS
SETSCS	■ CONTROL VARIABLE TO SET DEFAULT VALUES IN SUBROUTINE INSCS
T10	■ DUMMY NAMELIST VARIABLE
T30	■ DUMMY NAMELIST VARIABLE
T50	■ DUMMY NAMELIST VARIABLE
T70	■ DUMMY NAMELIST VARIABLE
WPG	■ DUMMY NAMELIST VARIABLE
WPP3	■ DUMMY NAMELIST VARIABLE
WPR1	■ DUMMY NAMELIST VARIABLE
WPR2	■ DUMMY NAMELIST VARIABLE
WPR3	■ DUMMY NAMELIST VARIABLE
WPR4	■ DUMMY NAMELIST VARIABLE
WSR1	■ DUMMY NAMELIST VARIABLE
WSR2	■ DUMMY NAMELIST VARIABLE
WSR3	■ DUMMY NAMELIST VARIABLE
YES	■ ALPHANUMERIC SYMBOL DESIGNATING A POSITIVE RESPONSE

NOMENCLATURE FOR SUBROUTINE OUTENG

VARIABLE DEFINITIONS FOR SUBROUTINE OUTENG ARE IDENTICAL TO THOSE GIVEN FOR SUBROUTINES OUTCCS, OUTLOS, OUTPRS, AND OUTSCS. ONLY THE UNITS HAVE BEEN CHANGED FROM THE SI SYSTEM TO A MIXTURE OF ENGINEERING UNITS.

COMBUSTION CHEMISTRY SECTION GENERAL NOTATION SCHEME

VARIABLES ARE DEFINED AS FOLLOWS:

PREFIX:

W = MASS FLOW RATE
 WF = MASS FRACTION
 X = MOLAR FLOW RATE
 XF = MOLE FRACTION

SUFFIX:

CP = CAVITY PRODUCT
 PG = MIRROR PURGE
 PP = PRIMARY COMBUSTOR PRODUCT
 PR = PRIMARY COMBUSTOR REACTANT
 SR = SECONDARY REACTANT

EXAMPLE: XFPP1 = MOLE FRACTION OF PRIMARY COMBUSTOR PRODUCT 1

LASER PRIMARY COMBUSTOR REACTANTS:

PR1 = C-N1 H-N2 (C-N1 D-N2)
 PR2 = HE
 PR3 = N2
 PR4 = N-N3 F-N4

LASER SECONDARY REACTANTS:

SR1 = O2 (H2)
 SR2 = HE
 SR3 = N2

LASER PRIMARY COMBUSTOR PRODUCTS:

PP1 = CF4
 PP2 = F2
 PP3 = F
 PP4 = HF (DF)
 PP5 = HE
 PP6 = N2

LASER CAVITY PRODUCTS:

CP1 = CF4
 CP2 = HF
 CP3 = DF
 CP4 = HE
 CP5 = N2
 CP6 = D (H)

NOTE: REACTANTS AND PRODUCTS ARE DEFINED FOR BOTH DF AND HF CHEMISTRY.
 SPECIES IN PARENTHESIS ARE FOR HF CHEMISTRY.

ALL VARIABLES NOT FOLLOWING THIS SCHEME ARE DEFINED IN THE
NOMENCLATURE FOR THE PROGRAM OR SUBROUTINE WHERE THEY APPEAR.

NOMENCLATURE FOR PROGRAM CCS AND SUBROUTINES INCCS, OUTCCS

AEXP	= NOZZLE BANK AREA OF THE EXPERIMENTAL DEVICE (M ²)
ALPHA	= FLUORINE DISSOCIATION FRACTION
CCSS1	= CONTROL VARIABLE DESIGNATING WHETHER OR NOT NEW COMBUSTION CHEMISTRY INPUTS ARE REQUIRED
CCSS2	= CONTROL VARIABLE DESIGNATING WHETHER OR NOT INPUT DATA SHOULD BE READ FROM TAPE 1
DF	= ALPHANUMERIC SYMBOL DESIGNATING OF LASER CHEMISTRY
DFORHF	= CONTROL VARIABLE SUCH THAT: = "DF" FOR DF CHEMICAL LASER = "HF" FOR HF CHEMICAL LASER
D2F	= HEAT OF COMBUSTION (J/KMOLE) FOR THE REACTION $D_2 + F = DF + D$
D2F2	= HEAT OF COMBUSTION (J/KMOLE) FOR THE REACTION $D_2 + F_2 = 2DF$
FDAF	= FREE FLUORINE FLUX (KMOLE/S-M ²)
HF	= ALPHANUMERIC SYMBOL DESIGNATING HF LASER CHEMISTRY
H2F	= HEAT OF COMBUSTION (J/KMOLE) FOR THE REACTION $H_2 + F = HF + H$
H2F2	= HEAT OF COMBUSTION (J/KMOLE) FOR THE REACTION $H_2 + F_2 = 2HF$
N0	= ALPHANUMERIC SYMBOL DESIGNATING A NEGATIVE RESPONSE
N1	= NUMBER OF CARBON ATOMS IN PRIMARY COMBUSTOR REACTANT 1
N2	= NUMBER OF HYDROGEN (DEUTERIUM) ATOMS IN PRIMARY COMBUSTOR REACTANT 1
N3	= NUMBER OF NITROGEN ATOMS IN PRIMARY COMBUSTOR REACTANT 4
N4	= NUMBER OF FLUORINE ATOMS IN PRIMARY COMBUSTOR REACTANT 4
OMEGA	= TOTAL LASER MOLAR DILUENT RATIO
OMEGTRW	= TOTAL LASER MOLAR DILUENT RATIO (TRW DEFINITION)
PSIC	= MOLAR COMBUSTOR DILUENT RATIO
PSIL	= MOLAR CAVITY DILUENT RATIO
PSILTRW	= MOLAR CAVITY DILUENT RATIO (TRW DEFINITION)
Q	= HEAT RELEASED PER KMOLE OF PRIMARY COMBUSTOR FLOW BY THE CHEMICAL REACTION OF FLUORINE IN THE LASER CAVITY (J/KMOLE)
RC	= MOLAR COMBUSTOR MIXTURE RATIO
RDATE	= ALPHANUMERIC SYMBOL FOR THE COMPUTER RUN DATE
RL	= MOLAR CAVITY MIXTURE RATIO
RLF	= TOTAL LASER CAVITY MIXTURE RATIO
SETCCS	= CONTROL VARIABLE TO SET DEFAULT VALUES
WCPTOT	= TOTAL CAVITY PRODUCT MASS FLOW RATE (KG/S)
WCP1	= MASS FLOW RATE OF CAVITY PRODUCT 1, CF4 (KG/S)
WCP2	= MASS FLOW RATE OF CAVITY PRODUCT 2, HF (KG/S)
WCP3	= MASS FLOW RATE OF CAVITY PRODUCT 3, DF (KG/S)
WCP4	= MASS FLOW RATE OF CAVITY PRODUCT 4, HE (KG/S)
WCP5	= MASS FLOW RATE OF CAVITY PRODUCT 5, N2 (KG/S)
WCP6	= MASS FLOW RATE OF CAVITY PRODUCT 6, D (H) (KG/S)
WFCP1	= MASS FRACTION OF CAVITY PRODUCT 1, CF4
WFCP2	= MASS FRACTION OF CAVITY PRODUCT 2, HF
WFCP3	= MASS FRACTION OF CAVITY PRODUCT 3, DF
WFCP4	= MASS FRACTION OF CAVITY PRODUCT 4, HE
WFCP5	= MASS FRACTION OF CAVITY PRODUCT 5, N2
WFCP6	= MASS FRACTION OF CAVITY PRODUCT 6, D (H)
WFPP1	= MASS FRACTION OF PRIMARY COMBUSTOR PRODUCT 1, CF4

WFPP2	■	MASS FRACTION OF PRIMARY COMBUSTOR PRODUCT 2, F2	
WFPP3	■	MASS FRACTION OF PRIMARY COMBUSTOR PRODUCT 3, F	
WFPP4	■	MASS FRACTION OF PRIMARY COMBUSTOR PRODUCT 4, HF (DF)	
WFPP5	■	MASS FRACTION OF PRIMARY COMBUSTOR PRODUCT 5, HE	
WFPP6	■	MASS FRACTION OF PRIMARY COMBUSTOR PRODUCT 6, N2	
WFPR1	■	MASS FRACTION OF PRIMARY COMBUSTOR REACTANT 1, C-N1 H-N2 (C-N1 O-N2)	
WFPR2	■	MASS FRACTION OF PRIMARY COMBUSTOR REACTANT 2, HE	
WFPR3	■	MASS FRACTION OF PRIMARY COMBUSTOR REACTANT 3, N2	
WFPR4	■	MASS FRACTION OF PRIMARY COMBUSTOR REACTANT 4, N-N3 F-N4	
WFSR1	■	MASS FRACTION OF SECONDARY REACTANT 1, D2 (H2)	
WFSR2	■	MASS FRACTION OF SECONDARY REACTANT 2, HE	
WFSR3	■	MASS FRACTION OF SECONDARY REACTANT 3, N2	
WPG	■	MASS FLOW RATE OF MIRROR PURGE N2 (KG/S)	
WPGWPP	■	MIRROR PURGE-TO-PRIMARY COMBUSTOR PRODUCT MASS FLOW RATIO	
WPPTOT	■	TOTAL MASS FLOW RATE OF PRIMARY COMBUSTOR PRODUCTS	(KG/S)
WPP1	■	MASS FLOW RATE OF PRIMARY COMBUSTOR PRODUCT 1, CF4	(KG/S)
WPP2	■	MASS FLOW RATE OF PRIMARY COMBUSTOR PRODUCT 2, F2	(KG/S)
WPP3	■	MASS FLOW RATE OF PRIMARY COMBUSTOR PRODUCT 3, F	(KG/S)
WPP4	■	MASS FLOW RATE OF PRIMARY COMBUSTOR PRODUCT 4, HF (DF)	(KG/S)
WPP5	■	MASS FLOW RATE OF PRIMARY COMBUSTOR PRODUCT 5, HE	(KG/S)
WPP6	■	MASS FLOW RATE OF PRIMARY COMBUSTOR PRODUCT 6, N2	(KG/S)
WPRTOT	■	TOTAL MASS FLOW RATE OF PRIMARY COMBUSTOR REACTANTS	(KG/S)
WPR1	■	MASS FLOW RATE OF PRIMARY COMBUSTOR REACTANT 1, C-N1 H-N2 (C-N1 O-N2) (KG/S)	
WPR2	■	MASS FLOW RATE OF PRIMARY COMBUSTOR REACTANT 2, HE (KG/S)	
WPR3	■	MASS FLOW RATE OF PRIMARY COMBUSTOR REACTANT 3, N2 (KG/S)	
WPR4	■	MASS FLOW RATE OF PRIMARY COMBUSTOR REACTANT 4, N-N1 F-N2 (KG/S)	
WSRTOT	■	TOTAL MASS FLOW RATE OF SECONDARY REACTANTS	(KG/S)
WSR1	■	MASS FLOW RATE OF SECONDARY REACTANT 1, D2 (H2) (KG/S)	
WSR2	■	MASS FLOW RATE OF SECONDARY REACTANT 2, HE (KG/S)	
WSR3	■	MASS FLOW RATE OF SECONDARY REACTANT 3, N2 (KG/S)	
XCPTOT	■	TOTAL MOLAR FLOW RATE OF CAVITY PRODUCTS	(KMOLE/S)
XCP1	■	MOLAR FLOW RATE OF CAVITY PRODUCT 1, CF4	(KMOLE/S)
XCP2	■	MOLAR FLOW RATE OF CAVITY PRODUCT 2, HF	(KMOLE/S)
XCP3	■	MOLAR FLOW RATE OF CAVITY PRODUCT 3, DF	(KMOLE/S)
XCP4	■	MOLAR FLOW RATE OF CAVITY PRODUCT 4, HE	(KMOLE/S)
XCP5	■	MOLAR FLOW RATE OF CAVITY PRODUCT 5, N2	(KMOLE/S)
XCP6	■	MOLAR FLOW RATE OF CAVITY PRODUCT 6, D (H) (KMOLE/S)	
XFCP1(1)	■	MOLE FRACTION OF CAVITY PRODUCT 1, CF4, W/O MIRROR PURGE	
(2)	■	MOLE FRACTION OF CAVITY PRODUCT 1, CF4, WITH MIRROR PURGE	
XFCP2(1)	■	MOLE FRACTION OF CAVITY PRODUCT 2, HF, W/O MIRROR PURGE	
(2)	■	MOLE FRACTION OF CAVITY PRODUCT 2, HF, WITH MIRROR PURGE	
XFCP3(1)	■	MOLE FRACTION OF CAVITY PRODUCT 3, DF, W/O MIRROR PURGE	
(2)	■	MOLE FRACTION OF CAVITY PRODUCT 3, DF, WITH MIRROR PURGE	
XFCP4(1)	■	MOLE FRACTION OF CAVITY PRODUCT 4, HE, W/O MIRROR PURGE	
(2)	■	MOLE FRACTION OF CAVITY PRODUCT 4, HE, WITH MIRROR PURGE	
XFCP5(1)	■	MOLE FRACTION OF CAVITY PRODUCT 5, N2, W/O MIRROR PURGE	
(2)	■	MOLE FRACTION OF CAVITY PRODUCT 5, N2, WITH MIRROR PURGE	
XFCP6(1)	■	MOLE FRACTION OF CAVITY PRODUCT 6, D (H), W/O MIRROR PURGE	
(2)	■	MOLE FRACTION OF CAVITY PRODUCT 6, D (H), WITH MIRROR PURGE	
XFPP1	■	MOLE FRACTION OF PRIMARY COMBUSTOR PRODUCT 1, CF4	
XFPP2	■	MOLE FRACTION OF PRIMARY COMBUSTOR PRODUCT 2, F2	
XFPP3	■	MOLE FRACTION OF PRIMARY COMBUSTOR PRODUCT 3, F	

XFPP4	■ MOLE FRACTION OF PRIMARY COMBUSTOR PRODUCT 4, HF (DF)
XFPP5	■ MOLE FRACTION OF PRIMARY COMBUSTOR PRODUCT 5, HE
XFPP6	■ MOLE FRACTION OF PRIMARY COMBUSTOR PRODUCT 6, N2
XFPR1	■ MOLE FRACTION OF PRIMARY COMBUSTOR REACTANT 1, C-N1 H-N2 (C-N1 O-N2)
XFPR2	■ MOLE FRACTION OF PRIMARY COMBUSTOR REACTANT 2, HE
XFPR3	■ MOLE FRACTION OF PRIMARY COMBUSTOR REACTANT 3, N2
XFPR4	■ MOLE FRACTION OF PRIMARY COMBUSTOR REACTANT 4, N-N3 F-N4
XFSR1	■ MOLE FRACTION OF SECONDARY REACTANT 1, D2 (H2)
XFSR2	■ MOLE FRACTION OF SECONDARY REACTANT 2, HE
XFSR3	■ MOLE FRACTION OF SECONDARY REACTANT 3, N2
XPPTOT	■ TOTAL MOLAR FLOW RATE OF PRIMARY COMBUSTOR PRODUCTS [KMOLE/S]
XPP1	■ MOLAR FLOW RATE OF PRIMARY COMBUSTOR PRODUCT 1, CF4 [KMOLE/S]
XPP2	■ MOLAR FLOW RATE OF PRIMARY COMBUSTOR PRODUCT 2, F2 [KMOLE/S]
XPP3	■ MOLAR FLOW RATE OF PRIMARY COMBUSTOR PRODUCT 3, F [KMOLE/S]
XPP3TM	■ MOLAR FLOW RATE OF PRIMARY COMBUSTOR PRODUCT 3, F [KMOLE/S], FOR TOTAL FLUORINE DISSOCIATION
XPP4	■ MOLAR FLOW RATE OF PRIMARY COMBUSTOR PRODUCT 4, HF (DF) [KMOLE/S]
XPP5	■ MOLAR FLOW RATE OF PRIMARY COMBUSTOR PRODUCT 5, HE [KMOLE/S]
XPP6	■ MOLAR FLOW RATE OF PRIMARY COMBUSTOR PRODUCT 6, N2 [KMOLE/S]
XPRTOT	■ TOTAL MOLAR FLOW RATE OF PRIMARY COMBUSTOR REACTANTS [KMOLE/S]
XPR1	■ MOLAR FLOW RATE OF PRIMARY COMBUSTOR REACTANT 1, C-N1 H-N2 (C-N1 O-N2) [KMOLE/S]
XPR2	■ MOLAR FLOW RATE OF PRIMARY COMBUSTOR REACTANT 2, HE [KMOLE/S]
XPR3	■ MOLAR FLOW RATE OF PRIMARY COMBUSTOR REACTANT 3, N2 [KMOLE/S]
XPR4	■ MOLAR FLOW RATE OF PRIMARY COMBUSTOR REACTANT 4, N-N1 F-N2 [KMOLE/S]
XSRTOT	■ TOTAL MOLAR FLOW RATE OF SECONDARY REACTANTS [KMOLE/S]
XSR1	■ MOLAR FLOW RATE OF SECONDARY REACTANT 1, D2 (H2) [KMOLE/S]
XSR2	■ MOLAR FLOW RATE OF SECONDARY REACTANT 2, HE [KMOLE/S]
XSR3	■ MOLAR FLOW RATE OF SECONDARY REACTANT 3, N2 [KMOLE/S]
YES	■ ALPHANUMERIC SYMBOL DESIGNATING A POSITIVE RESPONSE

LASER DEVICE SECTION GENERAL NOTATION SCHEME

VARIABLES ARE DEFINED AS FOLLOWS:

A : AREA PER KMOLE/S OF PRIMARY FLOW ($S-M^2/KMOLE$)
 D : DIAMETER (M)
 G : (GAMMA) SPECIFIC HEAT RATIO
 M : MACH NUMBER
 MW: MOLECULAR WEIGHT (KG/KMOLE)
 P : PRESSURE (PA)
 R : DENSITY (KG/M³)
 RE: REYNOLDS NUMBER
 T : TEMPERATURE (K)
 W : MASS FLOW RATE (KG/S)
 X : MOLAR FLOW RATE (KMOLE/S)

REPEATED LETTERS INDICATE RATIOS.
 EXAMPLE: $MW_2 = MW_6 / W_2$

VARIABLES ARE DESIGNATED AS TO LOCATION BY THE FOLLOWING:

POINT 1: PRIMARY NOZZLE EXIT - CONDITIONS BASED ON THE NOZZLE
 STAGNATION (COMBUSTOR) TEMPERATURE
 POINT 2: PRIMARY NOZZLE EXIT - CONDITIONS BASED ON THE NOZZLE
 EXIT TEMPERATURE
 POINT 3: SECONDARY NOZZLE EXIT - CONDITIONS BASED ON THE NOZZLE
 STAGNATION (COMBUSTOR) TEMPERATURE
 POINT 4: SECONDARY NOZZLE EXIT - CONDITIONS BASED ON THE NOZZLE
 EXIT TEMPERATURE
 POINT 5: EXIT OF THE CONSTANT-AREA MIXING REGION
 POINT 6: EXIT OF THE ISENTROPIC EXPANSION REGION
 POINT 7: MIRROR PURGE CONDITIONS
 POINT 8: LASER CAVITY EXIT
 EXAMPLE: MW_8 = MOLECULAR WEIGHT AT THE CAVITY EXIT

E: INDICATES "EFFECTIVE" CONDITIONS
 G: INDICATES "GEOMETRIC" CONDITIONS
 S: INDICATES "S" CONDITIONS
 O: INDICATES STAGNATION CONDITIONS
 EXAMPLE: $A1A1S_6 = A/A^*$ AT THE PRIMARY NOZZLE EXIT BASED ON THE NOZZLE
 GEOMETRY

NOTE: ALL VARIABLES NOT FOLLOWING THIS SCHEME ARE DEFINED IN THE
 NOMENCLATURE FOR THE PROGRAM OR SUBROUTINE WHERE THEY APPEAR.

NOMENCLATURE FOR PROGRAM LDS AND SUBROUTINES INLDS, OUTLDS

A	■ VISCOSITY COEFFICIENT ($\text{ALOG}(N-S/M^2)/\text{ALOG}(K)$)
R	■ VISCOSITY COEFFICIENT ($\text{ALOG}(N-S/M^2)$)
RRFRAC	■ NOZZLE BANK RELIEF FRACTION
CANGLE	■ LASER CAVITY HALF-ANGLE (RAD)
CCSS1	■ CONTROL VARIABLE DESIGNATING WHETHER OR NOT NEW COMBUSTION CHEMISTRY INPUTS ARE REQUIRED
CHOKE	■ ALPHANUMERIC SYMBOL DESIGNATING CHOKED FLOW
DFORMF	■ CONTROL VARIABLE DESIGNATING OF OR HF LASER CHEMISTRY
FAIL	■ ERROR FLAG
FLOW	■ CHOKED/SEPARATED/SUBSONIC/SUPERSONIC FLOW FLAG
GEOMPN	■ PRIMARY NOZZLE GEOMETRY CONTROL VARIABLE SUCH THAT: ■ "AX" FOR AXISYMMETRIC NOZZLES ■ "2D" FOR SLIT NOZZLES
GEOMSN	■ SECONDARY NOZZLE GEOMETRY CONTROL VARIABLE SUCH THAT: ■ "AX" FOR AXISYMMETRIC NOZZLES ■ "2D" FOR SLIT NOZZLES
GP	■ SPECIFIC HEAT RATIO OF THE CAVITY PRODUCT MIXTURE WITHOUT MIRROR PURGE
HBASE	■ HEIGHT OF NOZZLE BASE (M)
HF	■ ALPHANUMERIC SYMBOL DESIGNATING HF LASER CHEMISTRY
HNB	■ HEIGHT OF NOZZLE BANK (M)
K	■ DO LOOP INDEX
LCAV	■ LASER CAVITY CENTER LINE LENGTH (M)
LSS1	■ CONTROL VARIABLE DESIGNATING WHETHER OR NOT NEW LASER DEVICE INPUTS ARE REQUIRED
LSS2	■ CONTROL VARIABLE DESIGNATING AN INPUT VARIABLE AS EITHER: ■ "T10" FOR THE PRIMARY COMBUSTOR OR NOZZLE STAGNATION TEMPERATURE OR ■ "P10" FOR THE PRIMARY COMBUSTOR OR NOZZLE STAGNATION PRESSURE
LSS3	■ CONTROL VARIABLE DESIGNATING WHETHER OR NOT INPUT DATA SHOULD BE READ FROM TAPE2
LPNOZ	■ CENTER LINE LENGTH OF A PRIMARY NOZZLE FROM THROAT TO EXIT PLANE (M)
LSEP	■ CAVITY FLOW SEPARATION LENGTH FROM THE NOZZLE FACE (M)
LSLCAV	■ CAVITY FLOW SEPARATION LENGTH-TO-TOTAL CAVITY LENGTH RATIO
LSNOZ	■ CENTER LINE LENGTH OF A SECONDARY NOZZLE FROM THROAT TO EXIT PLANE (M)
MWP	■ MOLECULAR WEIGHT OF THE CAVITY PRODUCT MIXTURE WITHOUT MIRROR PURGE (KG/KMOLE)
MWPMW6	■ CAVITY PRODUCT MIXTURE (WITHOUT MIRROR PURGE)-TO-ISENTROPIC EXPANSION REGION EXIT MOLECULAR WEIGHT RATIO
NO	■ ALPHANUMERIC SYMBOL DESIGNATING A NEGATIVE RESPONSE
NPN0Z	■ NUMBER OF PRIMARY NOZZLES PER KMOLE/S OF PRIMARY FLOW (S/KMOLE)
NSNOZ	■ NUMBER OF SECONDARY NOZZLES PER KMOLE/S OF PRIMARY FLOW (S/KMOLE)
NSPNOZ	■ NUMBER OF SECONDARY-TO-PRIMARY NOZZLES
PKFRAC	■ NOZZLE PACKING FRACTION
Q	■ HEAT RELEASED PER KMOLE OF PRIMARY COMBUSTOR FLOW BY THE CHEMICAL REACTION OF FLUORINE IN THE LASER CAVITY (J/KMOLE)
Q68	■ DIMENSIONLESS HEAT RELEASE BETWEEN STATIONS 6 AND 8
RRAR	■ UNIVERSAL GAS CONSTANT (J/KMOLE-K)

SETLOS ■ CONTROL VARIABLE TO SET DEFAULT VALUES
SEF ■ ALPHANUMERIC SYMBOL DESIGNATING SEPARATED FLOW
SUP ■ ALPHANUMERIC SYMBOL DESIGNATING SUPERSONIC FLOW
TP ■ ESTIMATED STATIC TEMPERATURE OF THE CAVITY PRODUCT MIXTURE
 WITHOUT MIRROR PURGE (K)
XF ■ MOLE FRACTION ARRAY
XFCP1(1) ■ MOLE FRACTION OF CAVITY PRODUCT 1, CF4, W/O MIRROR PURGE
 (2) ■ MOLE FRACTION OF CAVITY PRODUCT 1, CF4, WITH MIRROR PURGE
XFCP2(1) ■ MOLE FRACTION OF CAVITY PRODUCT 2, HF, W/O MIRROR PURGE
 (2) ■ MOLE FRACTION OF CAVITY PRODUCT 2, HF, WITH MIRROR PURGE
XFCP3(1) ■ MOLE FRACTION OF CAVITY PRODUCT 3, DF, W/O MIRROR PURGE
 (2) ■ MOLE FRACTION OF CAVITY PRODUCT 3, DF, WITH MIRROR PURGE
XFCP4(1) ■ MOLE FRACTION OF CAVITY PRODUCT 4, HE, W/O MIRROR PURGE
 (2) ■ MOLE FRACTION OF CAVITY PRODUCT 4, HE, WITH MIRROR PURGE
XFCP5(1) ■ MOLE FRACTION OF CAVITY PRODUCT 5, N2, W/O MIRROR PURGE
 (2) ■ MOLE FRACTION OF CAVITY PRODUCT 5, N2, WITH MIRROR PURGE
XFCP6(1) ■ MOLE FRACTION OF CAVITY PRODUCT 6, D (H), W/O MIRROR PURGE
 (2) ■ MOLE FRACTION OF CAVITY PRODUCT 6, D (H), WITH MIRROR PURGE
YES ■ ALPHANUMERIC SYMBOL DESIGNATING A POSITIVE RESPONSE

NOMENCLATURE FOR SUBROUTINE CAMS

ASIAP1 = SECONDARY-TO-PRIMARY STREAM AREA RATIO
C1 = INTERMEDIATE CONSTANT
C2 = INTERMEDIATE CONSTANT
C3 = INTERMEDIATE CONSTANT
C4 = INTERMEDIATE CONSTANT
FAIL = ERROR FLAG
FFX = INTERMEDIATE CONSTANT
FLOW = SUBSONIC/SUPERSONIC FLOW FLAG
GM = MIXED STREAM SPECIFIC HEAT RATIO
GMAP = MIXED-TO-PRIMARY STREAM RATIO OF SPECIFIC HEAT RATIOS
GP = PRIMARY STREAM SPECIFIC HEAT RATIO
GP3 = INTERMEDIATE CONSTANT
GS = SECONDARY STREAM SPECIFIC HEAT RATIO
GS6P = SECONDARY-TO-PRIMARY STREAM RATIO OF SPECIFIC HEAT RATIOS
GS3 = INTERMEDIATE CONSTANT
MM3 = MIXED STREAM MACH NUMBR
MP1 = PRIMARY STREAM MACH NUMBER
MS1 = SECONDARY STREAM MACH NUMBER
MWMWP = MIXED-TO-PRIMARY STREAM MOLECULAR WEIGHT RATIO
MUPMWS = PRIMARY-TO-SECONDARY STREAM MOLECULAR WEIGHT RATIO
MWSMWP = SECONDARY-TO-PRIMARY STREAM MOLECULAR WEIGHT RATIO
PM3PP1 = MIXED-TO-PRIMARY STREAM STATIC PRESSURE RATIO
PS1PP1 = SECONDARY-TO-PRIMARY STREAM STATIC PRESSURE RATIO
SUP = ALPHANUMERIC SYMBOL DESIGNATING SUPERSONIC FLOW
TM0TP0 = MIXED-TO-PRIMARY STREAM STAGNATION TEMPERATURE RATIO
TS0TP0 = SECONDARY-TO-PRIMARY STREAM STAGNATION TEMPERATURE RATIO
WSWP = SECONDARY-TO-PRIMARY STREAM MASS FLOW RATIO
YES = ALPHANUMERIC SYMBOL DESIGNATING A POSITIVE RESPONSE

NOMENCLATURE FOR SUBROUTINE CPCALC

CP	▪ SPECIFIC HEAT DATA ARRAY ($1.0E-04$ J/KMOLF-K)
CPMIX	▪ SPECIFIC HEAT OF THE GAS MIXTURE (J/KMOLF-K)
CPTDZ	▪ SPECIFIC HEAT AT THE GAS MIXTURE TEMPERATURE (J/KMOLE-K)
FRAC	▪ INTERPOLATION WEIGHTING FACTOR
GMIX	▪ SPECIFIC HEAT RATIO OF THE GAS MIXTURE
I	▪ DO LOOP INDEX
J	▪ INTEGER FOR CP TABLE TEMPERATURE SELECTION
NW	▪ MOLECULAR WEIGHT DATA ARRAY (KG/KMOLE)
NWMIX	▪ MOLECULAR WEIGHT OF THE GAS MIXTURE (KG/KMOLE)
NS1	▪ DO LOOP LIMIT FOR SPECIES SELECTION
NS2	▪ DO LOOP LIMIT FOR SPECIES SELECTION
RRAR	▪ UNIVERSAL GAS CONSTANT (J/KMOLE-K)
TDZ	▪ TEMPERATURE OF THE GAS MIXTURE (K)
TLO	▪ LOW OR TEMPERATURE FOR LINEAR INTERPOLATION (K)
XF	▪ MOLE FRACTION ARRAY

NOMENCLATURE FOR SUBROUTINE FXPAN

A1A1S = A/A* FOR THE ENTERING STREAM
A2A1 = EXIT-TO-ENTRANCE AREA RATIO
FAIL = ERROR FLAG
Q = SPECIFIC HEAT RATIO
Q2 = INTERMEDIATE CONSTANT
Q4 = INTERMEDIATE CONSTANT
M1 = ENTRANCE MACH NUMBER
M2 = EXIT MACH NUMBER
P2P1 = EXIT-TO-ENTRANCE STATIC PRESSURE RATIO
P2OP1O = EXIT-TO-ENTRANCE STAGNATION PRESSURE RATIO
SUP = ALPHANUMERIC SYMBOL DESIGNATING SUPERSONIC FLOW
T2T1 = EXIT-TO-ENTRANCE STATIC TEMPERATURE RATIO
T2OT1O = EXIT-TO-ENTRANCE STAGNATION TEMPERATURE RATIO
YES = ALPHANUMERIC SYMBOL DESIGNATING A POSITIVE RESPONSE

NOMENCLATURE FOR SUBROUTINE IYFR

DX = STEP SIZE FOR CHANGING THE INDEPENDENT VARIABLE, X, IN THE
 INCREMENT MODE
ERRORX = MAXIMUM PERCENT DEVIATION IN THE CURRENT AND PREVIOUS VALUE OF
 X FOR A SOLUTION
ERRORY = MAXIMUM PERCENT ERROR IN Y AND YGIVEN FOR A SOLUTION
NYT = ITERATION NUMBER
NSIGN = INTERMEDIATE CONSTANT
NSIGN1 = INTERMEDIATE CONSTANT
NSIGN2 = INTERMEDIATE CONSTANT
NTYPE = CONTROL VARIABLE SUCH THAT:
 = 1, FOR THE INCREMENT MODE
 = 2, FOR THE INTERPOLATION MODE
 = 3, FOR A SOLUTION
RATIO = INTERPOLATION WEIGHTING FACTOR
SIGN = CONTROL VARIABLE FOR THE DIRECTION OF INCREMENT FROM THE
 INITIAL VALUE OF X
X = INDEPENDENT VARIABLE
XNEG = PREVIOUS VALUE OF X
XPOS = PREVIOUS VALUE OF X
XSAVE = PREVIOUS VALUE OF X
Y = DEPENDENT VARIABLE
YGIVEN = GIVEN VALUE OF THE DEPENDENT VARIABLE
YNEG = PREVIOUS VALUE OF Y
YPOS = PREVIOUS VALUE OF Y

NOMENCLATURE FOR SUBROUTINE L01AYR

A	= SLOPE OF VISCOSITY-TEMPERATURE RELATION $(\text{ALOG}(\text{N-S/M}^2)/\text{ALOG}(\text{K}))$
B	= INTERCEPT OF VISCOSITY-TEMPERATURE RELATION $(\text{ALOG}(\text{N-S/M}^2))$
DELTA	= BOUNDARY LAYER THICKNESS (M)
GEOFAC	= NOZZLE GEOMETRY FACTOR SUCH THAT: = 1.0, FOR AXISYMMETRIC NOZZLES = 0.0, FOR SLIT NOZZLES
L0NOZ	= NOZZLE BOUNDARY LAYER LENGTH (M)
MU	= ABSOLUTE VISCOSITY (N-S/M ²)
MW	= MOLECULAR WEIGHT (KG/KMOLE)
PE	= STATIC PRESSURE AT THE NOZZLE EXIT (PA)
RRAR	= UNIVERSAL GAS CONSTANT (J/KMOLE-K)
RE	= REYNOLDS NUMBER AT THE NOZZLE EXIT
T	= ADIABATIC WALL TEMPERATURE (K)
TE	= STATIC TEMPERATURE AT THE NOZZLE EXIT (K)
TO	= NOZZLE STAGNATION TEMPERATURE (K)
VE	= VELOCITY AT THE NOZZLE EXIT (M/S)

NOMENCLATURE FOR SUBROUTINES LCAS, LCFS

A2A1	▪ EXIT-TO-ENTRANCE AREA RATIO
CHOKF	▪ ALPHANUMERIC SYMBOL DESIGNATING CHOKED FLOW
C1	▪ INTERMEDIATE VARIABLE IN THE RUNGE-KUTTA ALGORITHM
C2	▪ INTERMEDIATE VARIABLE IN THE RUNGE-KUTTA ALGORITHM
C3	▪ INTERMEDIATE VARIABLE IN THE RUNGE-KUTTA ALGORITHM
C4	▪ INTERMEDIATE VARIABLE IN THE RUNGE-KUTTA ALGORITHM
DUM1	▪ DUMMY VARIABLE
DUM2	▪ DUMMY VARIABLE
DZ	▪ STEP SIZE FOR THE SIMPSON'S RULE INTEGRATION
DZRA1	▪ STEP SIZE FOR THE RUNGE-KUTTA INTEGRATION
D1	▪ INTERMEDIATE VARIABLE IN THE RUNGE-KUTTA ALGORITHM
D2	▪ INTERMEDIATE VARIABLE IN THE RUNGE-KUTTA ALGORITHM
D3	▪ INTERMEDIATE VARIABLE IN THE RUNGE-KUTTA ALGORITHM
D4	▪ INTERMEDIATE VARIABLE IN THE RUNGE-KUTTA ALGORITHM
FA	▪ AREA FUNCTION
FGM	▪ SPECIFIC HEAT RATIO FUNCTION
FH	▪ ENTHALPY FUNCTION
FLOW	▪ CHOKED/SEPARATED FLOW FLAG
FMSQ	▪ MACH NUMBER FUNCTION
FMMW	▪ MOLECULAR WEIGHT FUNCTION
FP	▪ STATIC PRESSURE FUNCTION
FTM	▪ STATIC TEMPERATURE FUNCTION
FXM	▪ MOLAR FLOW RATE FUNCTION
F1	▪ FUNCTION OF Z
F2	▪ FUNCTION OF Z
F3	▪ FUNCTION OF Z
GA	▪ SPECIFIC HEAT RATIO OF THE PURGE GAS
GA1	▪ INTERMEDIATE CONSTANT
GA2	▪ INTERMEDIATE CONSTANT
GM	▪ SPECIFIC HEAT RATIO OF THE MIXED STREAM
GP	▪ SPECIFIC HEAT RATIO OF THE PRODUCT GAS
GP1	▪ INTERMEDIATE CONSTANT
GP2	▪ INTERMEDIATE CONSTANT
GR	▪ SPECIFIC HEAT RATIO OF THE REACTANT GAS
GR1	▪ INTERMEDIATE CONSTANT
GR2	▪ INTERMEDIATE CONSTANT
I	▪ DO LOOP INDEX
J	▪ DO LOOP INDEX
K	▪ DO LOOP INDEX
LPMPR1	▪ NATURAL LOG OF THE LOCAL MIXED-TO-REACTANT STATIC PRESSURE RATIO
M1	▪ INITIAL MACH NUMBER FOR A ZUKOSKI SEPARATION CRITERIA
MM2	▪ MACH NUMBER OF THE MIXED STREAM AT THE CAVITY EXIT
MSQ	▪ SQUARE OF THE MACH NUMBER
MWAMWR	▪ PURGE-TO-REACTANT MOLECULAR WEIGHT RATIO
MWMWR	▪ MIXED-TO-REACTANT MOLECULAR WEIGHT RATIO
MWPWR	▪ PRODUCT-TO-REACTANT MOLECULAR WEIGHT RATIO
MWRMWA	▪ REACTANT-TO-PURGE MOLECULAR WEIGHT RATIO
MWRMWP	▪ REACTANT-TO-PRODUCT MOLECULAR WEIGHT RATIO
N	▪ COMPUTE GO TO STATEMENT INDEX
NPTS	▪ NUMBER OF POINTS FOR THE SIMPSON'S RULE INTEGRATION
PMPI	▪ LOCAL MIXED-TO-INITIAL STATIC PRESSURE RATIO

PMOPR0 = MIXED-TO-REACTANT STAGNATION PRESSURE RATIO
PM2PR1 = FINAL MIXED-TO-REACTANT STATIC PRESSURE RATIO
PR1PI = REACTANT-TO-INITIAL STATIC PRESSURE RATIO
PSEPP1 = ZUKOSKI SEPARATION-TO-INITIAL STATIC PRESSURE RATIO
Q = LOCAL DIMENSIONLESS HEAT RELEASE
Q1 = HEAT RELEASE COEFFICIENT
Q1P = DIMENSIONLESS HEAT RELEASE
Q2 = HEAT RELEASE COEFFICIENT
SEP = ALPHANUMERIC SYMBOL DESIGNATING SEPARATED FLOW
TAOTR1 = PURGE STAGNATION-TO-REACTANT STATIC TEMPERATURE RATIO
TMTR1 = LOCAL MIXED-TO-REACTANT STATIC TEMPERATURE RATIO
TMOTR0 = MIXED-TO-REACTANT STAGNATION TEMPERATURE RATIO
TM2TR1 = FINAL MIXED-TO-REACTANT STATIC TEMPERATURE RATIO
WA2WR1 = PURGE-TO-REACTANT MASS FLOW RATIO
XMXR1 = LOCAL MIXED-TO-REACTANT MOLAR FLOW RATIO
XMPXR1 = FINAL MIXED-TO-REACTANT MOLAR FLOW RATIO
Z = DIMENSIONLESS AXIAL COORDINATE
ZSEP = DIMENSIONLESS CAVITY FLOW SEPARATION LENGTH

NOMENCLATURE FOR SUBROUTINES LPNCS, LSNCS1, LSNCS2

A	■ VISCOSITY COEFFICIENT ($\text{ALOG}(N-2/M2)/\text{ALOG}(K)$)
AEASE	■ A/A^* , EFFECTIVE
AFASO	■ A/A^* , GEOMETRIC
AEF	■ EFFECTIVE NOZZLE EXIT AREA (M^2)
AFAC	■ AREA FACTOR (M^2)
AKMSC	■ TOTAL EFFECTIVE NOZZLE EXIT AREA FOR PRIMARY FLOW PER KMOL/S OF PRIMARY FLOW BASED ON THE COMBUSTOR TEMPERATURE ($S-M2/\text{KMOL}$)
AKNSE	■ TOTAL EFFECTIVE NOZZLE EXIT AREA FOR PRIMARY FLOW PER KMOL/S OF PRIMARY FLOW BASED ON THE EXIT TEMPERATURE ($S-M2/\text{KMOL}$)
AKMST	■ TOTAL AREA OF NOZZLE BANK PER KMOL/S OF PRIMARY FLOW BASED ON THE EXIT TEMPERATURE ($S-M2/\text{KMOL}$)
AS	■ A^* (M^2)
AX	■ ALPHANUMERIC SYMBOL DESIGNATING AN AXISYMMETRIC NOZZLE
R	■ VISCOSITY COEFFICIENT ($\text{ALOG}(N-S/M2)$)
C1	■ INTERMEDIATE CONSTANT
C2	■ INTERMEDIATE CONSTANT
C3	■ INTERMEDIATE CONSTANT
C4	■ INTERMEDIATE CONSTANT
C5	■ INTERMEDIATE CONSTANT
C6	■ INTERMEDIATE CONSTANT
C7	■ INTERMEDIATE CONSTANT
DE	■ NOZZLE EXIT DIAMETER, GEOMETRIC (M)
DEE	■ NOZZLE EXIT DIAMETER, EFFECTIVE (M)
DELME	■ INCREMENT IN EXIT MACH NUMBER FOR SUBROUTINE ITER
DELTA	■ BOUNDARY LAYER THICKNESS AT THE NOZZLE EXIT (M)
DFORMF	■ CONTROL VARIABLE DESIGNATING DF OR HF LASER CHEMISTRY
DPE	■ PRIMARY NOZZLE EXIT DIAMETER, GEOMETRIC (M)
DPEE	■ PRIMARY NOZZLE EXIT DIAMETER, EFFECTIVE (M)
DPS	■ D^* , PRIMARY NOZZLE (M)
DS	■ D^* (M)
DSE	■ SECONDARY NOZZLE EXIT DIAMETER, GEOMETRIC (M)
DUMMY	■ DUMMY VARIABLE
ERROR	■ SOLUTION TOLERANCE
F	■ LENGTH MEAN COEFFICIENT OF FRICTION
FAIL	■ ERROR FLAG
FDAF	■ FREF FLUORINE FLUX ($\text{KMOL}/S-M2$)
FFLD	■ $4 \cdot F \cdot L/D$
FX	■ PREVIOUS VALUE OF F IN ITERATION SCHEME
GC	■ SPECIFIC HEAT RATIO OF THE NOZZLE STREAM BASED ON THE COMBUSTOR OR NOZZLE STAGNATION TEMPERATURE
GE	■ SPECIFIC HEAT RATIO OF THE NOZZLE STREAM BASED ON THE NOZZLE EXIT TEMPERATURE
GEOFAC	■ NOZZLE GEOMETRY FACTOR SUCH THAT: ■ 1.0, FOR AXISYMMETRIC NOZZLES ■ 0.0, FOR SLIT NOZZLES
GFOMPN	■ PRIMARY NOZZLE GEOMETRY CONTROL VARIABLE SUCH THAT: ■ "AX", FOR AXISYMMETRIC NOZZLES ■ "2D", FOR SLIT NOZZLES
GEOMSN	■ SECONDARY NOZZLE GEOMETRY CONTROL VARIABLE SUCH THAT: ■ "AX", FOR AXISYMMETRIC NOZZLES ■ "2D", FOR SLIT NOZZLES
H	■ INTERMEDIATE CONSTANT

HF	■ ALPHANUMERIC SYMBOL DESIGNATING HF LASER CHEMISTRY
HNB	■ HEIGHT OF NOZZLE BANK (M)
HP	■ INTERMEDIATE CONSTANT
HYDIA	■ HYDRAULIC DIAMETER
I	■ DO LOOP INDEX
ITER1	■ DO LOOP INDEX
LRNOZ	■ NOZZLE BOUNDARY LAYER LENGTH (M)
LDSSZ	■ CONTROL VARIABLE DESIGNATING AN INPUT VARIABLE AS EITHER: ■ "T10" FOR THE PRIMARY COMBUSTOR OR NOZZLE STAGNATION TEMPERATURE OR ■ "P10" FOR THE PRIMARY NOZZLE STAGNATION PRESSURE
LPNOZ	■ CENTER LINE LENGTH OF A PRIMARY NOZZLE FROM THROAT TO EXIT PLANE (M)
LSNOZ	■ CENTER LINE LENGTH OF A SECONDARY NOZZLE FROM THROAT TO EXIT PLANE (M)
ME	■ NOZZLE EXIT MACH NUMBER
MSUPD	■ NOZZLE SUPERSONIC DESIGN MACH NUMBER
MU	■ ABSOLUTE VISCOSITY (N-S/M ²)
MW	■ MOLECULAR WEIGHT (KG/KMOLE)
M2	■ SQUARE OF THE MACH NUMBER
NIT	■ INTERMEDIATE CONSTANT FOR SUBROUTINE ITER
NPNOZ	■ NUMBER OF PRIMARY NOZZLES PER KMOLE/S OF PRIMARY FLOW (S/KMOLE)
NSIGN1	■ INTERMEDIATE CONSTANT FOR SUBROUTINE ITER
NSIGN2	■ INTERMEDIATE CONSTANT FOR SUBROUTINE ITER
NSNOZ	■ NUMBER OF SECONDARY NOZZLES PER KMOLE/S OF PRIMARY FLOW (S/KMOLE)
NSPNOZ	■ NUMBER OF SECONDARY-TO-PRIMARY NOZZLES
NTYPE	■ INTERMEDIATE CONSTANT FOR SUBROUTINE ITER
PE	■ STATIC PRESSURE AT THE NOZZLE EXIT (PA)
PI	■ THE CONSTANT PI
PKFRAC	■ NOZZLE PACKING FRACTION
PS	■ P*, STATIC PRESSURE FOR A MACH NUMBER OF ONE (PA)
P0	■ COMBUSTOR OR NOZZLE STAGNATION PRESSURE (PA)
POP0S	■ THE STAGNATION PRESSURE RATIO, P0/P0*
P0S	■ P0*, STAGNATION PRESSURE FOR A MACH NUMBER OF ONE (PA)
PBAR	■ UNIVERSAL GAS CONSTANT (J/KMOLE-K)
RE	■ REYNOLDS NUMBER AT THE NOZZLE EXIT
RL	■ MOLAR CAVITY MIXTURE RATIO
SIGMA	■ DEPENDENT VARIABLE FOR SUBROUTINE ITER
SUP	■ ALPHANUMERIC SYMBOL DESIGNATING SUPERSONIC FLOW
TE	■ STATIC TEMPERATURE AT THE NOZZLE EXIT (K)
T0	■ COMBUSTOR OR NOZZLE STAGNATION TEMPERATURE (K)
VE	■ VELOCITY AT THE NOZZLE EXIT (M/S)
WF	■ PRIMARY NOZZLE MASS FLOW RATE (KG/S)
WS	■ SECONDARY NOZZLE MASS FLOW RATE (KG/S)
XAEASE	■ PREVIOUS VALUE OF AEASE IN ITERATION SCHEME
XF	■ MOLE FRACTION ARRAY
XFPP1	■ MOLE FRACTION OF PRIMARY COMBUSTOR PRODUCT 1, CF4
XFPP2	■ MOLE FRACTION OF PRIMARY COMBUSTOR PRODUCT 2, F2
XFPP3	■ MOLE FRACTION OF PRIMARY COMBUSTOR PRODUCT 3, F
XFPP4	■ MOLE FRACTION OF PRIMARY COMBUSTOR PRODUCT 4, HF (DF)
XFPP5	■ MOLE FRACTION OF PRIMARY COMBUSTOR PRODUCT 5, HE
XFPP6	■ MOLE FRACTION OF PRIMARY COMBUSTOR PRODUCT 6, N2
XFSR1	■ MOLE FRACTION OF SECONDARY REACTANT 1, O2 (H2)
XFSR2	■ MOLE FRACTION OF SECONDARY REACTANT 2, HF

XFSR3 = MOLE FRACTION OF SECONDARY REACTANT 3, N_2
XKMS = TOTAL SECONDARY MOLAR FLOW RATE PER KMOL/S OF PRIMARY FLOW
XM2 = PREVIOUS VALUE OF M_2 IN ITERATION SCHEME
XNEG = INTERMEDIATE CONSTANT FOR SUBROUTINE ITER
XPOS = PRIMARY NOZZLE MOLAR FLOW RATE (KMOL/S)
XPOS = INTERMEDIATE CONSTANT FOR SUBROUTINE ITER
XS = SECONDARY NOZZLE MOLAR FLOW RATE (KMOL/S)
YES = ALPHANUMERIC SYMBOL DESIGNATING A POSITIVE RESPONSE
YNEG = INTERMEDIATE CONSTANT FOR SUBROUTINE ITER
YPOS = INTERMEDIATE CONSTANT FOR SUBROUTINE ITER

NOMENCLATURE FOR SUBROUTINE MAAS

ERROR = MAXIMUM PERCENT DEVIATION IN MOLD AND MNEW FOR A SOLUTION
FAIL = ERROR FLAG
FLOW = CONTROL VARIABLE SUCH THAT:
 = "SUB" FOR THE SUBSONIC BRANCH
 = "SUP" FOR THE SUPERSONIC BRANCH
G = SPECIFIC HEAT RATIO
G1 = INTERMEDIATE CONSTANT
G11 = INTERMEDIATE CONSTANT
G2 = INTERMEDIATE CONSTANT
G21 = INTERMEDIATE CONSTANT
G4 = INTERMEDIATE CONSTANT
G41 = INTERMEDIATE CONSTANT
J = DO LOOP INDEX
MINI = INITIAL VALUE OF MACH NUMBER
MNEW = CURRENT VALUE OF MACH NUMBER
MOLD = PRECEDING VALUE OF MACH NUMBER
SUP = ALPHANUMERIC SYMBOL DESIGNATING SUPERSONIC FLOW
XERROR = CURRENT PERCENT DEVIATION IN MOLD AND MNEW
YES = ALPHANUMERIC SYMBOL DESIGNATING A POSITIVE RESPONSE

NOMENCLATURE FOR SUBROUTINE VISC

A	■ VISCOSITY COEFFICIENT $(\text{ALOG}(N-S/M^2)/\text{ALOG}(K))$
R	■ VISCOSITY COEFFICIENT $(\text{ALOG}(N-S/M^2))$
C	■ INTERMEDIATE CONSTANT IN THE VISCOSITY CALCULATIONS
DEN	■ INTERMEDIATE CONSTANT IN THE VISCOSITY CALCULATIONS
DIV	■ INTERMEDIATE CONSTANT IN THE VISCOSITY CALCULATIONS
I	■ DO LOOP INDEX
J	■ DO LOOP INDEX
K	■ DO LOOP INDEX
MU	■ VISCOSITY DATA ARRAY $(1.0E+07 \text{ N-S/M}^2)$
MIMIX	■ VISCOSITY OF THE GAS MIXTURE $(N-S/M^2)$
MW	■ MOLECULAR WEIGHT DATA ARRAY (KG/KMOLE)
NS1	■ DO LOOP LIMIT FOR SPECIES SELECTION
NS2	■ DO LOOP LIMIT FOR SPECIES SELECTION
NUM	■ INTERMEDIATE CONSTANT IN THE VISCOSITY CALCULATIONS
PHI	■ INTERMEDIATE CONSTANT IN THE VISCOSITY CALCULATIONS
R1	■ INTERMEDIATE CONSTANT IN THE VISCOSITY CALCULATIONS
R2	■ INTERMEDIATE CONSTANT IN THE VISCOSITY CALCULATIONS
SUMI	■ INTERMEDIATE CONSTANT IN THE VISCOSITY CALCULATIONS
SUMJ	■ INTERMEDIATE CONSTANT IN THE VISCOSITY CALCULATIONS
SX	■ INTERMEDIATE CONSTANT IN THE LEAST SQUARES CALCULATIONS
SXY	■ INTERMEDIATE CONSTANT IN THE LEAST SQUARES CALCULATIONS
SX2	■ INTERMEDIATE CONSTANT IN THE LEAST SQUARES CALCULATIONS
SY	■ INTERMEDIATE CONSTANT IN THE LEAST SQUARES CALCULATIONS
T	■ TEMPERATURE OF THE GAS MIXTURE (K)
X	■ INTERMEDIATE CONSTANT IN THE LEAST SQUARES CALCULATIONS
XF	■ MOLE FRACTION ARRAY
Y	■ INTERMEDIATE CONSTANT IN THE LEAST SQUARES CALCULATIONS

PRESSURE RECOVERY SECTION GENERAL NOTATION SCHEME

A : AREA PER KMOLF/S OF LASER PRIMARY FLOW (S-M²/KMOLF)
G : (GAMMA) SPECIFIC HEAT RATIO
M : MACH NUMBER
MW: MOLECULAR WEIGHT (KG/KMOLF)
P : PRESSURE (PA)
R : DENSITY (KG/M³)
T : TEMPERATURE (K)
W : MASS FLOW RATE (KG/S)
X : MOLAR FLOW RATE (KMOLF/S)

REPEATED LETTFRS INDICATE RATIOS.
EXAMPLE: A2A1 = A2/A1

VARIABLES ARE DESIGNATED AS TO LOCATION BY THE FOLLOWING:

POINT 1: LASER CAVITY EXIT
POINT 2: NORMAL SHOCK DIFFUSER EXIT
POINT 3: SUBSONIC DIFFUSER EXIT
POINT 4: EJECTOR SECONDARY NOZZLE EXIT
POINT 5: EJECTOR PRIMARY NOZZLE EXIT
POINT 6: EJECTOR MIXING TUBE EXIT
POINT 7: SUBSONIC DIFFUSER EXIT
EXAMPLE: M5 = EJECTOR PRIMARY NOZZLE EXIT MACH NUMBER

0: INDICATES STAGNATION CONDITIONS
EXAMPLE: T20 = NORMAL SHOCK DIFFUSER EXIT STAGNATION TEMPERATURE

NOTE: ALL VARIABLES NOT FOLLOWING THIS SCHEME ARE DEFINED IN THE
NOMENCLATURE FOR THE PROGRAM OR SUBROUTINE WHERE THEY APPEAR.

NOMENCLATURE FOR PROGRAM PRS AND SUBROUTINES CAEOS, INPRS, OUTPRS, SSEOS

CAF	= ALPHANUMERIC SYMBOL DESIGNATING A SUBSONIC-SUPERSONIC EJECTOR FOR PRESSURE RECOVERY
EJECT	= CONTROL VARIABLE DESIGNATING THE PRESSURE RECOVERY SYSTEM SUCH THAT: = "NO" FOR NO PRESSURE RECOVERY SYSTEM = "DIF" FOR A SUPERSONIC-SUBSONIC DIFFUSED SYSTEM = "CAF" FOR A CONSTANT-AREA, SUBSONIC-SUPERSONIC EJECTOR SYSTEM = "SSE" FOR A CONSTANT-AREA, SUPERSONIC-SUPERSONIC EJECTOR SYSTEM
ETA12	= NORMAL SHOCK DIFFUSER COEFFICIENT FOR THE FLOW BETWEEN STATIONS 1 AND 2
ETA23	= SUBSONIC DIFFUSER COEFFICIENT FOR THE FLOW BETWEEN STATIONS 2 AND 3
ETA67	= SUBSONIC DIFFUSER COEFFICIENT FOR THE FLOW BETWEEN STATIONS 6 AND 7
FAIL	= ERROR FLAG
GM	= EJECTOR MIXED STREAM SPECIFIC HEAT RATIO
GP	= EJECTOR PRIMARY STREAM SPECIFIC HEAT RATIO
GS	= EJECTOR SECONDARY STREAM SPECIFIC HEAT RATIO
ITER1	= DO LOOP INDEX
ITER2	= DO LOOP INDEX
ITER3	= DO LOOP INDEX
K	= DO LOOP INDEX
LOSS1	= CONTROL VARIABLE DESIGNATING WHETHER OR NOT NEW LASER DEVICE INPUTS ARE REQUIRED
LIMIT	= CONTROL VARIABLE TO SET THE LIMITING CONDITION ON CONSTANT-AREA, SUPERSONIC-SUPERSONIC EJECTOR OPERATION SUCH THAT: = "MPP" FOR THE MATCHED PRESSURE POINT = "ZSP" FOR THE ZUKOSKI SEPARATION POINT = "ULP" FOR THE UPPER LIMIT POINT
MPP	= ALPHANUMERIC SYMBOL DESIGNATING THE MATCHED PRESSURE POINT
MMMW	= EJECTOR MIXED-TO-PRIMARY STREAM MOLECULAR WEIGHT RATIO
MWPM	= EJECTOR PRIMARY-TO-SECONDARY STREAM MOLECULAR WEIGHT RATIO
MWSM	= EJECTOR SECONDARY-TO-PRIMARY STREAM MOLECULAR WEIGHT RATIO
NI1	= INTERMEDIATE CONSTANT FOR SUBROUTINE MIN
NI2	= INTERMEDIATE CONSTANT FOR SUBROUTINE ITER
NI3	= INTERMEDIATE CONSTANT FOR SUBROUTINE ITER
NO	= ALPHANUMERIC SYMBOL DESIGNATING A NEGATIVE RESPONSE
NSIGN1	= INTERMEDIATE CONSTANT FOR SUBROUTINE ITER
NSIGN2	= INTERMEDIATE CONSTANT FOR SUBROUTINE ITER
NSIGN3	= INTERMEDIATE CONSTANT FOR SUBROUTINE ITER
NSIGN4	= INTERMEDIATE CONSTANT FOR SUBROUTINE ITER
NTYPE1	= INTERMEDIATE CONSTANT FOR SUBROUTINE MIN
NTYPE2	= INTERMEDIATE CONSTANT FOR SUBROUTINE ITER
NTYPE3	= INTERMEDIATE CONSTANT FOR SUBROUTINE ITER
PDP	= DISTURBED-TO-UNDISTURBED STATIC PRESSURE RATIO
PRSS1	= CONTROL VARIABLE DESIGNATING WHETHER OR NOT NEW PRESSURE RECOVERY INPUTS ARE REQUIRED
PRSS2	= CONTROL VARIABLE DESIGNATING WHETHER OR NOT INPUT DATA SHOULD BE READ FROM TAPE3
RRAR	= UNIVERSAL GAS CONSTANT [J/KMOLE-K]
SETPRS	= CONTROL VARIABLE TO SET DEFAULT VALUES

SSF	■ ALPHANUMERIC SYMBOL DESIGNATING A SUPERSONIC-SUPERSONIC EJECTOR FOR PRESSURE RECOVERY
ULP	■ ALPHANUMERIC SYMBOL DESIGNATING THE UPPER LIMIT POINT
WPWS	■ EJECTOR PRIMARY-TO-SECONDARY MASS FLOW RATIO
WSWP	■ EJECTOR SECONDARY-TO-PRIMARY MASS FLOW RATIO
XNEG2	■ INTERMEDIATE CONSTANT FOR SUBROUTINE ITER
XNEG3	■ INTERMEDIATE CONSTANT FOR SUBROUTINE ITER
XPOS2	■ INTERMEDIATE CONSTANT FOR SUBROUTINE ITER
XPOS3	■ INTERMEDIATE CONSTANT FOR SUBROUTINE ITER
XP50P1	■ PREVIOUS VALUE OF P50P1 IN ITERATION SCHEME
XP50P40	■ PREVIOUS VALUE OF P50P40 IN ITERATION SCHEME
XP7P1	■ PREVIOUS VALUE OF P7P1 IN ITERATION SCHEME
XP7P40	■ PREVIOUS VALUE OF P7P40 IN ITERATION SCHEME
XWPWS	■ PREVIOUS VALUE OF WPWS IN ITERATION SCHEME
YFS	■ ALPHANUMERIC SYMBOL DESIGNATING A POSITIVE RESPONSE
YNEG2	■ INTERMEDIATE CONSTANT FOR SUBROUTINE ITER
YNEG3	■ INTERMEDIATE CONSTANT FOR SUBROUTINE ITER
YPOS2	■ INTERMEDIATE CONSTANT FOR SUBROUTINE ITER
YPOS3	■ INTERMEDIATE CONSTANT FOR SUBROUTINE ITER
ZSP	■ ALPHANUMERIC SYMBOL DESIGNATING A ZUKOSKI SEPARATION POINT

NOMENCLATURE FOR SUBROUTINES CAEFC, CAEOCV, SSES

APIAM3 ■ ENTRANCE PRIMARY-TO-EXIT MIXED STREAM AREA RATIO
 APIAPS ■ A/A* FOR THE ENTERING PRIMARY STREAM
 AP2APS ■ A/A* FOR THE PRIMARY STREAM AT THE MINIMUM POINT
 ASSAS1 ■ A*/A FOR THE ENTERING SECONDARY STREAM
 ASIAP1 ■ ENTERING SECONDARY-TO-PRIMARY STREAM AREA RATIO
 ASIASS ■ A/A* FOR THE ENTERING SECONDARY STREAM
 AS2ASS ■ A/A* FOR THE SECONDARY STREAM AT THE MINIMUM POINT
 AS2AS1 ■ MINIMUM POINT-TO-ENTERING AREA RATIO FOR THE SECONDARY STREAM
 CPSCPP ■ SECONDARY-TO-PRIMARY STREAM SPECIFIC HEAT RATIO
 C0 ■ INTERMEDIATE CONSTANT
 C1 ■ INTERMEDIATE CONSTANT
 C2 ■ INTERMEDIATE CONSTANT
 C3 ■ INTERMEDIATE CONSTANT
 C4 ■ INTERMEDIATE CONSTANT
 C5 ■ INTERMEDIATE CONSTANT
 C6 ■ INTERMEDIATE CONSTANT
 FAIL ■ ERROR FLAG
 FFX ■ INTERMEDIATE CONSTANT
 FGPMP1 ■ INTERMEDIATE CONSTANT
 FGSMS1 ■ INTERMEDIATE CONSTANT
 FLOW ■ SUBSONIC/SUPERSONIC FLOW FLAG
 GRPMP1 ■ INTERMEDIATE CONSTANT
 GRSMS1 ■ INTERMEDIATE CONSTANT
 GM ■ MIXED STREAM SPECIFIC HEAT RATIO
 GMGP ■ MIXED-TO-PRIMARY STREAM RATIO OF SPECIFIC HEAT RATIOS
 GP ■ PRIMARY STREAM SPECIFIC HEAT RATIO
 GP3 ■ INTERMEDIATE CONSTANT
 GS ■ SECONDARY STREAM SPECIFIC HEAT RATIO
 GSOP ■ SECONDARY-TO-PRIMARY STREAM RATIO OF SPECIFIC HEAT RATIOS
 GS3 ■ INTERMEDIATE CONSTANT
 LIMIT ■ CONTROL VARIABLE TO SET THE LIMITING CONDITION ON CONSTANT-
 AREA, SUPERSONIC-SUPERSONIC EJECTOR OPERATION SUCH THAT:
 ■ "MPP" FOR THE MATCHED PRESSURE POINT
 ■ "ZSP" FOR THE ZUKOSKI SEPARATION POINT
 ■ "ULP" FOR THE UPPER LIMIT POINT
 MM3 ■ EXITING MIXED STREAM MACH NUMBER
 MM3M ■ ONE OF TWO POSSIBLE SOLUTIONS FOR MM3
 MM3P ■ ONE OF TWO POSSIBLE SOLUTIONS FOR MM3
 MPP ■ ALPHANUMERIC SYMBOL DESIGNATING THE MATCHED PRESSURE POINT
 MP1 ■ ENTERING PRIMARY STREAM MACH NUMBER
 MP2 ■ PRIMARY STREAM MACH NUMBER AT THE MINIMUM POINT
 MSOD3M ■ THE SQUARE OF MM3M
 MSOD3P ■ THE SQUARE OF MM3P
 MS1 ■ ENTERING SECONDARY STREAM MACH NUMBER
 MS2 ■ SECONDARY STREAM MACH NUMBER AT THE MINIMUM POINT
 MWMWP ■ MIXED-TO-PRIMARY STREAM MOLECULAR WEIGHT RATIO
 MWPMS ■ PRIMARY-TO-SECONDARY STREAM MOLECULAR WEIGHT RATIO
 MWSMWP ■ SECONDARY-TO-PRIMARY STREAM MOLECULAR WEIGHT RATIO
 PART ■ ALPHANUMERIC SYMBOL DESIGNATING NON-FATAL OR PARTIAL ERROR
 PM3PP1 ■ EXITING MIXED-TO-ENTERING PRIMARY STATIC PRESSURE RATIO
 PM3PS0 ■ EXITING MIXED STATIC-TO-ENTERING SECONDARY STAGNATION PRESSURE
 RATIO

PM3PS1 = EXITING MIXED-TO-ENTERING SECONDARY STATIC PRESSURE RATIO
PP0PS0 = ENTERING PRIMARY-TO-SECONDARY STAGNATION PRESSURE RATIO
PP0PS1 = ENTERING PRIMARY STAGNATION-TO-SECONDARY STATIC PRESSURE RATIO
PS1PP0 = ENTERING SECONDARY STATIC-TO-PRIMARY STAGNATION PRESSURE RATIO
PS1PP1 = ENTERING SECONDARY-TO-PRIMARY STATIC PRESSURE RATIO
PS1PS0 = ENTERING SECONDARY STATIC-TO-STAGNATION PRESSURE RATIO
PS2PS0 = STATIC-TO-STAGNATION PRESSURE RATIO FOR THE SECONDARY STREAM AT
THE MINIMUM POINT
PS2PS1 = MINIMUM POINT-TO-ENTERING SECONDARY STREAM STATIC PRESSURE
RATIO
SUP = ALPHANUMERIC SYMBOL DESIGNATING SUPERSONIC FLOW
TM0TP0 = MIXED-TO-PRIMARY STAGNATION TEMPERATURE RATIO
TM3 = INTERMEDIATE CONSTANT
TM3MIN = INTERMEDIATE CONSTANT
TS0TP0 = SECONDARY-TO-PRIMARY STAGNATION TEMPERATURE RATIO
ULP = ALPHANUMERIC SYMBOL DESIGNATING THE UPPER LIMIT POINT
VN = INTERMEDIATE CONSTANT
VN = INTERMEDIATE CONSTANT
WSWP = SECONDARY-TO-PRIMARY STREAM MASS FLOW RATIO
YES = ALPHANUMERIC SYMBOL DESIGNATING A POSITIVE RESPONSE

APPENDIX F

NOMENCLATURE
OVERLAY PRS

PAGE F-29

NOMENCLATURE FOR SUBROUTINE ITER

SEE THE NOMENCLATURE FOR SUBROUTINE ITER LISTED UNDER OVERLAY LDS.

APPENDIX F

NOMENCLATURE
OVERLAY PRS

PAGE F-30

NOMENCLATURE FOR SUBROUTINE MAAS

SEE THE NOMENCLATURE FOR SUBROUTINE MAAS LISTED UNDER OVERLAY LDS.

NOMENCLATURE FOR SUBROUTINE MIN

DMS1 = INCREMENT IN MS1
DX = INITIAL INCREMENT IN MS1
FAIL = ERROR FLAG
FUNC = FUNCTION OF MS1 TO BE MINIMIZED
MS1 = SECONDARY MACH NUMBER AT THE MIXING TUBE ENTRANCE
MS1LOW = LOWER BOUND ON MS1
NIT = NUMBER OF ITERATIONS
NO = ALPHANUMERIC SYMBOL DESIGNATING A NEGATIVE RESPONSE
NTYPE = CONTROL VARIABLE SUCH THAT:
= 1.2 FOR THE SEARCH MODE
= 3.4 FOR A SOLUTION
PART = ALPHANUMERIC SYMBOL DESIGNATING A NON-FATAL OR PARTIAL ERROR
XERROR = MAXIMUM PERCENT DEVIATION IN THE CURRENT AND PREVIOUS VALUE OF
MS1 FOR A SOLUTION
YLOW = INITIAL LOWER BOUND ON MS1
X1 = PREVIOUS VALUE OF MS1
X2 = PREVIOUS VALUE OF MS1
YERROR = MAXIMUM PERCENT DEVIATION IN THE CURRENT AND PREVIOUS VALUE OF
FUNC FOR A SOLUTION
YES = ALPHANUMERIC SYMBOL DESIGNATING A POSITIVE RESPONSE
Y1 = PREVIOUS VALUE OF FUNC
Y2 = PREVIOUS VALUE OF FUNC

NOMENCLATURE FOR SUBROUTINES WSDS, SDS

A1A1S = A/A* FOR THE ENTERING STREAM
A2A1 = EXIT-TO-ENTRANCE AREA RATIO
A2A2S = A/A* FOR THE EXITING STREAM
EFF = SUBSONIC DIFFUSER EFFICIENCY
FAIL = ERROR FLAG
G = SPECIFIC HEAT RATIO
G2 = INTERMEDIATE CONSTANT
G4 = INTERMEDIATE CONSTANT
M1 = ENTRANCE MACH NUMBER
M2 = EXIT MACH NUMBER
P10P1 = ENTRANCE STAGNATION-TO-STATIC PRESSURE RATIO
P2P1 = EXIT-TO-ENTRANCE STATIC PRESSURE RATIO
P20P10 = EXIT-TO-ENTRANCE STAGNATION PRESSURE RATIO
P20P2 = EXIT STAGNATION-TO-STATIC PRESSURE RATIO
RD = DIFFUSER COEFFICIENT
SUR = ALPHANUMERIC SYMBOL DESIGNATING SUBSONIC FLOW
T10T1 = ENTRANCE STAGNATION-TO-STATIC TEMPERATURE RATIO
T2T1 = EXIT-TO-ENTRANCE STATIC TEMPERATURE RATIO
T20T10 = EXIT-TO-ENTRANCE STAGNATION TEMPERATURE RATIO
T20T2 = EXIT STAGNATION-TO-STATIC TEMPERATURE RATIO
YFS = ALPHANUMERIC SYMBOL DESIGNATING A POSITIVE RESPONSE

NOMENCLATURE FOR PROGRAM SCS AND SUBROUTINES INSCS, OUTSCS

ARASE	■ AREA OF A NOZZLE BASE (M ²) - INCLUDES THE NOZZLE BANK AREA PLUS BANK RELIEF
ACONE	■ EXIT AREA OF AN EJECTOR PRIMARY NOZZLE CONE (M ²)
AF	■ AREA AT STATION F (M ²), THE EJECTOR, CONSTANT-AREA, MIXING SHROUD
AFPNT	■ TOTAL AREA OF THE EJECTOR PRIMARY NOZZLE EXITS PER KMOL/S OF LASER PRIMARY FLOW (S-M ² /KMOL)
AESHRD	■ TOTAL AREA OF THE EJECTOR, CONSTANT-AREA, MIXING SHROUDS PER KMOL/S OF LASER PRIMARY FLOW (S-M ² /KMOL)
ANR	■ AREA OF A NOZZLE BANK (M ²)
ASCAV	■ SURFACE AREA OF A LASER CAVITY (M ²)
ASCONE	■ SURFACE AREA OF AN EJECTOR PRIMARY NOZZLE CONE (M ²)
ASPLEN	■ SURFACE AREA OF AN EJECTOR PRIMARY NOZZLE PLENUM (M ²)
ASSHRD	■ SURFACE AREA OF AN EJECTOR MIXING SHROUD (M ²) - INCLUDES THE FINAL SUBSONIC DIFFUSER
ASSTR	■ SURFACE AREA OF AN EJECTOR PRIMARY NOZZLE STRUT (M ²)
ASSURD	■ SURFACE AREA OF A SUBSONIC DIFFUSER (M ²)
ASSUPD	■ SURFACE AREA OF A SUPERSONIC DIFFUSER (M ²)
ASTAR	■ A* FOR AN EJECTOR PRIMARY NOZZLE (M ²)
ASTR	■ SURFACE AREA OF AN EJECTOR TRANSITION PIECE (M ²)
R	■ OPTICAL BENCH DIAMETER (M)
	■ INTERMEDIATE CONSTANT
RRFRAC	■ BANK RELIEF FRACTION
C	■ INTERMEDIATE CONSTANT
CAF	■ ALPHANUMERIC SYMBOL DESIGNATING A SUBSONIC-SUPERSONIC EJECTOR FOR PRESSURE RECOVERY
CANGLE	■ LASER CAVITY HALF-ANGLE (RAD)
DA	■ DIAMETER AT STATION A (M), THE LASER CAVITY EXIT
DR	■ DIAMETER AT STATION R (M), THE SUBSONIC DIFFUSER EXIT
DC	■ DIAMETER AT STATION C (M), THE INITIAL TRANSITION SECTION EXIT
DD	■ DIAMETER AT STATION D (M), THE FINAL TRANSITION SECTION EXIT
DF	■ DIAMETER AT STATION F (M), THE EJECTOR, CONSTANT-AREA, MIXING SHROUD
DESCR	■ ARRAY OF ALPHANUMERIC STORAGE MODE DESCRIPTORS FOR I/O
DF	■ ALPHANUMERIC SYMBOL DESIGNATING OF LASER CHEMISTRY
	■ DIAMETER AT STATION F (M), THE EJECTOR SUBSONIC-DIFFUSER EXIT
DFORMF	■ CONTROL VARIABLE DESIGNATING OF OR HF LASER CHEMISTRY
DIF	■ ALPHANUMERIC SYMBOL DESIGNATING A SUPERSONIC-SUBSONIC DIFFUSER FOR PRESSURE RECOVERY
DL	■ DIAMETER AT STATION L (M), THE MAXIMUM DIAMETER OF A SUBSONIC-SUPERSONIC EJECTOR SHROUD
DMAX	■ INTERMEDIATE CONSTANT
DMIR	■ MIRROR DIAMETER (M)
DPLEN	■ DIAMETER OF AN EJECTOR PRIMARY NOZZLE PLENUM (M)
DSTAR	■ D* FOR AN EJECTOR PRIMARY NOZZLE (M)
DSTRUT	■ DIAMETER OF AN EJECTOR PRIMARY NOZZLE STRUT (M)
EJECT	■ CONTROL VARIABLE DESIGNATING THE PRESSURE RECOVERY SYSTEM
EREACT	■ CONTROL VARIABLE DESIGNATING THE EJECTOR PRIMARY REACTANT
FAIL	■ ERROR FLAG
FDAF	■ FREE FLUORINE FLUX (KMOL/S-M ²)
GEP	■ GAMMA, SPECIFIC HEAT RATIO, FOR THE EJECTOR PRIMARY REACTANT
HBASE	■ HEIGHT OF A NOZZLE BASE (M)

HPXDEV	■ HEIGHT OF THE BOX DEVICE (M)
HF	■ ALPHANUMERIC SYMBOL DESIGNATING HF LASER CHEMISTRY
HNR	■ HEIGHT OF A NOZZLE BANK (M)
I	■ DO LOOP INDEX
J	■ DO LOOP INDEX
K	■ STORAGE MODE CONTROL ARRAY
L	■ DO LOOP INDEX
LHXDEV	■ LENGTH OF THE BOX DEVICE (M)
LCAV	■ LENGTH OF A LASER CAVITY (M)
LCOMB	■ LENGTH OF A COMBUSTOR (M) - INCLUDES THE INJECTOR AND NOZZLE BANK
LCONE	■ LENGTH OF AN EJECTOR PRIMARY NOZZLE CONE (M)
LEJECT	■ LENGTH OF AN EJECTOR (M)
LIJ	■ LENGTH OF AN INJECTOR (M)
LLDS	■ LENGTH OF THE LASER DEVICE SECTION (M)
LLINE	■ LENGTH OF REACTANT FEED LINES (M)
LPHS	■ LENGTH OF THE PRESSURE RECOVERY SYSTEM (M)
LSURD	■ LENGTH OF A SUBSONIC DIFFUSER (M)
LSUPD	■ LENGTH OF A SUPERSONIC DIFFUSER (M)
LTR1	■ LENGTH OF AN INITIAL TRANSITION SECTION (M)
LTR2	■ LENGTH OF A FINAL TRANSITION SECTION (M)
MAW	■ TOTAL MASS OF THE AERO-WINDOWS (KG)
MAWF	■ DELIVERED MASS OF THE AERO-WINDOW FLUID (KG)
MRASE	■ TOTAL MASS OF THE LASER NOZZLE BASES (KG)
MCAV	■ TOTAL MASS OF THE LASER CAVITIES (KG)
MCR	■ TOTAL MASS OF THE COMBUSTOR RODIES (KG)
MCONE	■ TOTAL MASS OF THE EJECTOR PRIMARY NOZZLE CONES (KG)
MCS	■ MASS OF THE COOLING SYSTEM (KG)
MCSF	■ MASS OF THE COOLING SYSTEM FLUID (KG)
MDS	■ MASS OF THE DEVICE SUPPORT (KG)
MEJECT	■ TOTAL MASS OF THE EJECTORS (KG)
MELINE	■ MASS OF THE EJECTOR REACTANT FEED LINES (KG)
MEPNE	■ MACH NO. AT THE EJECTOR PRIMARY NOZZLE EXIT
MEPR	■ DELIVERED MASS OF THE EJECTOR PRIMARY REACTANT (KG)
MERREG	■ MASS OF THE EJECTOR PRIMARY REACTANT REGULATOR (KG)
MEFT	■ MASS OF THE EJECTOR PRIMARY REACTANT TANKAGE AND FLUID (KG)
MHE	■ DELIVERED MASS OF HE (KG)
MIJ	■ TOTAL MASS OF THE INJECTORS (KG)
MLDHDW	■ MASS OF THE LASER DEVICE HARDWARE (KG)
MLDS	■ MASS OF THE LASER DEVICE SYSTEM (KG)
MLLINE	■ MASS OF THE LASER REACTANT FEED LINES (KG)
MLPR	■ DELIVERED MASS OF THE LASER PRIMARY REACTANT (KG)
MLRREG	■ MASS OF THE LASER REACTANT REGULATOR (KG)
MLRT	■ MASS OF THE LASER REACTANT TANKAGE AND FLUID (KG)
MLSR	■ DELIVERED MASS OF THE LASER SECONDARY REACTANT (KG)
MMIR	■ MASS OF A MIRROR (KG)
MMISC	■ MASS OF MISCELLANEOUS ITEMS (KG)
MOPT	■ TOTAL MASS OF THE LASER OPTICS (KG)
MPLFN	■ TOTAL MASS OF THE EJECTOR PRIMARY NOZZLE PLENUMS (KG)
MPRHDW	■ MASS OF THE PRESSURE RECOVERY HARDWARE (KG)
MPRS	■ MASS OF THE PRESSURE RECOVERY SYSTEM (KG)
MSHRD	■ TOTAL MASS OF THE EJECTOR SHROUDS (KG)
MSTRUT	■ TOTAL MASS OF THE EJECTOR PRIMARY NOZZLE STRUTS (KG)
MSURD	■ TOTAL MASS OF THE SUBSONIC DIFFUSERS (KG)
MSUPD	■ TOTAL MASS OF THE SUPERSONIC DIFFUSERS (KG)

MTOTAL	■ TOTAL SYSTEM MASS (KG)
MTR	■ TOTAL MASS OF THE TRANSITION SECTIONS (KG)
NRANK	■ NUMBER OF LASER BANKS
NEJECT	■ NUMBER OF EJECTORS PER LASER BANK
	■ 0, FOR THE MAXIMUM ALLOWABLE
NMAX	■ INTERMEDIATE CONSTANT
N0	■ ALPHANUMERIC SYMBOL DESIGNATING A NEGATIVE RESPONSE
NTANK	■ NUMBER OF TANKS
N1	■ NUMBER OF CARBON ATOMS IN LASER PRIMARY REACTANT 1
N2	■ NUMBER OF HYDROGEN (DEUTERIUM) ATOMS IN LASER PRIMARY REACTANT 2
N3	■ NUMBER OF NITROGEN ATOMS IN LASER PRIMARY REACTANT 4
N4	■ NUMBER OF FLUORINE ATOMS IN LASER PRIMARY REACTANT 4
P0	■ STAGNATION PRESSURE (PA)
P0EP	■ EJECTOR PRIMARY STAGNATION PRESSURE (PA)
P0LP	■ LASER PRIMARY STAGNATION PRESSURE (PA)
P0LS	■ LASER SECONDARY STAGNATION PRESSURE (PA)
Q	■ HEAT RELEASED PER KMOLE OF PRIMARY FLOW BY THE CHEMICAL REACTION OF FLUORINE IN THE LASER CAVITY (J/KMOLE)
RTIME	■ RUN TIME (S)
SCSS1	■ CONTROL VARIABLE DESIGNATING WHETHER OR NOT NEW SYSTEM CALCULATION INPUTS ARE REQUIRED
SCSS2	■ CONTROL VARIABLE DESIGNATING WHETHER OR NOT SYSTEM CALCULATIONS ARE TO BE PERFORMED
SCSS3	■ CONTROL VARIABLE DESIGNATING WHETHER OR NOT INPUT DATA SHOULD BE READ FROM TAPE4
SCSS4	■ CONTROL VARIABLE DESIGNATING WHETHER OR NOT NEW REACTANT STORAGE MODES ARE REQUIRED
SDANGL	■ SUBSONIC DIFFUSER HALF-ANGLE (RAD)
SETSCS	■ CONTROL VARIABLE TO SET DEFAULT VALUES
SSF	■ ALPHANUMERIC SYMBOL DESIGNATING A SUPERSONIC-SUPERSONIC EJECTOR FOR PRESSURE RECOVERY
STAW	■ STORAGE MODE DESCRIPTOR DATA ARRAY FOR N2-AW
STCS	■ STORAGE MODE DESCRIPTOR DATA ARRAY FOR H2O-CS
STC2H4	■ STORAGE MODE DESCRIPTOR DATA ARRAY FOR C2H4
STD2	■ STORAGE MODE DESCRIPTOR DATA ARRAY FOR D2
STF2	■ STORAGE MODE DESCRIPTOR DATA ARRAY FOR F2
STHE	■ STORAGE MODE DESCRIPTOR DATA ARRAY FOR HE
STH2	■ STORAGE MODE DESCRIPTOR DATA ARRAY FOR H2
STIRFNA	■ STORAGE MODE DESCRIPTOR DATA ARRAY FOR IRFNA
STMH	■ STORAGE MODE DESCRIPTOR DATA ARRAY FOR MMH
STMODE	■ REACTANT STORAGE MODE DESCRIPTOR ARRAY
STNF3	■ STORAGE MODE DESCRIPTOR DATA ARRAY FOR NF3
STN2	■ STORAGE MODE DESCRIPTOR DATA ARRAY FOR N2
STN2H4	■ STORAGE MODE DESCRIPTOR DATA ARRAY FOR N2H4
TAU	■ MATERIAL THICKNESS (M)
THETA	■ INITIAL TRANSITION SECTION HALF-ANGLE IN THE HORIZONTAL PLANE (RAD)
TITLE	■ ARRAY OF STORAGE MODE HEADINGS FOR I/O
TRANG1	■ INITIAL TRANSITION SECTION HALF-ANGLE IN THE VERTICAL PLANE (RAD)
TRANG2	■ FINAL TRANSITION SECTION HALF-ANGLE (RAD)
VAV	■ TOTAL VOLUME OF THE AERO-WINDOWS (M3)
VRXDEV	■ VOLUME OF THE BOX DEVICE (M3)
VCAV	■ TOTAL VOLUME OF THE LASER CAVITIES (M3)

VCOMR	= TOTAL VOLUME OF THE LASER COMBUSTORS (M ³)
VCS	= VOLUME OF THE COOLING SYSTEM (M ³)
VFJCT	= TOTAL VOLUME OF THE EJECTORS (M ³)
VERT	= VOLUME OF THE EJECTOR PRIMARY REACTANT TANKAGE (M ³)
VLDHW	= VOLUME OF THE LASER DEVICE HARDWARE (M ³)
VLDS	= VOLUME OF THE LASER DEVICE SYSTEM (M ³)
VLRT	= VOLUME OF THE LASER REACTANT TANKAGE (M ³)
VOPT	= TOTAL VOLUME OF THE LASER OPTICS (M ³)
VPRHW	= VOLUME OF THE PRESSURE RECOVERY HARDWARE (M ³)
VPRS	= VOLUME OF THE PRESSURE RECOVERY SYSTEM (M ³)
VSUBD	= TOTAL VOLUME OF THE SUPERSONIC DIFFUSERS (M ³)
VSUPD	= TOTAL VOLUME OF THE SUPERSONIC DIFFUSERS (M ³)
VSYSM	= TOTAL VOLUME CONTAINING THE SYSTEM (M ³)
VTOTAL	= TOTAL VOLUME OCCUPIED BY THE SYSTEM (M ³)
VTR	= TOTAL VOLUME OF THE TRANSITION SECTIONS (M ³)
WAW	= AERO-WINDOW MASS FLOW RATE (KG/S)
WAWL	= AERO-WINDOW FLUID LEAKAGE RATE (KG/S)
WRASE	= WIDTH OF A NOZZLE BASE (M)
WRXDEV	= WIDTH OF THE ROX DEVICE (M)
WCR	= WIDTH OF A COMBUSTOR BODY (M)
WCS	= COOLING SYSTEM MASS FLOW RATE (KG/S)
WEP	= EJECTOR PRIMARY REACTANT MASS FLOW RATE (KG/S)
WEPWLT	= EJECTOR PRIMARY-TO-TOTAL LASER MASS FLOW RATIO
WFPP3	= MASS FRACTION OF LASER PRIMARY PRODUCT 3 (FREE FLUORINE)
WFPR1	= MASS FRACTION OF LASER PRIMARY REACTANT 1
WFPR2	= MASS FRACTION OF LASER PRIMARY REACTANT 2
WFPR3	= MASS FRACTION OF LASER PRIMARY REACTANT 3
WFPR4	= MASS FRACTION OF LASER PRIMARY REACTANT 4
WFSR1	= MASS FRACTION OF LASER SECONDARY REACTANT 1
WFSR2	= MASS FRACTION OF LASER SECONDARY REACTANT 2
WFSR3	= MASS FRACTION OF LASER SECONDARY REACTANT 3
WLP	= LASER PRIMARY REACTANT MASS FLOW RATE (KG/S)
WLS	= LASER SECONDARY REACTANT MASS FLOW RATE (KG/S)
WLSWLP	= LASER SECONDARY-TO-PRIMARY REACTANT MASS FLOW RATIO
WLT	= TOTAL LASER MASS FLOW RATE (KG/S)
WNR	= WIDTH OF A NOZZLE HANK (M)
WPGWLP	= LASER CAVITY PURGE-TO-PRIMARY REACTANT MASS FLOW RATIO
WPP3	= MASS FLOW RATE OF LASER PRIMARY PRODUCT 3 (FREE FLUORINE) (KG/S)
WPURGE	= CAVITY PURGE MASS FLOW RATE (KG/S)
WTR	= WIDTH OF A TRANSITION SECTION ENTRANCE (M)
WFPP3	= MOLE FRACTION OF LASER PRIMARY PRODUCT 3 (FREE FLUORINE)
XLP	= LASER PRIMARY PRODUCT MOLAR FLOW RATE (KMOL/S)
YES	= ALPHANUMERIC SYMBOL DESIGNATING A POSITIVE RESPONSE

REACTANT STORAGE MODE NOTATION SCHEME

THE STORAGE MODE DESCRIPTOR ARRAY, STMODE(I,J), STORES DATA BY
DESCRIPTOR (ROW) AS FOLLOWS:

1 DESCRIPTOR	1 DESCRIPTOR
1 REACTANT	6 STORAGE TIME (DAYS)
2 PHASE	7 STORAGE PRESSURE (PA)
3 CONTAINER	8 STORAGE PRESSURE (PSI)
4 STORAGE TEMPERATURE (K)	9 REACTANT FEED SYSTEM
5 STORAGE TIME (S)	10 MATERIAL

AND BY FLUID (COLUMN) AS FOLLOWS:

J	1
1 DESCRIPTOR	1 LASER REACTANT 1
2 LASER REACTANT 1	7 AERO-WINDOW FLUID
3 LASER REACTANT 2	8 COOLING SYSTEM FLUID
4 LASER REACTANT 3	9 EJECTOR REACTANT 1
5 LASER REACTANT 4	10 EJECTOR REACTANT 2

SOME POSSIBLE ALPHANUMERIC DESCRIPTOR VALUES ARE:

REACTANT -	C2H4, O2, F2, HF, H2, IRFNA MMH, NF3, N2, N2H4 F2/HE - F2 AND HE GAS MIXTURE NF3/HE - NF3 AND HE GAS MIXTURE N2-AW - N2 FOR THE AERO-WINDOW H2O-CS - H2O FOR THE COOLING SYSTEM
PHASE -	GAS LIQ, LIQUID
CONTAINER -	SPH, SPHERE CYL, CYLINDER
REACTANT FEED SYSTEM -	RLO, BLOW-DOWN HPS, HEATER PRESSURIZATION SYSTEM PFS, PUMP FEED SYSTEM PGS, PRESSURIZED GAS SYSTEM RFP, RADIATOR-FAN-PUMP
MATERIAL -	AL, ALUMINUM SS, STAINLESS STEEL TI, TITANIUM

NOMENCLATURE FOR SUBROUTINES VMAW, VMCS, VMC2H4, VMD2,
VMF2, VMHE, VMH2, VMIRFNA, VMMM, VMNF3, VMN2, VMN2H4

AF	= ADIABATIC FACTOR
G	= SPECIFIC HEAT RATIO
I	= DO LOOP INDEX
II	= DO LOOP INDEX
J	= STORAGE MODE CONTROL VARIABLE
K	= STORAGE MODE CONTROL ARRAY
MCS	= MASS OF THE COOLING SYSTEM (KG)
MC2H4	= DELIVERED MASS OF C2H4 (KG)
MD2	= DELIVERED MASS OF D2 (KG)
MF2	= DELIVERED MASS OF F2 (KG)
MHE	= DELIVERED MASS OF HE (KG)
MH2	= DELIVERED MASS OF H2 (KG)
MH2O	= DELIVERED MASS OF H2O (KG)
MIRFNA	= DELIVERED MASS OF IRFNA (KG)
MMM	= DELIVERED MASS OF MMH (KG)
MMT	= TANK AND FLUID MASS USING MINIMUM THICKNESS EQUATIONS (KG)
MNF3	= DELIVERED MASS OF NF3 (KG)
MN2	= DELIVERED MASS OF N2 (KG)
MN2H4	= DELIVERED MASS OF N2H4 (KG)
MPGS	= DELIVERED MASS OF FLUID FROM A PRESSURIZED GAS SYSTEM (KG)
MTANK	= MASS OF REACTANT TANKAGE AND FLUID (KG)
MTOTAL	= DELIVERED MASS OF GAS MIXTURE (KG)
MTTHPS	= MASS OF TANK AND FLUID FOR A HEATER PRESSURIZATION SYSTEM (KG)
MTTPGS	= MASS OF TANK AND FLUID FOR A PRESSURIZED GAS SYSTEM (KG)
MVT	= TANK AND FLUID MASS USING VARIABLE THICKNESS EQUATIONS (KG)
MW	= MOLECULAR WEIGHT (KG/KMOLE)
PHE	= PARTIAL PRESSURE OF HE (PA)
PS	= REACTANT STORAGE PRESSURE (PA)
P0	= COMBUSTOR OR NOZZLE STAGNATION PRESSURE (PA)
RTIME	= RUN TIME (S)
STAW	= STORAGE MODE DESCRIPTOR DATA ARRAY FOR H2-AW
STCS	= STORAGE MODE DESCRIPTOR DATA ARRAY FOR H2O-CS
STC2H4	= STORAGE MODE DESCRIPTOR DATA ARRAY FOR C2H4
STD2	= STORAGE MODE DESCRIPTOR DATA ARRAY FOR D2
STF2	= STORAGE MODE DESCRIPTOR DATA ARRAY FOR F2
STHE	= STORAGE MODE DESCRIPTOR DATA ARRAY FOR HE
STM2	= STORAGE MODE DESCRIPTOR DATA ARRAY FOR H2
STIRFNA	= STORAGE MODE DESCRIPTOR DATA ARRAY FOR IRFNA
STMMH	= STORAGE MODE DESCRIPTOR DATA ARRAY FOR MMH
STMODE	= REACTANT STORAGE MODE DESCRIPTOR ARRAY
STNF3	= STORAGE MODE DESCRIPTOR DATA ARRAY FOR NF3
STN2	= STORAGE MODE DESCRIPTOR DATA ARRAY FOR N2
STN2H4	= STORAGE MODE DESCRIPTOR DATA ARRAY FOR N2H4
VC5	= VOLUME OF THE COOLING SYSTEM (M3)
VTANK	= VOLUME OF THE REACTANT TANKAGE (M3)
VTTHPS	= VOLUME OF A HEATER PRESSURIZATION SYSTEM (M3)
VTPGS	= VOLUME OF A PRESSURIZED GAS SYSTEM (M3)
XFF2	= MOLE FRACTION OF F2
XFHE	= MOLE FRACTION OF HE
XFN3	= MOLE FRACTION OF NF3
Z	= COMPRESSIBILITY FACTOR

APPENDIX F

NOMENCLATURE
OVERLAY SCS

PAGE F-39

ZHE = COMPRESSIBILITY FACTOR FOR HF

FUNCTION STATEMENT GENERAL NOTATION SCHEME

AASM	■	ISENTROPIC, COMPRESSIBLE FLOW EQUATION FOR A/A^* AS A FUNCTION OF MACH NUMBER
PP0M	■	ISENTROPIC, COMPRESSIBLE FLOW EQUATION FOR P/P_0 AS A FUNCTION OF MACH NUMBER
P0PM	■	ISENTROPIC, COMPRESSIBLE FLOW EQUATION FOR P_0/P AS A FUNCTION OF MACH NUMBER
RHO	■	DENSITY FROM THE IDEAL GAS EQUATION OF STATE
R0RM	■	ISENTROPIC, COMPRESSIBLE FLOW EQUATION FOR R_0/R AS A FUNCTION OF MACH NUMBER
T0TM	■	ISENTROPIC, COMPRESSIBLE FLOW EQUATION FOR T_0/T AS A FUNCTION OF MACH NUMBER
WM	■	ISENTROPIC, COMPRESSIBLE FLOW EQUATION FOR THE DIMENSIONLESS MASS FLOW RATE AS A FUNCTION OF MACH NUMBER

**Appendix G. CHEMICAL LASER ANALYSIS PROGRAM (CLAP)-SAMPLE
INPUT/OUTPUT**

APPENDIX 6

CLAP SAMPLE INPUT/OUTPUT

SAMPLE CASE 1 (DEFAULT CASE): INPUT

ARE NEW COMBUSTION CHEMISTRY INPUTS REQUIRED?

NO

ARE NEW LASER DEVICE INPUTS REQUIRED?

NO

APPENDIX 6

CLAP SAMPLE INPUT/OUTPUT

NOTE: T10 =	.162100E+04 K	P10 =	.192105E+07 PA
NOTE: T10 =	.162100E+04 K	P10 =	.192105E+07 PA
NOTE: T10 =	.162100E+04 K	P10 =	.192105E+07 PA
NOTE: T10 =	.162100E+04 K	P10 =	.192105E+07 PA
NOTE: T10 =	.162100E+04 K	P10 =	.192105E+07 PA
NOTE: T10 =	.162100E+04 K	P10 =	.192105E+07 PA
NOTE: T10 =	.162100E+04 K	P10 =	.192105E+07 PA
NOTE: T10 =	.162100E+04 K	P10 =	.192105E+07 PA
NOTE: T10 =	.162100E+04 K	P10 =	.192105E+07 PA
NOTE: T10 =	.162100E+04 K	P10 =	.192105E+07 PA

ARE NEW PRESSURE RECOVERY INPUTS REQUIRED?

NO

APPENDIX 8

CLAP SAMPLE INPUT/OUTPUT

NOTE: P3 =	.270412E+05 PA	MS =	.305005E+01
NOTE: P3 =	.270412E+05 PA	MS =	.305005E+01
NOTE: P3 =	.270412E+05 PA	MS =	.305005E+01
NOTE: P3 =	.270412E+05 PA	MS =	.305005E+01
NOTE: P3 =	.270412E+05 PA	MS =	.305005E+01
NOTE: P3 =	.270412E+05 PA	MS =	.305005E+01
NOTE: P3 =	.270412E+05 PA	MS =	.305005E+01
NOTE: P3 =	.270412E+05 PA	MS =	.305005E+01
NOTE: P3 =	.270412E+05 PA	MS =	.305005E+01
NOTE: P3 =	.270412E+05 PA	MS =	.305005E+01

ARE NEW SYSTEM CALCULATION INPUTS REQUIRED?

NO

APPENDIX 6

CLAP SAMPLE INPUT/OUTPUT

TO RESTART PROGRAM ENTER "YES"

TO STOP PROGRAM ENTER "NO"

NO

APPENDIX 6

CLAP SAMPLE INPUT/OUTPUT

SAMPLE CASE 1 (DEFAULT CASE): OUTPUT (SI UNITS)

CHEMICAL LASER ANALYSIS PROGRAM (CLAP)

WRITTEN BY: C.L. ADAMS
A.L. ADOY
R.D. MASSEY
C.D. MIKKELSEN
G.F. MORR
R.L. OBLUKIAN
B.J. WALKER

1 JANUARY 77

AERODYNAMICS GROUP (ORDMI-TDK)
SYSTEM SIMULATION DIRECTORATE
U.S. ARMY MISSILE RESEARCH & DEVELOPMENT COMMAND
REDSTONE ARSENAL, ALABAMA 35809

RUN DATE 12/05/78

COMBUSTION CHEMISTRY SECTION

INITIAL DATA:

AEXP	=	.361935E-02	M2	ALPHA	=	.802700E+00	
OFORNF	=	DF		N1	=		2 ATOMS C
N2	=		4 ATOMS H	N3	=		2 ATOMS N
N4	=		3 ATOMS F	WPS	=	0.	KG/S N2
WPR1	=	.362160E-02	KG/S C2H4	WPR2	=	.172416E-01	KG/S HE
WPR3	=	0.	KG/S N2	WPR4	=	.571093E-01	KG/S N1F3
WSR1	=	.437250E-02	KG/S O2	WSR2	=	.330510E-01	KG/S HE
WSR3	=	0.	KG/S N2				

RESULTANT DATA:

FDA	=	.191592E+00	KMOLE/S-M2	OMEGA	=	.347901E+02	
OMEGTRW	=	.322770E+02		PSIC	=	.126969E+02	
PSIL	=	.220931E+02		PSILTRW	=	.195801E+02	
Q	=	.210542E+08	J/KMOLE	RC	=	.207600E+01	
RL	=	.251301E+01		RLF	=	.220901E+02	
WFCP1	=	.195543E+00	CF4	XFCP1	=	.160238E-01	CF4
WFCP2	=	.889077E-01	HF	XFCP2	=	.320476E-01	HF
WFCP3	=	.156220E+00	DF	XFCP3	=	.536149E-01	HF
WFCP4	=	.439714E+00	HE	XFCP4	=	.792234E+00	HE
WFCP5	=	.969568E-01	N2	XFCP5	=	.249596E-01	N2
WFCP6	=	.226560E-01	D	XFCP6	=	.811199E-01	D

APPENDIX 8

CLAP SAMPLE INPUT/OUTPUT

LASER DEVICE SECTION

INITIAL DATA:

RRFRAC	=	.100000E+01	CANGLE	=	.174533E+00 RAD
D1	=	.177800E-02 M	D1S	=	.669534E-04 M
D3	=	.137160E-02 M	D3S	=	.685800E-04 M
GEOMPN	=	20	GEOMSN	=	20
WBASE	=	.349250E-01 M	WNB	=	.349250E-01 M
LCAV	=	.762000E-01 M	LPNOZ	=	.250190E-02 M
LSNOZ	=	.185166E-02 M	NSPNOZ	=	.103846E+01
PKFRAC	=	.803431E+00	P10	=	.192105E+07 PA
T30	=	.600000E+03 K	T70	=	.300000E+03 K

RESULTANT DATA:

POINT 1 PRIMARY NOZZLE EXIT - CONDITIONS BASED ON THE NOZZLE STAGNATION (COMBUSTOR) TEMPERATURE

A1	=	.173248E+00 S-M2/KMOLE	A1A1SE	=	.178471E+02
A1A1S0	=	.265958E+02	G1	=	.145968E+01
W1	=	.124497E+02 KG/KMOLE	M1	=	.491266E+01
NPNOZ	=	.415138E+04 S/KMOLE	P1	=	.492323E+04 PA
P10	=	.192105E+07 PA	RE1	=	.222422E+04
R1	=	.297744E-01 KG/M3	R10	=	.177455E+01 KG/M3
T1	=	.247594E+03 K	T10	=	.162100E+04 K

POINT 2 PRIMARY NOZZLE EXIT - CONDITIONS BASED ON THE NOZZLE EXIT TEMPERATURE

A2	=	.157485E+00 S-M2/KMOLE	G2	=	.153963E+01
W2	=	.124497E+02 KG/KMOLE	M2	=	.491266E+01
P2	=	.492323E+04 PA	P20	=	.192105E+07 PA
R2	=	.297744E-01 KG/M3	R20	=	.177455E+01 KG/M3
T2	=	.247594E+03 K	T20	=	.162100E+04 K

POINT 3 SECONDARY NOZZLE EXIT - CONDITIONS BASED ON THE NOZZLE STAGNATION (COMBUSTOR) TEMPERATURE

A3	=	.135591E+00 S-M2/KMOLE	A3A3SE	=	.131315E+02
A3A3S0	=	.200000E+02	G3	=	.161679E+01
W3	=	.400551E+01 KG/KMOLE	M3	=	.530231E+01
NSNOZ	=	.431104E+04 S/KMOLE	P3	=	.239593E+04 PA
P30	=	.917516E+06 PA	RE3	=	.187829E+04
R3	=	.186036E-01 KG/M3	R30	=	.736704E+00 KG/M3
T3	=	.620454E+02 K	T30	=	.600000E+03 K
W3W1	=	.490228E+00	X3X1	=	.152370E+01

POINT 4 SECONDARY NOZZLE EXIT - CONDITIONS BASED ON THE NOZZLE EXIT TEMPERATURE

A4	=	.136095E+00 S-M2/KMOLE	G4	=	.161322E+01
W4	=	.400551E+01 KG/KMOLE	M4	=	.530231E+01
P4	=	.239593E+04 PA	P40	=	.917516E+06 PA
R4	=	.186036E-01 KG/M3	R40	=	.736704E+00 KG/M3
T4	=	.620454E+02 K	T40	=	.600000E+03 K
W4W2	=	.490228E+00	X4X2	=	.152370E+01

APPENDIX 6

CLAP SAMPLE INPUT/OUTPUT

POINT 5 CONSTANT-AREA MIXING REGION EXIT

A5	=	.293579E+00	S-M2/KMOLE	G5	=	.158178E+01
WV5	=	.735148E+01	KG/KMOLE	M5	=	.489482E+01
P5	=	.391429E+04	PA	P30	=	.110540E+07 PA
R5	=	.269217E-01	KG/M3	R50	=	.953972E+00 KG/M3
T5	=	.128558E+03	K	T50	=	.102454E+04 K
W5W2	=	.149023E+01		X5X2	=	.252370E+01

POINT 6 ISENTROPIC EXPANSION REGION EXIT

A6	=	.577895E+00	S-M2/KMOLE	G6	=	.158178E+01
WV6	=	.735148E+01	KG/KMOLE	M6	=	.614393E+01
P6	=	.129211E+04	PA	P60	=	.110540E+07 PA
R6	=	.133595E-01	KG/M3	R60	=	.953972E+00 KG/M3
T6	=	.855175E+02	K	T60	=	.102454E+04 K
W6W2	=	.149023E+01		X6X2	=	.252370E+01

POINT 7 MIRROR PURGE CONDITIONS

G7	=	.139962E+01		WV7	=	.280134E+02 KG/KMOLE
T70	=	.300000E+03	K	W7W2	=	0.
X7X2	=	0.				

POINT 8 LASER CAVITY EXIT

A8	=	.102254E+01	S-M2/KMOLE	G8	=	.157796E+01
WV8	=	.721149E+01	KG/KMOLE	M8	=	.226203E+01
P8	=	.511063E+04	PA	P80	=	.609213E+05 PA
RE8	=	.379253E+05		R8	=	.795592E-02 KG/M3
R80	=	.382623E-01	KG/M3	T8	=	.557161E+03 K
T80	=	.138100E+04	K	W8W2	=	.149023E+01
X8X2	=	.257269E+01				

APPENDIX 6

CLAP SAMPLE INPUT/OUTPUT

PRESSURE RECOVERY SECTION

INITIAL DATA:

A3A2	=	.300000E+01	A7A6	=	.300000E+01
EJECT	=	CAE	ETA12	=	.750000E+00
Q5	=	.129000E+01	MW5	=	.202040E+02 KG/KMOLE
P50	=	.310264E+07 PA	P7	=	.101325E+06 PA
T50	=	.281480E+04 K			

RESULTANT DATA:

POINT 1 LASER CAVITY EXIT AND NORMAL SHOCK DIFFUSER ENTRANCE

A1	=	.102254E+01 S-M2/KMOLE	O1	=	.157796E+01
M1	=	.721149E+01 KG/KMOLE	M1	=	.226203E+01
P1	=	.511063E+04 PA	P10	=	.609213E+05 PA
R1	=	.795592E-02 KG/M3	R10	=	.382623E-01 KG/M3
T1	=	.557161E+03 K	T10	=	.138100E+04 K

POINT 2 NORMAL SHOCK DIFFUSER EXIT AND SUBSONIC DIFFUSER ENTRANCE

A2	=	.102254E+01 S-M2/KMOLE	ETA12	=	.750000E+00
O2	=	.157796E+01	MW2	=	.721149E+01 KG/KMOLE
M2	=	.554255E+00	P2	=	.231501E+05 PA
P20	=	.294386E+05 PA	R2	=	.158775E-01 KG/M3
R20	=	.184892E-01 KG/M3	T2	=	.126465E+04 K
T20	=	.138100E+04 K	W2W1	=	.100000E+01
X2X1	=	.100000E+01			

POINT 3 SUBSONIC DIFFUSER EXIT AND SUDDEN ENLARGEMENT ENTRANCE

A3	=	.304763E+01 S-M2/KMOLE	ETA23	=	.964251E+00
O3	=	.157796E+01	MW3	=	.721149E+01 KG/KMOLE
M3	=	.157029E+00	P3	=	.278412E+05 PA
P30	=	.283862E+05 PA	R3	=	.176106E-01 KG/M3
R30	=	.178283E-01 KG/M3	T3	=	.137123E+04 K
T30	=	.138100E+04 K	W3W1	=	.100000E+01
X3X1	=	.100000E+01			

POINT 4 CONSTANT-AREA, SUBSONIC-SUPERSONIC EJECTOR SECONDARY NOZZLE EXIT

A4	=	.120834E+01 S-M2/KMOLE	O4	=	.157796E+01
MW4	=	.721149E+01 KG/KMOLE	M4	=	.775000E+00
P4	=	.183449E+05 PA	P40	=	.283862E+05 PA
R4	=	.135215E-01 KG/M3	R40	=	.178283E-01 KG/M3
T4	=	.117676E+04 K	T40	=	.138100E+04 K
W4W1	=	.100000E+01	X4X1	=	.100000E+01

POINT 5 CONSTANT-AREA, SUBSONIC-SUPERSONIC EJECTOR PRIMARY NOZZLE EXIT

A5	=	.391545E+00 S-M2/KMOLE	O5	=	.129000E+01
MW5	=	.202040E+02 KG/KMOLE	M5	=	.305905E+01
P5	=	.185938E+05 PA	P50	=	.310264E+07 PA
R5	=	.507143E-01 KG/M3	R50	=	.287851E+01 KG/M3
T5	=	.890936E+03 K	T50	=	.281480E+04 K
W5W1	=	.284443E+01	X5X1	=	.101527E+01

APPENDIX 6

CLAP SAMPLE INPUT/OUTPUT

POINT 6 CONSTANT-AREA, SUBSONIC-SUPERSONIC EJECTOR EXIT AND SUBSONIC
DIFFUSER ENTRANCE

A6	=	.159989E+01	S-M2/KMOLE	G6	=	.138524E+01
MW6	=	.137570E+02	KG/KMOLE	M6	=	.402248E+00
P6	=	.899720E+05	PA	P60	=	.105327E+06 PA
R6	=	.683883E-01	KG/M3	R60	=	.766185E-01 KG/M3
T6	=	.217787E+04	K	T60	=	.227459E+04 K
W6W1	=	.384443E+01		X6X1	=	.201527E+01

POINT 7 SUBSONIC DIFFUSER EXIT

A7	=	.479966E+01	S-M2/KMOLE	ETA67	=	.975871E+00
G7	=	.138524E+01		MW7	=	.137570E+02 KG/KMOLE
M7	=	.142052E+00		P7	=	.101325E+06 PA
P70	=	.102786E+06	PA	R7	=	.739935E-01 KG/M3
R70	=	.747698E-01	KG/M3	T7	=	.226579E+04 K
T70	=	.227459E+04	K	W7W1	=	.384443E+01
X7X1	=	.201527E+01				

APPENDIX G

CLAP SAMPLE INPUT/OUTPUT

SYSTEM CALCULATION SECTION

INITIAL DATA:

```

EREACT = IRFNA/MMH          NBANK = 1
NEJECT = 1                  RTIME = .600000E+02 s
WPP3 = .129645E+01 KG/S

```

REACTANT STORAGE METHOD

REACT	C2H4	HE	NF3	D2
PHASE	GAS	GAS	GAS	GAS
CONT	SPH	SPH	SPH	SPH
STEMP	300.0 K	300.0 K	300.0 K	300.0 K
STIME	INFINITE	INFINITE	INFINITE	INFINITE
SPRES	4.1E+07 PA (6000 PSI)	4.1E+07 PA (6000 PSI)	1.2E+07 PA (1800 PSI)	4.1E+07 PA (6000 PSI)
RFSYS	BLD	BLD	BLD	BLD
MATER	TI	TI	SS	TI
REACT	N2-AV	N2O-CS	MMH	IRFNA
PHASE	GAS	LIG	LIG	LIG
CONT	SPH	SPH	SPH	SPH
STEMP	300.0 K	300.0 K	300.0 K	300.0 K
STIME	INFINITE	INFINITE	INFINITE	INFINITE
SPRES	4.1E+07 PA (6000 PSI)	2.8E+06 PA (400 PSI)	1.25*P0	1.25*P0
RFSYS	BLD	P0S	P0S	P0S
MATER	TI	TI	TI	AL

RESULTANT DATA:

SYSTEM SCALE-UP FACTOR

XLP = .901567E+00 (KMOLE/S)

LASER DEVICE SYSTEM VOLUME/MASS

MINJ	= .502582E+02 KG	VCOMB	= .592590E-01 M3
MCB	= .835375E+02 KG	VCAV	= .549746E-01 M3
MBASE	= .785727E+02 KG	VAW	= .100258E-01 M3
MCAV	= .232102E+02 KG	VCS	= .634179E+00 M3
MAW	= .144447E+02 KG	VOPT	= .107473E+01 M3
MCS	= .626465E+03 KG		
MOP7	= .114917E+04 KG		
MDS	= .138475E+03 KG		
MLPREG	= .669069E+02 KG		
MLLINE	= .259070E+02 KG		
MLDMOV	= .225645E+04 KG	VLDMOV	= .183397E+01 M3
MLRT	= .908326E+04 KG	VLRT	= .132811E+02 M3
MLDS	= .113402E+05 KG	VLDS	= .151151E+02 M3

APPENDIX 6

CLAP SAMPLE INPUT/OUTPUT

PRESSURE RECOVERY SYSTEM VOLUME/MASS

MSUPD	=	.250459E+03	K0	VSUPD	=	.512733E+00	M3
MSUBD	=	.941716E+02	K0	VSUBD	=	.233867E+00	M3
MEJECT	=	.156135E+05	K0	VEJECT	=	.101376E+03	M3
MERREC	=	.118949E+03	K0				
MELINE	=	.675493E+01	K0				
MPRHOW	=	.160839E+05	K0	VPRHOW	=	.102123E+03	M3
MERT	=	.407555E+04	K0	VERT	=	.390099E+01	M3
MPRS	=	.201594E+05	K0	VPRS	=	.106024E+03	M3

SYSTEM VOLUME/MASS SUMMARY

MLDS	=	.113402E+05	K0	VLDS	=	.151151E+02	M3
MPRS	=	.201594E+05	K0	VPRS	=	.106024E+03	M3
MMISC	=	.362874E+03	K0				
MTOTAL	=	.318625E+05	K0	VTOTAL	=	.121139E+03	M3
				VSYSTEM	=	.242277E+03	M3
WBASE	=	.149180E+02	M	LLDS	=	.169938E+00	M
LPRS	=	.337820E+02	M				
LBXDEV	=	.339219E+02	M	WBXDEV	=	.164098E+02	M
WBXDEV	=	.430213E+01	M	VBXDEV	=	.239479E+04	M3

APPENDIX G

CLAP SAMPLE INPUT/OUTPUT

SAMPLE CASE 1 (DEFAULT CASE): OUTPUT (ENGINEERING UNITS)

CHEMICAL LASER ANALYSIS PROGRAM (CLAP)

WRITTEN BY: C.L. ADAMS
A.L. ADDY
R.D. MASSEY
C.D. MIKKELSEN
G.F. MORR
R.L. OBLUKIAH
R.J. WALKER

1 JANUARY 77

AERODYNAMICS GROUP (DROMI-TOK)
SYSTEM SIMULATION DIRECTORATE
U.S. ARMY MISSILE RESEARCH & DEVELOPMENT COMMAND
REDSTONE ARSENAL, ALABAMA 35899

RUN DATE 12/05/78

COMBUSTION CHEMISTRY SECTION

INITIAL DATA:

AEXP	=	.561000E+01	IN2	ALPHA	=	.802700E+00
DFORMF	=	0.		N1	=	2 ATOMS C
N2	=	4 ATOMS H		N3	=	1 ATOMS N
N4	=	3 ATOMS F		WPG	=	0.
WPR1	=	.362100E+01	GM/S C2H4	WPR2	=	.172416E+02
WPR3	=	0.	GM/S N2	WPR4	=	.571093E+02
WSR1	=	.437350E+01	GM/S O2	WSR2	=	.330510E+02
WSR3	=	0.	GM/S N2			

RESULTANT DATA:

FDAA	=	.123607E+00	GMOLE/S-IN2	OMEGA	=	.347901E+02
OMEGTRV	=	.322770E+02		PSIC	=	.126969E+02
PSIL	=	.220931E+02		PSILTRV	=	.195801E+02
Q	=	.522329E+04	CAL/GMOLE	RC	=	.207680E+01
RL	=	.251301E+01		RLF	=	.220931E+02
WFCP1	=	.195545E+00	CF4	XFCP1	=	.160238E-01
WFCP2	=	.889077E-01	HF	XFCP2	=	.320476E-01
WFCP3	=	.156220E+00	DF	XFCP3	=	.536149E-01
WFCP4	=	.439714E+00	HE	XFCP4	=	.792234E+00
WFCP5	=	.969568E-01	N2	XFCP5	=	.249596E-01
WFCP6	=	.275560E-01	D	XFCP6	=	.811199E-01

APPENDIX 6

CLAP SAMPLE INPUT/OUTPUT

LASER DEVICE SECTION

INITIAL DATA:

BRFRAC	=	.100000E+01	CANGLE	=	.100000E+02 DEG
D1	=	.700000E-01 IN	D15	=	.263596E-02 IN
D3	=	.540000E-01 IN	D35	=	.270000E-02 IN
GEUMPH	=	20	GEOMSN	=	20
MBASE	=	.137500E+01 IN	MWB	=	.137500E+01 IN
LCAY	=	.300000E+01 IN	LPNOZ	=	.985000E-01 IN
LSNOZ	=	.729000E-01 IN	NSFNOZ	=	.103846E+01
PKFRAC	=	.803431E+00	P10	=	.278625E+03 PSIA
T30	=	.600000E+03 K	T70	=	.300000E+03 K

RESULTANT DATA:

POINT 1 PRIMARY NOZZLE EXIT - CONDITIONS BASED ON THE NOZZLE STAGNATION (COMBUSTOR) TEMPERATURE

A1	=	.121805E+03 S-IN2/LBMOLE	A1A1SE	=	.178471E+02
A1A1S6	=	.265550E+02	01	=	.145960E+01
MW1	=	.124497E+02 LBM/LBMOLE	M1	=	.491266E+01
NPNOZ	=	.188302E+04 S/LBMOLE	P1	=	.369273E+02 TORR
P10	=	.278625E+03 PSIA	RE1	=	.222422E+04
R1	=	.297744E-04 GM/CM3	R10	=	.177455E-02 GM/CM3
T1	=	.247594E+03 K	T10	=	.162100E+04 K

POINT 2 PRIMARY NOZZLE EXIT - CONDITIONS BASED ON THE NOZZLE EXIT TEMPERATURE

A2	=	.110722E+03 S-IN2/LBMOLE	02	=	.153963E+01
MW2	=	.124497E+02 LBM/LBMOLE	M2	=	.491266E+01
P2	=	.369273E+02 TORR	P20	=	.278625E+03 PSIA
R2	=	.297744E-04 GM/CM3	R2	=	.177455E-02 GM/CM3
T2	=	.247594E+03 K	T20	=	.162100E+04 K

POINT 3 SECONDARY NOZZLE EXIT - CONDITIONS BASED ON THE NOZZLE STAGNATION (COMBUSTOR) TEMPERATURE

A3	=	.953294E+02 S-IN2/LBMOLE	A3A3SE	=	.131315E+02
A3A3S6	=	.200000E+02	03	=	.161670E+01
MW3	=	.400551E+01 LBM/LBMOLE	M3	=	.530231E+01
NSNOZ3	=	.195544E+04 S/LBMOLE	P3	=	.179710E+02 TORR
P30	=	.133074E+03 PSIA	RE3	=	.187829E+04
R3	=	.186036E-04 GM/CM3	R30	=	.736704E-03 GM/CM3
T3	=	.620434E+02 K	T30	=	.600000E+03 K
W3W1	=	.490228E+00	X3X1	=	.152370E+01

POINT 4 SECONDARY NOZZLE EXIT - CONDITIONS BASED ON THE NOZZLE EXIT TEMPERATURE

A4	=	.956835E+02 S-IN2/LBMOLE	04	=	.161322E+01
MW4	=	.400551E+01 LBM/LBMOLE	M4	=	.530231E+01
P4	=	.179710E+02 TORR	P40	=	.133074E+03 PSIA
R4	=	.186036E-04 GM/CM3	R40	=	.736704E-03 GM/CM3
T4	=	.620434E+02 K	T40	=	.600000E+03 K
W4W2	=	.490228E+00	X4X2	=	.152370E+01

APPENDIX B

CLAP SAMPLE INPUT/OUTPUT

POINT 5 CONSTANT-AREA MIXING REGION EXIT

A5	=	.206406E+03	S-IN2/LBMOLE	Q5	=	.158178E+01
MW5	=	.735148E+01	LBW/LBMOLE	M5	=	.489482E+01
P5	=	.293596E+02	TORR	P50	=	.829117E+04 TORR
R5	=	.269217E-04	GM/CM3	R50	=	.953972E-03 GM/CM3
T5	=	.128558E+03	K	T50	=	.102454E+04 K
WSW2	=	.149023E+01		X5X2	=	.252370E+01

POINT 6 ISENTROPIC EXPANSION REGION EXIT

A6	=	.406298E+03	S-IN2/LBMOLE	Q6	=	.158178E+01
MW6	=	.735148E+01	LBW/LBMOLE	M6	=	.614393E+01
P6	=	.969160E+01	TORR	P60	=	.829117E+04 TORR
R6	=	.133595E-04	GM/CM3	R60	=	.953972E-03 GM/CM3
T6	=	.855175E+02	K	T60	=	.102454E+04 K
WSW2	=	.149023E+01		X6X2	=	.252370E+01

POINT 7 MIRROR PURGE CONDITIONS

Q7	=	.139962E+01		MW7	=	.280134E+02 LBW/LBMOLE
T70	=	.300000E+03 K		W7W2	=	0.
X7X2	=	0.				

POINT 8 LASER CAVITY EXIT

A8	=	.718915E+03	S-IN2/LBMOLE	Q8	=	.157796E+01
MW8	=	.721149E+01	LBW/LBMOLE	M8	=	.226203E+01
P8	=	.383378E+02	TORR	P80	=	.456947E+03 TORR
R8	=	.379253E-05		R8	=	.795592E-05 GM/CM3
RA8	=	.382623E-04	GM/CM3	T8	=	.557161E+03 K
T80	=	.138100E+04 K		WSW2	=	.149023E+01
X8X2	=	.257269E+01				

APPENDIX 6

CLAP SAMPLE INPUT/OUTPUT

PRESSURE RECOVERY SECTION

INITIAL DATA:

A3A2	=	.300000E+01	A7A6	=	.300000E+01
EJECT	=	CAE	ETA12	=	.750000E+00
Q5	=	.129000E+01	MW5	=	.202040E+02 LBM/LBMOLE
P50	=	.450000E+03 PSIA	PT	=	.760000E+03 TORR
T50	=	.281480E+04 K			

RESULTANT DATA:

POINT 1 LASER CAVITY EXIT AND NORMAL SHOCK DIFFUSER ENTRANCE

A1	=	.718915E+03 S-IN2/LBMOLE	G1	=	.157796E+01
MW1	=	.721149E+01 LBM/LBMOLE	M1	=	.226203E+01
P1	=	.383328E+02 TORR	P10	=	.456947E+03 TORR
R1	=	.795592E-05 GM/CM3	R10	=	.382623E-04 GM/CM3
T1	=	.557161E+03 K	T10	=	.138100E+04 K

POINT 2 NORMAL SHOCK DIFFUSER EXIT AND SURSONIC DIFFUSER ENTRANCE

A2	=	.718915E+03 S-IN2/LBMOLE	ETA12	=	.750000E+00
G2	=	.157796E+01	MW2	=	.721149E+01 LBM/LBMOLE
M2	=	.564255E+00	P2	=	.173640E+03 TORR
P20	=	.220807E+03 TORR	R2	=	.156775E-04 GM/CM3
R20	=	.184892E-04 GM/CM3	T2	=	.126465E+04 K
T20	=	.138100E+04 K	W2W1	=	.100000E+01
X2X1	=	.100000E+01			

POINT 3 SURSONIC DIFFUSER EXIT AND SUDDEN ENLARGEMENT ENTRANCE

A3	=	.215675E+04 S-IN2/LBMOLE	ETA23	=	.964251E+00
G3	=	.157796E+01	MW3	=	.721149E+01 LBM/LBMOLE
M3	=	.157029E+00	P3	=	.208816E+03 TORR
P30	=	.212914E+03 TORR	R3	=	.176100E-04 GM/CM3
R30	=	.178283E-04 GM/CM3	T3	=	.137123E+04 K
T30	=	.138100E+04 K	W3W1	=	.100000E+01
X3X1	=	.100000E+01			

POINT 4 CONSTANT-AREA, SUBSONIC-SUPERSONIC EJECTOR SECONDARY NOZZLE EXIT

A4	=	.849544E+03 S-IN2/LBMOLE	G4	=	.157796E+01
MW4	=	.721149E+01 LBM/LBMOLE	M4	=	.775000E+00
P4	=	.137500E+03 TORR	P40	=	.212914E+03 TORR
R4	=	.135215E-04 GM/CM3	R40	=	.178283E-04 GM/CM3
T4	=	.117676E+04 K	T40	=	.138100E+04 K
W4W1	=	.100000E+01	X4X1	=	.100000E+01

POINT 5 CONSTANT-AREA, SUBSONIC-SUPERSONIC EJECTOR PRIMARY NOZZLE EXIT

A5	=	.275282E+03 S-IN2/LBMOLE	G5	=	.129000E+01
MW5	=	.202040E+02 LBM/LBMOLE	M5	=	.385985E+01
P5	=	.139465E+03 TORR	P50	=	.450000E+03 PSIA
R5	=	.507143E-04 GM/CM3	R50	=	.267851E-02 GM/CM3
T5	=	.890936E+03 K	T50	=	.281480E+04 K
W5W1	=	.284443E+01	X5X1	=	.101527E+01

APPENDIX G

CLAP SAMPLE INPUT/OUTPUT

POINT 6 CONSTANT-AREA, SUBSONIC-SUPERSONIC EJECTOR EXIT AND SUBSONIC
DIFFUSER ENTRANCE

A6	=	.112483E+04	S-IN2/LBMOLE	06	=	.138524E+01
MW6	=	.137570E+02	LBM/LBMOLE	M6	=	.482248E+00
P6	=	.674846E+03	TORR	P60	=	.790020E+03 TORR
RA	=	.683803E-04	GM/CM3	R60	=	.766185E-04 GM/CM3
T6	=	.217707E+04	K	T60	=	.227459E+04 K
W6W1	=	.384443E+01		X6X1	=	.201527E+01

POINT 7 SUBSONIC DIFFUSER EXIT

A7	=	.337448E+04	S-IN2/LBMOLE	ETA67	=	.975871E+00
07	=	.138524E+01		MW7	=	.137570E+02 LBM/LBMOLE
M7	=	.142052E+00		P7	=	.760000E+03 TORR
P70	=	.770958E+03	TORR	R7	=	.739935E-04 GM/CM3
R70	=	.747698E-04	GM/CM3	T7	=	.226579E+04 K
T70	=	.227459E+04	K	W7W1	=	.384443E+01
X7X1	=	.201527E+01				

APPENDIX 6

CLAP SAMPLE INPUT/OUTPUT

SYSTEM CALCULATION SECTION

INITIAL DATA:

EREACT = IPFNA/MMH NBANK = 1
 REJECT = 1 RTIME = .600000E+02 S
 WPP3 = .183645E+04 GM/S

REACTANT STORAGE METHOD

REACT	C2H4	HE		NF3	O2
PHASE	GAS	GAS		GAS	GAS
CONT	SPH	SPH		SPH	SPH
STEMP	300.0 K	300.0 K		300.0 K	300.0 K
STIME	INFINITE	INFINITE		INFINITE	INFINITE
SPRES	4.1E+07 PA (6000 PSI)	4.1E+07 PA (6000 PSI)		1.2E+07 PA (1800 PSI)	4.1E+07 PA (6000 PSI)
RFSYS	BLD	BLD		BLD	BLD
WATER	TI	TI		SS	TI

REACT	N2-LV	H2O-CS	MCH	IPFNA
PHASE	GAS	LIO	LIO	LIO
CONT	SPH	SPH	SPH	SPH
STEMP	300.0 K	300.0 K	300.0 K	300.0 K
STIME	INFINITE	INFINITE	INFINITE	INFINITE
SPRES	4.1E+07 PA (6000 PSI)	2.8E+06 PA (400 PSI)	1.25*P0	1.25*P0
RFSYS	BLD	P0S	P0S	P0S
WATER	TI	TI	TI	AL

RESULTANT DATA:

SYSTEM SCALE-UP FACTOR

XLP = .901567E-03 GWOLE/S

LASER DEVICE SYSTEM VOLUME/MASS

MTNJ	= .110800E+03 LBM	VCOMB	= .209271E+01 FT3
MCH	= .184169E+03 LBM	VCAV	= .194141E+01 FT3
MRASE	= .173223E+03 LBM	VAV	= .382311E+00 FT3
MCAV	= .511697E+02 LBM	VCS	= .223958E+02 FT3
MAW	= .318450E+02 LBM	VOPT	= .379538E+02 FT3
MCS	= .138112E+04 LBM		
MOPT	= .253349E+04 LBM		
MOS	= .305296E+03 LBM		
MLRREG	= .147504E+03 LBM		
MLLINE	= .571152E+02 LBM		
MLDHDW	= .497572E+04 LBM	VLDHDW	= .647661E+02 FT3
MLRT	= .200252E+05 LBM	VLRT	= .469017E+03 FT3
MLDS	= .250009E+05 LBM	VLOS	= .533763E+03 FT3

APPENDIX 0

CLAP SAMPLE INPUT/OUTPUT

PRESSURE RECOVERY SYSTEM VOLUME/MASS

MSUPD	=	.552167E+03 LBM	VSUPD	=	.181073E+02 FT3
MSUBD	=	.207613E+03 LBM	VSUBD	=	.825893E+01 FT3
MEJECT	=	.344228E+04 LBM	VEJECT	=	.358006E+04 FT3
MEHREG	=	.262238E+03 LBM			
MELINE	=	.148921E+02 LBM			
MPRMDV	=	.354589E+05 LBM	VPRMDV	=	.360643E+04 FT3
MFRT	=	.898584E+04 LBM	VERT	=	.137762E+03 FT3
MPRS	=	.444439E+05 LBM	VPRS	=	.374419E+04 FT3

SYSTEM VOLUME/MASS SUMMARY

MLDS	=	.250009E+05 LBM	VLDS	=	.533783E+03 FT3
MPRS	=	.444439E+05 LBM	VPRS	=	.374419E+04 FT3
MMISC	=	.800000E+03 LBM			
MTOTAL	=	.702448E+05 LBM	VTOTAL	=	.427747E+04 FT3
			VSYSTM	=	.855595E+04 FT3
WRASE	=	.587323E+02 IN	LLOS	=	.747789E+01 IN
LPRS	=	.132803E+04 IN			
LHXDEV	=	.133551E+04 IN	WRXDEV	=	.646055E+03 IN
HRXDEV	=	.169375E+03 IN	VRXDEV	=	.845712E+05 FT3

APPENDIX 8

CLAP SAMPLE INPUT/OUTPUT

SAMPLE CASE 21 INPUT

ARE NEW COMBUSTION CHEMISTRY INPUTS REQUIRED?

YES

SHOULD INPUT DATA BE READ FROM TAPE?

NO

SELECT THE LASER CHEMISTRY FROM THE FOLLOWING LIST:

"DF" FOR A DF CHEMICAL LASER

"HF" FOR A HF CHEMICAL LASER

DF

APPENDIX 6

CLAP SAMPLE INPUT/OUTPUT

INPUT DATA FOR THE COMBUSTION CHEMISTRY SECTION BY NAMELIST.
CURRENT VALUES ARE:

BNLCCS		AEXP	=	.361935E-02	ALPHA	=	.802700E+00	
N1	=	2	N2	=	4	N3	=	1
N4	=	3	MPG	=	0.	WPR1	=	.362160E-02
WPR2	=	.172416E-01	WPR3	=	0.	WPR4	=	.571093E-01
WSR1	=	.437250E-02	WSR2	=	.330510E-01	WSR3	=	0.

BNLCCS MPG=0.116197E-02 0

ARE NEW LASER DEVICE INPUTS REQUIRED?

YES

SHOULD INPUT DATA BE READ FROM TAPE?

NO

APPENDIX 6

CLAP SAMPLE INPUT/OUTPUT

INPUT THE LASER PRIMARY NOZZLE GEOMETRY FROM THE FOLLOWING LIST:

"AX" FOR AXISYMMETRIC NOZZLES
"2D" FOR SLIT NOZZLES

2D

INPUT THE LASER SECONDARY NOZZLE GEOMETRY FROM THE FOLLOWING LIST:

"AX" FOR AXISYMMETRIC NOZZLES
"2D" FOR SLIT NOZZLES

2D

SELECT A LASER DEVICE INPUT VARIABLE FROM THE FOLLOWING LIST:

"P10" FOR THE PRIMARY COMBUSTOR OR NOZZLE STAGNATION PRESSURE
"T10" FOR THE PRIMARY COMBUSTOR OR NOZZLE STAGNATION TEMPERATURE

P10

APPENDIX 6

CLAP SAMPLE INPUT/OUTPUT

INPUT DATA FOR THE LASER DEVICE SECTION BY NAMELIST
CURRENT VALUES ARE:

BNLLDS		BRFRAC	=	.100000E+01	CANGLE	=	.174533E+00	
D1	=	.177000E-02	D1S	=	.669534E-04	D3	=	.137160E-02
D3E	=	.605000E-04	HBASE	=	.349250E-01	HNB	=	.349250E-01
LCAV	=	.762000E-01	LPHOZ	=	.250190E-02	LSHOZ	=	.105166E-02
NSPHOZ	=	.103046E+01	PKFRAC	=	.003431E+00	P10	=	.192105E+07
T30	=	.600000E+03	T70	=	.300000E+03			

BNLLDS P10=0.2E+07

NOTE: T10	=	.175525E+04	K	P10	=	.200000E+07	PA
NOTE: T10	=	.175525E+04	K	P10	=	.200000E+07	PA
NOTE: T10	=	.175525E+04	K	P10	=	.200000E+07	PA
NOTE: T10	=	.175525E+04	K	P10	=	.200000E+07	PA
NOTE: T10	=	.175525E+04	K	P10	=	.200000E+07	PA
NOTE: T10	=	.175525E+04	K	P10	=	.200000E+07	PA
NOTE: T10	=	.175525E+04	K	P10	=	.200000E+07	PA
NOTE: T10	=	.175525E+04	K	P10	=	.200000E+07	PA
NOTE: T10	=	.175525E+04	K	P10	=	.200000E+07	PA
NOTE: T10	=	.175525E+04	K	P10	=	.200000E+07	PA

APPENDIX B

CLAP SAMPLE INPUT/OUTPUT

ARE NEW PRESSURE RECOVERY INPUTS REQUIRED?

YES

SHOULD INPUT DATA BE READ FROM TAPE?

NO

INPUT THE PRESSURE RECOVERY SUBSYSTEM FROM THE FOLLOWING LIST:

"NO" FOR NO PRESSURE RECOVERY SUBSYSTEM

"DIF" FOR A SUPERSONIC-SUBSONIC DIFFUSER SUBSYSTEM

"CAE" FOR A CONSTANT-AREA, SUBSONIC-SUPERSONIC EJECTOR SUBSYSTEM

"SSE" FOR A CONSTANT-AREA, SUPERSONIC-SUPERSONIC EJECTOR SUBSYSTEM

CAE

APPENDIX 0

CLAP SAMPLE INPUT/OUTPUT

INPUT DATA FOR THE PRESSURE RECOVERY SECTION BY NAMELIST.
CURRENT VALUES ARE:

INLPRS		A3A2	=	.300000E+01	A7A6	=	.000000E+01	
ETA12	=	.750000E+00	G5	=	.129000E+01	MW5	=	.202040E+02
PS0	=	.310264E+07	P7	=	.101325E+06	T50	=	.201400E+04

INLPRS A3A2=2.75

NOTE: P3	=	.207320E+05	PA	M5	=	.303364E+01
NOTE: P3	=	.207320E+05	PA	M5	=	.303364E+01
NOTE: P3	=	.207320E+05	PA	M5	=	.303364E+01
NOTE: P3	=	.207320E+05	PA	M5	=	.303364E+01
NOTE: P3	=	.207320E+05	PA	M5	=	.303364E+01
NOTE: P3	=	.207320E+05	PA	M5	=	.303364E+01
NOTE: P3	=	.207320E+05	PA	M5	=	.303364E+01
NOTE: P3	=	.207320E+05	PA	M5	=	.303364E+01
NOTE: P3	=	.207320E+05	PA	M5	=	.303364E+01
NOTE: P3	=	.207320E+05	PA	M5	=	.303364E+01

APPENDIX 6

CLAP SAMPLE INPUT/OUTPUT

ARE NEW SYSTEM CALCULATION INPUTS REQUIRED?

YES

ARE SYSTEM CALCULATIONS DESIRED?

YES

SHOULD INPUT DATA BE READ FROM TAPE?

NO

APPENDIX 6

CLAP SAMPLE INPUT/OUTPUT

INPUT DATA FOR THE SYSTEM CALCULATION SECTION BY NAMELIST.
CURRENT VALUES ARE:

BNLSCS NBANK = 1 REJECT = 1
RTIME = .600000E+02 WPP3 = .189645E+01 0
BNLSCS NBANK=2 0

ARE NEW REACTANT STORAGE MODES REQUIRED?

YES

LASER PRIMARY & SECONDARY REACTANT STORAGE INPUT SECTION

C2H4 MAY BE STORED ANY OF THE FOLLOWING WAYS. INPUT K.

K	1	2
PHASE	GAS	GAS
CONT	SPH	CVL
STEMP	300.0 K	300.0 K
STIME	INFINITE	INFINITE
SPRES	4.1E+07 PA (6000 PSI)	4.1E+07 PA (6000 PSI)
RFSYS	BLD	BLD
MATER	TI	TI

1

APPENDIX 8

CLAP SAMPLE INPUT/OUTPUT

MF3 MAY BE STORED ANY OF THE FOLLOWING WAYS. INPUT K.

K	1	2	3	4
PHASE	GAS	GAS	LIO	LIO
CONT	SPH	CYL	SPH	SPH
STEMP	300.0 K	300.0 K	77.5 K	77.5 K
STIME	INFINITE	INFINITE	8.6E+05 S (10 DAY)	1.6E+07 S (180 DAY)
SPRES	1.2E+07 PA (1800 PSI)	1.2E+07 PA (1800 PSI)	1.25+P0	1.25+P0
RFSYS	BLD	BLD	PGS	PGS
MATER	SS	SS	SS	SS

1

ME MAY BE STORED ANY OF THE FOLLOWING WAYS. INPUT K.

K	1	2	3	4
PHASE	GAS	GAS	GAS	GAS
CONT	SPH	CYL	SPH	SPH
STEMP	300.0 K	300.0 K	77.5 K	77.5 K
STIME	INFINITE	INFINITE	8.6E+05 S (10 DAY)	1.6E+07 S (180 DAY)
SPRES	4.1E+07 PA (6000 PSI)	4.1E+07 PA (6000 PSI)	4.1E+07 PA (6000 PSI)	4.1E+07 PA (6000 PSI)
RFSYS	BLD	BLD	BLD	BLD
MATER	TI	TI	SS	SS

2

APPENDIX B

CLAP SAMPLE INPUT/OUTPUT

D2 MAY BE STORED ANY OF THE FOLLOWING WAYS. INPUT K.

K	1	2	3	4
PHASE	GAS	GAS	GAS	GAS
CONT	SPH	CYL	SPH	SPH
STEMP	300.0 K	300.0 K	77.5 K	77.5 K
STIME	INFINITE	INFINITE	3.6E+05 S (10 DAY)	1.6E+07 S (180 DAY)
SPRES	4.1E+07 PA (6000 PSI)	4.1E+07 PA (6000 PSI)	4.1E+07 PA (6000 PSI)	4.1E+07 PA (6000 PSI)
RFSYS	BLD	BLD	BLD	BLD
MATER	TI	TI	SS	SS

2

AERO-WINDOW FLUID STORAGE INPUT SECTION

APPENDIX 6

CLAP SAMPLE INPUT/OUTPUT

N2-AW MAY BE STORED ANY OF THE FOLLOWING WAYS. INPUT K.

K	1	2	3	4
PHASE	GAS	GAS	LIO	LIO
CONT	SPH	CYL	SPH	SPH
TEMP	300.0 K	300.0 K	77.5 K	77.5 K
STIME	INFINITE	INFINITE	0.0E+00 S (10 DAY)	1.0E+07 S (100 DAY)
SPRES	4.1E+07 PA (6000 PSI)	4.1E+07 PA (6000 PSI)	1.8E+06 PA (220 PSI)	1.8E+06 PA (220 PSI)
RFSYS	BLD	BLD	HPS	HPS
MATER	TI	TI	SS	SS

COOLING SYSTEM FLUID STORAGE INPUT SECTION

APPENDIX 6

CLAP SAMPLE INPUT/OUTPUT

H2O-C5 MAY BE STORED ANY OF THE FOLLOWING WAYS. INPUT K.

K	1	2	3	4
PHASE	LIG	LIG	LIG	LIG
CONT	SPH	CYL	SPH	CYL
STEMP	300.0 K	300.0 K	300.0 K	300.0 K
STIME	INFINITE	INFINITE	INFINITE	INFINITE
SPRES	2.0E+06 PA (400 PSI)	2.0E+06 PA (400 PSI)	1 ATM	1 ATM
RFSYS	POS	POS	PFS	PFS
WATER	TI	TI	AL	AL

K	5
PHASE	LIG
CONT	SPH
STEMP	300-300 K
STIME	INFINITE
SPRES	1 ATM
RFSYS	RFP
WATER	AL

5

APPENDIX 6

CLAP SAMPLE INPUT/OUTPUT

INPUT THE EJECTOR PRIMARY REACTANT FROM THE FOLLOWING LIST:

"N2H4" FOR A MONOPROPELLANT DRIVER
 "IRFNA/MMH" FOR A BIROPELLANT DRIVER

IRFNA/MMH

MMH MAY BE STORED ANY OF THE FOLLOWING WAYS. INPUT K.

K	1	2	3	4
PHASE	LIG	LIG	LIG	LIG
CONT	SPH	CYL	SPH	CYL
STEMP	300.0 K	300.0 K	300.0 K	300.0 K
STIME	INFINITE	INFINITE	INFINITE	INFINITE
SPRES	1.25*P0	1.25*P0	1 ATM	1 ATM
RFSYS	PGS	PGS	PFS	PFS
MATER	TI	TI	AL	AL

2

APPENDIX 6

CLAP SAMPLE INPUT/OUTPUT

IRFNA MAY BE STORED ANY OF THE FOLLOWING WAYS. INPUT K.

K	1	2	3	4
PHASE	LIO	LIO	LIO	LIA
CONT	SPH	CYL	SPH	CYL
STEMP	300.0 K	300.0 K	300.0 K	300.0 K
STIME	INFINITE	INFINITE	INFINITE	INFINITE
SPRES	1.25*P0	1.25*P0	1 ATM	1 ATM
RFSYS	POS	POS	RFS	RFS
MATER	AL	AL	AL	AL

1

TO RESTART PROGRAM ENTER "YES"

TO STOP PROGRAM ENTER "NO"

NO

APPENDIX G

CLAP SAMPLE INPUT/OUTPUT

SAMPLE CASE 2: OUTPUT (SI UNITS)

CHEMICAL LASER ANALYSIS PROGRAM (CLAP)

WRITTEN BY: C.L. ADAMS
 A.L. ADDY
 R.D. MASSEY
 C.D. MIKKELSEN
 G.P. MORR
 R.L. OBLUKIAN
 B.J. WALKER

1 JANUARY 77

AERODYNAMICS GROUP (DROMS-TOK)
 SYSTEM SIMULATION DIRECTORATE
 U.S. ARMY MISSILE RESEARCH & DEVELOPMENT COMMAND
 REDSTONE ARSENAL, ALABAMA 35809

RUN DATE 12/06/78

COMBUSTION CHEMISTRY SECTION

INITIAL DATA:

AEXP	=	.361935E-02	N2	ALPHA	=	.802700E+00
OFORMF	=	DF		N1	=	2 ATOMS C
N2	=		4 ATOMS H	N3	=	1 ATOMS N
N4	=		3 ATOMS F	WPO	=	.116197E-02
WPR1	=	.362160E-02	KG/S C2H4	WPR2	=	.172416E-01
WPR3	=	0.	KG/S N2	WPR4	=	.571093E-01
WSR1	=	.437250E-02	KG/S D2	WSR2	=	.338518E-01
WSR3	=	0.	KG/S N2			

RESULTANT DATA:

FDA	=	.191592E+00	KI XLE/S-M2	OMEGA	=	.347901E+02
OMEGTRW	=	.322770E+02		PSIC	=	.126969E+02
PSIL	=	.220931E+02		PSILTRW	=	.195801E+02
Q	=	.218942E+08	J/KMOLE	RC	=	.207688E+01
RL	=	.251301E+01		RLP	=	.220931E+02
WFCP1	=	.193609E+00	CF4	XFCP1	=	.159827E-01
WFCP2	=	.880274E-01	HF	XFCP2	=	.319653E-01
WFCP3	=	.154674E+00	DF	XFCP3	=	.534772E-01
WFCP4	=	.435361E+00	HE	XFCP4	=	.790200E+00
WFCP5	=	.105898E+00	N2	XFCP5	=	.274632E-01
WFCP6	=	.224317E-01	O	XFCP6	=	.809116E-01

LASER DEVICE SECTION

INITIAL DATA:

RRFRAC	=	.100000E+01	CANGLE	=	.174533E+00 RAD
D1	=	.177800E-02 M	D1S	=	.669534E-04 M
D3	=	.137160E-02 M	D3S	=	.685800E-04 M
GEOMPN	=	20	GEOMSN	=	20
WBASE	=	.349250E-01 M	MNB	=	.349250E-01 M
LCAV	=	.762000E-01 M	LPNOZ	=	.250190E-02 M
LSNOZ	=	.185166E-02 M	NSPNOZ	=	.103846E+01
PKFRAC	=	.803431E+00	P10	=	.200000E+07 PA
T30	=	.600000E+03 K	T70	=	.300000E+03 K

RESULTANT DATA:

POINT 1 PRIMARY NOZZLE EXIT - CONDITIONS BASED ON THE NOZZLE STAGNATION (COMBUSTOR) TEMPERATURE

A1	=	.171526E+00 S-M2/KMOLE	A1A1SE	=	.176697E+02
A1A1S6	=	.265558E+02	G1	=	.145759E+01
MW1	=	.124497E+02 KG/KMOLE	M1	=	.486785E+01
NPNOZ	=	.415138E+04 S/KMOLE	P1	=	.523849E+04 PA
P10	=	.200000E+07 PA	RE1	=	.213634E+04
R1	=	.288884E-01 KG/M3	R10	=	.170617E+01 KG/M3
T1	=	.271528E+03 K	T10	=	.175525E+04 K

POINT 2 PRIMARY NOZZLE EXIT - CONDITIONS BASED ON THE NOZZLE EXIT TEMPERATURE

A2	=	.156421E+00 S-M2/KMOLE	G2	=	.153454E+01
MW2	=	.124497E+02 KG/KMOLE	M2	=	.486785E+01
P2	=	.523849E+04 PA	P20	=	.200000E+07 PA
R2	=	.288884E-01 KG/M3	R20	=	.170617E+01 KG/M3
T2	=	.271528E+03 K	T20	=	.175525E+04 K

POINT 3 SECONDARY NOZZLE EXIT - CONDITIONS BASED ON THE NOZZLE STAGNATION (COMBUSTOR) TEMPERATURE

A3	=	.135591E+00 S-M2/KMOLE	A3A3SE	=	.131315E+02
A3A3S6	=	.200000E+02	G3	=	.161679E+01
MW3	=	.400551E+01 KG/KMOLE	M3	=	.530231E+01
NSNOZ	=	.431104E+04 S/KMOLE	P3	=	.239593E+04 PA
P30	=	.917516E+06 PA	RE3	=	.187829E+04
R3	=	.186036E-01 KG/M3	R30	=	.736704E+00 KG/M3
T3	=	.620454E+02 K	T30	=	.600000E+03 K
W3W1	=	.490228E+00	X3X1	=	.152370E+01

POINT 4 SECONDARY NOZZLE EXIT - CONDITIONS BASED ON THE NOZZLE EXIT TEMPERATURE

A4	=	.136095E+00 S-M2/KMOLE	G4	=	.161322E+01
MW4	=	.400551E+01 KG/KMOLE	M4	=	.530231E+01
P4	=	.239593E+04 PA	P40	=	.917516E+06 PA
R4	=	.186036E-01 KG/M3	R40	=	.736704E+00 KG/M3
T4	=	.620454E+02 K	T40	=	.600000E+03 K
W4W2	=	.490228E+00	X4X2	=	.152370E+01

APPENDIX A

CLAP SAMPLE INPUT/OUTPUT

POINT 5 CONSTANT-AREA MIXING REGION EXIT

A5	=	.292516E+00 S-M2/KMOLE	G5	=	.157943E+01
MW5	=	.735148E+01 KG/KMOLE	M5	=	.486401E+01
P5	=	.409570E+04 PA	P50	=	.112701E+07 PA
R5	=	.262852E-01 KG/M3	R50	=	.921547E+00 KG/M3
T5	=	.137773E+03 K	T50	=	.108210E+04 K
W5W2	=	.149023E+01	X5X2	=	.252370E+01

POINT 6 ISENTROPIC EXPANSION REGION EXIT

A6	=	.577895E+00 S-M2/KMOLE	G6	=	.157943E+01
MW6	=	.735148E+01 KG/KMOLE	M6	=	.610993E+01
P6	=	.134559E+04 PA	P60	=	.112701E+07 PA
R6	=	.129910E-01 KG/M3	R60	=	.921547E+00 KG/M3
T6	=	.915840E+02 K	T60	=	.108210E+04 K
W6W2	=	.149023E+01	X6X2	=	.252370E+01

POINT 7 MIRROR PURGE CONDITIONS

G7	=	.139962E+01	MW7	=	.280134E+02 KG/KMOLE
T70	=	.300000E+03 K	W7W2	=	.149023E+01
X7X2	=	0.			

POINT 8 LASER CAVITY EXIT

A8	=	.102254E+01 S-M2/KMOLE	G8	=	.157692E+01
MW8	=	.726491E+01 KG/KMOLE	M8	=	.226388E+01
P8	=	.517077E+04 PA	P80	=	.636011E+05 PA
R80	=	.375835E+05	R8	=	.788141E-02 KG/M3
R80	=	.387849E-01 KG/M3	T8	=	.573263E+03 K
T80	=	.143582E+04 K	W8W2	=	.150513E+01
X8X2	=	.257931E+01			

APPENDIX 1

CLAP SAMPLE INPUT/OUTPUT

PRESSURE RECOVERY SECTION

INITIAL DATA:

A3A2	=	.275000E+01	A7A6	=	.300000E+01
EJECT	=	CNE	ETA12	=	.750000E+00
G5	=	.129000E+01	MW5	=	.202040E+02 KG/KMOLE
P50	=	.310264E+07 PA	P7	=	.101325E+06 PA
T50	=	.281400E+04 K			

RESULTANT DATA:

POINT 1 LASER CAVITY EXIT AND NORMAL SHOCK DIFFUSER ENTRANCE

A1	=	.102254E+01 S-M2/KMOLE	G1	=	.157692E+01
MW1	=	.726491E+01 KG/KMOLE	M1	=	.228308E+01
P1	=	.517077E+04 PA	P10	=	.636011E+05 PA
R1	=	.788141E-02 KG/M3	R10	=	.387049E-01 KG/M3
T1	=	.573263E+03 K	T10	=	.143582E+04 K

POINT 2 NORMAL SHOCK DIFFUSER EXIT AND SUBSONIC DIFFUSER ENTRANCE

A2	=	.102254E+01 S-M2/KMOLE	ETA12	=	.750000E+00
G2	=	.157692E+01	MW2	=	.726491E+01 KG/KMOLE
M2	=	.561754E+00	P2	=	.238891E+05 PA
P20	=	.303123E+05 PA	R2	=	.158612E-01 KG/M3
R20	=	.184468E-01 KG/M3	T2	=	.131603E+04 K
T20	=	.143582E+04 K	MW1	=	.100000E+01
X2X1	=	.100000E+01			

POINT 3 SUBSONIC DIFFUSER EXIT AND SUDDEN ENLARGEMENT ENTRANCE

A3	=	.281199E+01 S-M2/KMOLE	ETA23	=	.969997E+00
G3	=	.157692E+01	MW3	=	.726491E+01 KG/KMOLE
M3	=	.171354E+00	P3	=	.287328E+05 PA
P30	=	.294029E+05 PA	R3	=	.176336E-01 KG/M3
R30	=	.178933E-01 KG/M3	T3	=	.142376E+04 K
T30	=	.143582E+04 K	MW1	=	.100000E+01
X3X1	=	.100000E+01			

POINT 4 CONSTANT-AREA, SUBSONIC-SUPERSONIC EJECTOR SECONDARY NOZZLE EXIT

A4	=	.119781E+01 S-M2/KMOLE	G4	=	.157692E+01
MW4	=	.726491E+01 KG/KMOLE	M4	=	.775000E+00
P4	=	.190064E+05 PA	P40	=	.294029E+05 PA
R4	=	.135704E-01 KG/M3	R40	=	.178933E-01 KG/M3
T4	=	.122379E+04 K	T40	=	.143582E+04 K
MW1	=	.100000E+01	X4X1	=	.100000E+01

POINT 5 CONSTANT-AREA, SUBSONIC-SUPERSONIC EJECTOR PRIMARY NOZZLE EXIT

A5	=	.368370E+00 S-M2/KMOLE	G5	=	.129000E+01
MW5	=	.202040E+02 KG/KMOLE	M5	=	.383364E+01
P5	=	.193543E+05 PA	P50	=	.310264E+07 PA
R5	=	.523150E-01 KG/M3	R50	=	.267851E+01 KG/M3
T5	=	.899001E+03 K	T50	=	.281400E+04 K
MW1	=	.272616E+01	X5X1	=	.980266E+00

APPENDIX A

CLAP SAMPLE INPUT/OUTPUT

POINT 6 CONSTANT-AREA, SUBSONIC-SUPERSONIC EJECTOR EXIT AND SUBSONIC
DIFFUSER ENTRANCE

A6	=	.156618E+01	S-M2/KMOLE	06	=	.138726E+01
MM6	=	.136700E+02	KG/KMOLE	M6	=	.485225E+00
P6	=	.898218E+05	PA	P60	=	.105375E+06 PA
R6	=	.676222E-01	KG/M3	R60	=	.758725E-01 KG/M3
T6	=	.218390E+04	K	T60	=	.228346E+04 K
W6W1	=	.372616E+01		X6X1	=	.198027E+01

POINT 7 SUBSONIC DIFFUSER EXIT

A7	=	.469854E+01	S-M2/KMOLE	ETA67	=	.975543E+00
07	=	.138726E+01		MM7	=	.136700E+02 KG/KMOLE
M7	=	.142498E+00		P7	=	.101325E+06 PA
P70	=	.102800E+06	PA	R7	=	.732439E-01 KG/M3
R70	=	.748184E-01	KG/M3	T7	=	.227450E+04 K
T70	=	.228346E+04	K	WTW1	=	.372616E+01
X7X1	=	.198027E+01				

APPENDIX A

CLAP SAMPLE INPUT/OUTPUT

SYSTEM CALCULATION SECTION

INITIAL DATA:

```

FReact = IRFNA/MMH          NBANK = 2
NEJECT = 1                  RTIME = .600000E+02 s
WPP3 = .109645E+01 kg/s

```

REACTANT STORAGE METHOD

REACT	C2H4	HE	WF3	D2
PHASE	GAS	GAS	GAS	GAS
CONT	SPH	CYL	SPH	CYL
STEMP	300.0 K	300.0 K	300.0 K	300.0 K
STIME	INFINITE	INFINITE	INFINITE	INFINITE
SPRES	4.1E+07 PA (6000 PSI)	4.1E+07 PA (6000 PSI)	1.2E+07 PA (1800 PSI)	4.1E+07 PA (6000 PSI)
RFSYS	BLD	BLD	BLD	BLD
WATER	TI	TI	SS	TI
REACT	N2-AW	H2O-CS	MMH	IRFNA
PHASE	GAS	LIG	LIG	LIG
CONT	SPH	SPH	CYL	SPH
STEMP	300.0 K	300-300 K	300.0 K	300.0 K
STIME	INFINITE	INFINITE	INFINITE	INFINITE
SPRES	4.1E+07 PA (6000 PSI)	1 ATM	1.25*P0	1.25*P0
RFSYS	BLD	RFP	PSS	PSS
WATER	TI	AL	TI	AL

RESULTANT DATA:

SYSTEM SCALE-UP FACTOR

KLP = .901567E+00 KMOL/S

LASER DEVICE SYSTEM VOLUME/MASS

WINJ	= .503707E+02 KG	VCOMB	= .592742E-01 M3
WCB	= .055397E+02 KG	VCAV	= .549746E-01 M3
WBASE	= .705727E+02 KG	VAV	= .216517E-01 M3
WCAV	= .232102E+02 KG	VCS	= .355570E+00 M3
WAV	= .288893E+02 KG	VOPT	= .190601E+01 M3
WCS	= .340163E+03 KG		
WOPT	= .724745E+03 KG		
WDS	= .962447E+02 KG		
WLRRES	= .669069E+02 KG		
WLLINE	= .258933E+02 KG		
WLDHOM	= .152054E+04 KG	VLDHOM	= .247748E+01 M3
WLRT	= .115267E+05 KG	VLRT	= .134211E+02 M3
WLDS	= .130472E+05 KG	VLDS	= .158986E+02 M3

APPENDIX A

CLAP SAMPLE INPUT/OUTPUT

PRESSURE RECOVERY SYSTEM VOLUME/MASS

MSUPD	=	.250459E+03	KG	VSUPD	=	.512733E+00	M3
MSUBD	=	.941716E+02	KG	VSUBD	=	.233867E+00	M3
MEJECT	=	.104693E+05	KG	VEJECT	=	.695109E+02	M3
MEEREG	=	.115147E+03	KG				
MELINE	=	.759847E+01	KG				
MPRHOW	=	<u>.109367E+05</u>	KG	VPHOW	=	<u>.702571E+02</u>	M3
MERT	=	.397195E+04	KG	VERT	=	.377629E+01	M3
MPRS	=	<u>.149086E+05</u>	KG	VPRS	=	<u>.740334E+02</u>	M3

SYSTEM VOLUME/MASS SUMMARY

MLDS	=	.130472E+05	KG	VLDS	=	.158986E+02	M3
MPRS	=	.149086E+05	KG	VPRS	=	.740334E+02	M3
MMISC	=	.362874E+03	KG				
MTOTAL	=	<u>.283167E+05</u>	KG	VTOTAL	=	<u>.899320E+02</u>	M3
				VSYSTEM	=	.179864E+03	M3
WBASE	=	.745900E+01	M	LLDS	=	.189968E+00	M
LPRS	=	.238036E+02	M				
LBXDEV	=	.239936E+02	M	WBXDEV	=	.820490E+01	M
WBXDEV	=	.601315E+01	M	VBXDEV	=	.118378E+04	M3

CHEMICAL LASER ANALYSIS PROGRAM (CLAP)

WRITTEN BY: C.L. ADAMS
A.L. ADDY
R.D. MASSEY
C.D. MIKKELSEN
G.F. MORR
R.L. OBLUNIAN
R.J. WALKER

1 JANUARY 77

AERODYNAMICS GROUP (DROMI-TDK)
SYSTEM SIMULATION DIRECTORATE
U.S. ARMY MISSILE RESEARCH & DEVELOPMENT COMMAND
REDSTONE ARSENAL, ALABAMA 35809

RUN DATE 12/06/78

COMBUSTION CHEMISTRY SECTION

INITIAL DATA:

AEXP	=	.361935E-02	N2	ALPHA	=	.802700E+00
WFORM	=	DP		N1	=	2 ATOMS C
N2	=		4 ATOMS H	N3	=	1 ATOMS N
N4	=		3 ATOMS F	WPG	=	0.
						KG/S N2

APPENDIX 6

CLAP SAMPLE INPUT/OUTPUT

SAMPLE CASE 2: OUTPUT (ENGINEERING UNITS)

CHEMICAL LASER ANALYSIS PROGRAM (CLAP)

WRITTEN BY: C.L. ADAMS
 A.L. ADDY
 R.D. MASSEY
 C.D. MIKKELSEN
 G.F. MORR
 R.L. OGLUKIAN
 B.J. WALKER

1 JANUARY 77

AERODYNAMICS GROUP (DROMI-TDK)
 SYSTEM SIMULATION DIRECTORATE
 U.S. ARMY MISSILE RESEARCH & DEVELOPMENT COMMAND
 REDSTONE ARSENAL, ALABAMA 35809

RUN DATE 12/06/78

COMBUSTION CHEMISTRY SECTION

INITIAL DATA:

AFXP	=	.561000E+01	IN2	ALPHA	=	.802700E+00
DFORMF	=	DF		N1	=	2 ATOMS C
N2	=	4	ATOMS H	N3	=	1 ATOMS N
N4	=	3	ATOMS F	WPG	=	.116197E+01 GM/S N2
WPR1	=	.362160E+01	GM/S C2H4	WPR2	=	.172416E+02 GM/S HF
WPR3	=	0.	GM/S N2	WPR4	=	.571093E+02 GM/S N1F3
WSR1	=	.437250E+01	GM/S O2	WSR2	=	.330518E+02 GM/S HE
WSR3	=	0.	GM/S N2			

RESULTANT DATA:

PDAA	=	.123607E+00	GMOLE/S-IN2	OMEGA	=	.347901E+02
OMEGTRW	=	.322770E+02		PSIC	=	.126969E+02
PSIL	=	.220931E+02		PSILTRW	=	.195801E+02
Q	=	.522329E+04	CAL/GMOLE	RC	=	.207688E+01
RL	=	.251301E+01		RLF	=	.220931E+02
WFCP1	=	.193689E+00	CF4	XPCP1	=	.150827E-01
WFCP2	=	.880274E-01	HF	XPCP2	=	.319653E-01
WFCP3	=	.154674E+00	DF	XPCP3	=	.534772E-01
WFCP4	=	.435361E+00	HE	XPCP4	=	.790200E+00
WFCP5	=	.105898E+00	N2	XPCP5	=	.274632E-01
WFCP6	=	.224317E-01	D	XPCP6	=	.809116E-01

LASER DEVICE SECTION

INITIAL DATA:

BRFRAC	=	.100000E+01	CANBLE	=	.100000E+02 DEG
D1	=	.700000E-01 IN	D1S	=	.263596E-02 IN
D3	=	.540000E-01 IN	D3S	=	.270000E-02 IN
GEOMPN	=	20	GEOMSN	=	20
HRASE	=	.137500E+01 IN	MNB	=	.137500E+01 IN
LCAV	=	.300000E+01 IN	LPNOZ	=	.985000E-01 IN
LSNOZ	=	.729039E-01 IN	NSPNOZ	=	.100446E+01
PKFRAC	=	.803431E+00	P10	=	.290075E+03 PSIA
T30	=	.600000E+03 K	T70	=	.300000E+03 K

RESULTANT DATA:

POINT 1 PRIMARY NOZZLE EXIT - CONDITIONS BASED ON THE NOZZLE STAGNATION (COMBUSTOR) TEMPERATURE

A1	=	.120594E+03 S-IN2/LBMOLE	A1A1SE	=	.176697E+02
A1A1S6	=	.265568E+02	01	=	.145759E+01
MW1	=	.124497E+02 LBW/LBMOLE	M1	=	.488705E+01
NPNOZ	=	.188302E+04 S/LBMOLE	P1	=	.392919E+02 TORR
P10	=	.290075E+03 PSIA	RE1	=	.213634E+04
R1	=	.288884E-04 GM/CM3	R10	=	.170617E-02 GM/CM3
T1	=	.271528E+03 K	T10	=	.175525E+04 K

POINT 2 PRIMARY NOZZLE EXIT - CONDITIONS BASED ON THE NOZZLE EXIT TEMPERATURE

A2	=	.109974E+03 S-IN2/LBMOLE	02	=	.53454E+01
MW2	=	.124497E+02 LBW/LBMOLE	M2	=	.488705E+01
P2	=	.392919E+02 TORR	P20	=	.290075E+03 PSIA
R2	=	.288884E-04 GM/CM3	R2	=	.170617E-02 GM/CM3
T2	=	.271528E+03 K	T20	=	.175525E+04 K

POINT 3 SECONDARY NOZZLE EXIT - CONDITIONS BASED ON THE NOZZLE STAGNATION (COMBUSTOR) TEMPERATURE

A3	=	.953294E+02 S-IN2/LBMOLE	A3A3SE	=	.131315E+02
A3A3S6	=	.200000E+02	03	=	.161679E+01
MW3	=	.400551E+01 LBW/LBMOLE	M3	=	.530231E+01
NSNOZ3	=	.195544E+04 S/LBMOLE	P3	=	.179710E+02 TORR
P30	=	.133074E+03 PSIA	RE3	=	.187829E+04
R3	=	.186036E-04 GM/CM3	R30	=	.736704E-03 GM/CM3
T3	=	.620454E+02 K	T30	=	.600000E+03 K
W3W1	=	.490228E+00	X3X1	=	.152370E+01

POINT 4 SECONDARY NOZZLE EXIT - CONDITIONS BASED ON THE NOZZLE EXIT TEMPERATURE

A4	=	.956835E+02 S-IN2/LBMOLE	04	=	.161322E+01
MW4	=	.400551E+01 LBW/LBMOLE	M4	=	.530231E+01
P4	=	.179710E+02 TORR	P40	=	.133074E+03 PSIA
R4	=	.186036E-04 GM/CM3	R40	=	.736704E-03 GM/CM3
T4	=	.620454E+02 K	T40	=	.600000E+03 K
W4W2	=	.490228E+00	X4X2	=	.152370E+01

APPENDIX 6

CLAP SAMPLE INPUT/OUTPUT

POINT 5 CONSTANT-AREA MIXING REGION EXIT

A5	=	.20565E+03	S-IN2/LBMOLE	M5	=	.157943E+01
MW5	=	.73514E+01	LBH/LBMOLE	M5	=	.486401E+01
P5	=	.307203E+02	TORR	P50	=	.845923E+04
R5	=	.262852E-04	GM/CM3	R50	=	.921547E-03
T5	=	.137773E+03	K	T50	=	.108210E+04
MW2	=	.149023E+01		X5X2	=	.252370E+01

POINT 6 ISENTROPIC EXPANSION REGION EXIT

A6	=	.406298E+03	S-IN2/LBMOLE	M6	=	.157943E+01
MW6	=	.73514E+01	LBH/LBMOLE	M6	=	.610993E+01
P6	=	.100928E+02	TORR	P60	=	.845928E+04
R6	=	.129910E-04	GM/CM3	R60	=	.921547E-03
T6	=	.915840E+02	K	T60	=	.108210E+04
MW2	=	.149023E+01		X6X2	=	.252370E+01

POINT 7 MIRROR PURGE CONDITIONS

G7	=	.139962E+01		MW7	=	.280134E+02
T70	=	.300000E+03	K	MW2	=	.149023E+01
X7X2	=	0.				

POINT 8 LASER CAVITY EXIT

A8	=	.710915E+03	S-IN2/LBMOLE	M8	=	.157692E+01
MW8	=	.724491E+01	LBH/LBMOLE	M8	=	.228308E+01
P8	=	.387840E+02	TORR	P80	=	.477047E+03
R8	=	.375835E-05		R8	=	.788141E-05
RA8	=	.387840E-04	GM/CM3	T8	=	.573263E+03
TA8	=	.143582E+04	K	MW2	=	.150513E+01
X8X2	=	.257931E+01				

APPENDIX 6

CLAP SAMPLE INPUT/OUTPUT

PRESSURE RECOVERY SECTION

INITIAL DATA:

A7A2	=	.275000E+01	A7A6	=	.300000E+01
EJECT	=	CAE	ETA12	=	.750000E+00
Q5	=	.129000E+01	MW5	=	.202040E+02 LBM/LBMOLE
P50	=	.450000E+03 PSIA	P7	=	.760000E+03 TORR
T50	=	.281480E+04 K			

RESULTANT DATA:

POINT 1 LASER CAVITY EXIT AND NORMAL SHOCK DIFFUSER ENTRANCE

A1	=	.718915E+03 S-IN2/LBMOLE	G1	=	.157692E+01
MW1	=	.726491E+01 LBM/LBMOLE	M1	=	.228388E+01
P1	=	.387840E+02 TORR	P10	=	.477047E+03 TORR
R1	=	.788141E-05 GM/CM3	R10	=	.387049E-04 GM/CM3
T1	=	.573263E+03 K	T10	=	.143582E+04 K

POINT 2 NORMAL SHOCK DIFFUSER EXIT AND SUBSONIC DIFFUSER ENTRANCE

A2	=	.718915E+03 S-IN2/LBMOLE	ETA12	=	.750000E+00
G2	=	.157692E+01	MW2	=	.726491E+01 LBM/LBMOLE
M2	=	.561754E+00	P2	=	.179183E+03 TORR
P20	=	.227361E+03 TORR	R2	=	.158612E-04 GM/CM3
R20	=	.184468E-04 GM/CM3	T2	=	.131603E+04 K
T20	=	.143582E+04 K	W2W1	=	.100000E+01
X2X1	=	.100000E+01			

POINT 3 SUBSONIC DIFFUSER EXIT AND SUDDEN ENLARGEMENT ENTRANCE

A3	=	.197702E+04 S-IN2/LBMOLE	ETA23	=	.969997E+00
G3	=	.157692E+01	MW3	=	.726491E+01 LBM/LBMOLE
M3	=	.171354E+00	P3	=	.215514E+03 TORR
P30	=	.220540E+03 TORR	R3	=	.176336E-04 GM/CM3
R30	=	.178933E-04 GM/CM3	T3	=	.142376E+04 K
T30	=	.143582E+04 K	W3W1	=	.100000E+01
X3X1	=	.100000E+01			

POINT 4 CONSTANT-AREA, SUBSONIC-SUPERSONIC EJECTOR SECONDARY NOZZLE EXIT

A4	=	.842138E+03 S-IN2/LBMOLE	G4	=	.157692E+01
MW4	=	.726491E+01 LBM/LBMOLE	M4	=	.775000E+00
P4	=	.142559E+03 TORR	P40	=	.220540E+03 TORR
R4	=	.135704E-04 GM/CM3	R40	=	.178933E-04 GM/CM3
T4	=	.122379E+04 K	T40	=	.143582E+04 K
W4W1	=	.100000E+01	X4X1	=	.100000E+01

POINT 5 CONSTANT-AREA, SUBSONIC-SUPERSONIC EJECTOR PRIMARY NOZZLE EXIT

A5	=	.258989E+03 S-IN2/LBMOLE	G5	=	.129000E+01
MW5	=	.202040E+02 LBM/LBMOLE	M5	=	.583364E+01
P5	=	.145169E+03 TORR	P50	=	.450000E+03 PSIA
R5	=	.523150E-04 GM/CM3	R50	=	.267851E-02 GM/CM3
T5	=	.899001E+03 K	T50	=	.281480E+04 K
W5W1	=	.272516E+01	X5X1	=	.980266E+00

APPENDIX G

CLAP SAMPLE INPUT/OUTPUT

POINT 6 CONSTANT-AREA, SUBSONIC-SUPERSONIC EJECTOR EXIT AND SUBSONIC
DIFFUSER ENTRANCE

A6	=	.110113E+04	S-IN2/LBMOLE	G6	=	.136726E+01
W6	=	.136700E+02	LBW/LBMOLE	M6	=	.485229E+00
P6	=	.673719E+03	TORR	P60	=	.790379E+03 TORR
R6	=	.676222E-04	GM/CM3	R60	=	.758725E-04 GM/CM3
T6	=	.218350E+04	K	T60	=	.228346E+04 K
W6W1	=	.372616E+01		X6X1	=	.198027E+01

POINT 7 SUBSONIC DIFFUSER EXIT

A7	=	.330338E+04	S-IN2/LBMOLE	ETA67	=	.975563E+00
G7	=	.136726E+01		W7	=	.136700E+02 LBW/LBMOLE
M7	=	.142690E+00		P7	=	.760000E+03 TORR
P70	=	.711065E+03	TORR	R7	=	.732439E-04 GM/CM3
R70	=	.740184E-04	GM/CM3	T7	=	.227450E+04 K
T70	=	.228346E+04	K	W7W1	=	.372616E+01
X7X1	=	.198027E+01				

APPENDIX G

CLAP SAMPLE INPUT/OUTPUT

SYSTEM CALCULATION SECTION

INITIAL DATA:

EREACT = IRFNA/MMH
 NJECT = 1
 WPP3 = .189645E+04 GM/S
 NBANK = 2
 RTIME = .600000E+02 S

REACTANT STORAGE METHOD

REACT	C2H4	HE	NF3	O2
PHASE	GAS	GAS	GAS	GAS
CONT	SPH	CYL	SPH	CYL
STEMP	300.0 K	300.0 K	300.0 K	300.0 K
STIME	INFINITE	INFINITE	INFINITE	INFINITE
SPRES	4.1E+07 PA (6000 PSI)	4.1E+07 PA (6000 PSI)	1.2E+07 PA (1800 PSI)	4.1E+07 PA (6000 PSI)
RFSYS	BLD	BLD	BLD	BLD
MATER	TI	TI	SS	TI
REACT	N2-AW	H2O-CS	MMH	IRFNA
PHASE	GAS	LIQ	LIQ	LIQ
CONT	SPH	SPH	CYL	SPH
STEMP	300.0 K	368-388 K	300.0 K	300.0 K
STIME	INFINITE	INFINITE	INFINITE	INFINITE
SPRES	4.1E+07 PA (6000 PSI)	1 ATM	1.25*P0	1.25*P0
RFSYS	BLD	RFP	PGS	PGS
MATER	TI	AL	TI	AL

RESULTANT DATA:

SYSTEM SCALE-UP FACTOR

ALP = .901567E+03 G/MOLE/S

LASER DEVICE SYSTEM VOLUME/MASS

MINJ	= .111066E+03 LBM	VCOMB	= .209325E+01 FT3
MCD	= .188583E+03 LBM	VCAV	= .194141E+01 FT3
MMASE	= .173223E+03 LBM	VAV	= .764622E+00 FT3
MCAV	= .511697E+02 LBM	VCS	= .125568E+02 FT3
MAV	= .636901E+02 LBM	VOPY	= .701353E+02 FT3
MCS	= .749931E+03 LBM		
MOPY	= .159779E+04 LBM		
MOS	= .212183E+03 LBM		
MURGE6	= .147564E+03 LBM		
MLINE	= .570849E+02 LBM		
MLOWM	= .335223E+04 LBM	VLOWM	= .874914E+02 FT3
MLRT	= .254120E+05 LBM	VLRT	= .473961E+03 FT3
MLOS	= .287642E+05 LBM	VLOS	= .561452E+03 FT3

APPENDIX 6

CLAP SAMPLE INPUT/OUTPUT

PRESSURE RECOVERY SYSTEM VOLUME/MASS

MSUPD	=	.552167E+03 LBM	VSUPD	=	.181070E+02 FT3
MSUBD	=	.207613E+03 LBM	VSUBD	=	.825893E+01 FT3
MEJECT	=	.230809E+05 LBM	VEJECT	=	.245474E+04 FT3
MEEREG	=	.253855E+03 LBM			
MELINE	=	.167518E+02 LBM			
MPRMDW	=	.241112E+05 LBM	VPRMDW	=	.248111E+04 FT3
MERT	=	.875665E+04 LBM	VERT	=	.133359E+03 FT3
MPRS	=	.328679E+05 LBM	VPRS	=	.261447E+04 FT3

SYSTEM VOLUME/MASS SUMMARY

MLDS	=	.287642E+05 LBM	VLDS	=	.561452E+03 FT3
MPRS	=	.328679E+05 LBM	VPRS	=	.261447E+04 FT3
MMISC	=	.800000E+03 LBM			
MTOTAL	=	.624321E+05 LBM	VTOTAL	=	.317592E+04 FT3
			VSYSTEM	=	.635184E+04 FT3
WBASE	=	.293662E+03 IN	LLDS	=	.747904E+01 IN
LPRS	=	.937150E+03 IN			
LHXDEV	=	.944629E+03 IN	WBXDEV	=	.323028E+03 IN
HXDEV	=	.236738E+03 IN	VBXDEV	=	.418048E+05 FT3

DISTRIBUTION

	No. of Copies
Defense Documentation Center Cameron Station Alexandria, Virginia 22314	12
Air Force Weapons Laboratory Attn: AFWL-ALD	2
-DYT	2
Kirtland Air Force Base, New Mexico	
Commander Wright-Patterson AFB Attn: ARL/LF, Dr. J. Drewry Wright-Patterson AFB, 45433	1
Commander US Army DARCOM Attn: AMCRD-PT	1
-TP	1
Washington, D.C. 20315	
Commander US Army Research Office-Durham Box CM, Duke Station Durham, North Carolina 27706	1
Chief of Research and Development Department of the Army Army Research Office Attn: Mr. Stoessel Washington, D.C. 20310	1
US Army Materiel Systems Analysis Activity Attn: DRXSY-MP Aberdeen Proving Ground, MD 21005	1
DRCPM-HEL	10
DRSHI-LP, Mr. Voigt	1
-T, Dr. Kobler	1
-TDK	10
-TBD	3
-TI (Record Copy)	1
(Reference Set)	1