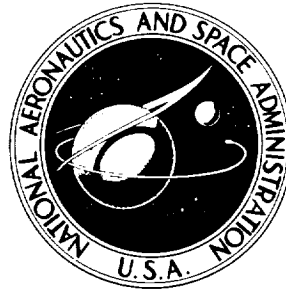


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PERFORMANCE OF TURBOJET AND TURBOFAN ENGINES  
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## DYNGEN - A PROGRAM FOR CALCULATING STEADY-STATE AND TRANSIENT PERFORMANCE OF TURBOJET AND TURBOFAN ENGINES

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16. Abstract DYNGEN, a digital computer program for analyzing the steady-state and transient performance of turbojet and turbofan engines, is described. DYNGEN is based on earlier computer codes (SMOTE, GENENG, and GENENG II) which are capable of calculating the steady-state performance of turbojet and turbofan engines at design and off-design operating conditions. DYNGEN has the combined capabilities of GENENG and GENENG II for calculating steady-state performance; to these have been added the further capability for calculating transient performance. DYNGEN can be used to analyze one- and two-spool turbojet engines or two- and three-spool turbofan engines without modification to the basic program. DYNGEN uses a modified Euler method to solve the differential equations which model the dynamics of the engine. This new method frees the programmer from having to minimize the number of equations which require iterative solution. As a result, some of the approximations normally used in transient engine simulations can be eliminated. This tends to produce better agreement when answers are compared with those from purely steady-state simulations. The modified Euler method also permits the user to specify large time steps (about 0.10 sec) to be used in the solution of the differential equations. This saves computer execution time when long transients are run. However, convergence problems are sometimes encountered with DYNGEN when small time steps (less than 1 msec) are used. Examples of the use of the program are included in the report, and program results are compared with those from an existing hybrid-computer simulation of a two-spool turbofan.		
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## SUMMARY

This report describes DYNGEN, a digital computer program for analyzing the steady-state and transient performance of turbojet and turbofan engines. DYNGEN is based on earlier computer codes (SMOTE, GENENG, and GENENG II) which are capable of calculating the steady-state performance of turbojet and turbofan engines at design and off-design operating conditions. DYNGEN has the combined capabilities of GENENG and GENENG II for calculating steady-state performance; to these have been added the further capability for calculating transient performance. DYNGEN can be used to analyze one- and two-spool turbojet engines or two- and three-spool turbofan engines without modification to the basic program. The user needs only to supply appropriate component performance maps and certain design-point information.

DYNGEN uses a modified Euler method to solve the differential equations which model the dynamics of the engine. This modified Euler method is significantly different from the numerical integration methods which have typically been used in all-digital transient engine simulations. The major advantage of this new method is that it frees the programmer from having to minimize the number of equations which require iterative solution. As a result, some of the approximations normally used in transient engine simulations can be eliminated. This tends to produce better agreement when answers are compared with those from purely steady-state simulations. The modified Euler method also permits the user to specify large time steps (about 0.10 sec) to be used in the solution of the differential equations. This saves computer execution time when long transients are run. However, convergence problems are sometimes encountered with DYNGEN when small time steps (less than 1 msec) are used. A further discussion of the advantages and disadvantages of the modified Euler method is included in this report.

The intent of this report is to describe DYNGEN to make it useful for other researchers. A complete FORTRAN program listing is included in an appendix. Examples of the use of the program are included in the report, and program results are compared with those from an existing hybrid-computer simulation of a two-spool turbofan.

## INTRODUCTION

Computer programs which predict the performance of theoretical turbojet and turbofan engines have long been recognized as valuable tools for preliminary and detail design work. Digital computer codes such as SMOTE (refs. 1 and 2), GENENG (ref. 3), and GENENG II (ref. 4) now enable the user to analyze the steady-state performance of a wide variety of engines simply by providing component performance maps and other pertinent data; the task of writing a new computer program for each engine configuration is largely eliminated.

GENENG and GENENG II (herein referred to simply as "GENENG") are only capable of calculating steady-state engine performance. However, the need to predict the transient performance of turbojet and turbofan engines is becoming more important in preliminary design. Thrust response requirements are becoming more stringent, especially for V/STOL aircraft, and the need to meet transient performance criteria can have a significant effect on overall engine design. As engines grow more complex, their control systems assume a greater importance, and this importance further implies the need for good transient performance prediction during preliminary design.

Digital, analog, and hybrid computer methods are available for use in generalized computer codes for transient engine analysis. Each approach has its merits, and no consensus exists as to which is the best method. The major advantage of analog and hybrid methods is the use of electronic amplifiers for integrating the differential equations which model the dynamics of the engine. Digital engine simulations have, in the past, used time-consuming numerical integration techniques, which can result in prohibitively long execution times. A disadvantage which digital, analog, and hybrid simulations have traditionally shared is the need to minimize the number of equations which require iterative solution. Such equations are to be avoided, either because an analog computer cannot easily solve them or because they take too long to solve in connection with a digital integration algorithm which may require thousands of passes through the engine modeling equations. Transient engine simulations usually resort to assumptions and approximations in an effort to avoid iterative solution procedures. As a result, their steady-state solutions tend to disagree with the solutions produced by purely steady-state programs, such as GENENG, which are written without any prohibition on iterative solution methods.

Despite the difficulties just mentioned, progress has been made in developing transient simulations which, like GENENG, can handle many engine configurations without changing the basic computer program. The HYDES program for hybrid computers (ref. 5) has proven to be a flexible tool for preliminary control studies on a wide variety of engine types. HYDES uses electronic amplifiers for integration and digital subroutines for most of the function generation and algebraic computations.

This report describes a digital computer program, DYNGEN, which enables the user to analyze the transient performance of many engine configurations and which also eliminates some of the problems frequently connected with all-digital transient simulations. DYNGEN solves the system of differential equations by a method substantially different from the forward-difference integration techniques frequently used in digital engine simulations. The new method used by DYNGEN is similar to the well-known Euler method of solving differential equations and will be called the "modified Euler method." It gives the analyst great freedom in selecting the equations needed to describe the system and eliminates the discrepancies which often occur between answers generated by transient and steady-state simulations. In fact, DYNGEN is a direct modification of GENENG and, although the capability to perform transient calculations has been added, none of the steady-state capabilities of GENENG have been sacrificed. Without modification to the basic program, DYNGEN can be used to analyze one- and two-spool turbojets and two- and three-spool turbofans. Possible engine configurations are described in the next section of this report. Another section describes the modified Euler method of solving the system of differential equations and clarifies its advantages and disadvantages. Appendix A discusses the modified Euler method from a numerical analysis viewpoint.

The program is written in FORTRAN IV and can be used without modification on any IBM 7094 Model 2 computer. With modifications, the program can be used on all computers that have a FORTRAN compiler.

The iteration and integration techniques used in DYNGEN are described in appendix A. A complete program listing, flow chart, subroutine descriptions, and an example case are shown in appendix B. Appendix C explains methods of control system simulation, and appendix D provides debugging hints. For users who are already familiar with GENENG or GENENG II, appendix E enumerates the differences between DYNGEN and those programs. All symbols are defined in appendix F.

## ENGINE TYPES

Before describing the analytical techniques used in DYNGEN, a brief discussion of engine types will be given to inform potential users of their options for analyzing different engine configurations. Since DYNGEN is derived from GENENG, the user is referred to references 3 and 4 for a more detailed discussion of this subject. Figures 1 to 11 show some of the engine types that can be analyzed. The three-spool, three-stream turbofan (type a, fig. 1) is the most complicated configuration; all other types are derived from it by changes to the calculation procedure inside the program. Input requirements for the various configurations are discussed in the section PROGRAM INPUTS. The one-spool turbojet (type k, fig. 11) is the simplest engine that can be

analyzed. In between configurations a and k are found such engines as the three-spool, two-stream turbofan (type d, fig. 4); the two-spool, two-stream turbofan (type e, fig. 5); and the two-spool, two-stream, aft-fan engine (type h, fig. 8). All the turbofan engines shown in figures 1 to 9 have separate core and fan ducts. If desired, the user may specify mixed flow, in which case fan and core flow will exhaust through a common nozzle. The user may also specify core duct or fan duct afterburning.

The engines in figures 1, 2, 3, 6, and 7 have a third duct which is supplied with bleed air from the intermediate compressor. The third duct is referred to as the "wing duct" since it was originally intended to supply air for blown-flap or ejector-wing STOL aircraft.

## ENGINE MODELING TECHNIQUES

DYNGEN was formed by directly modifying its predecessor, GENENG. Except for the addition of differential equations to model rotor and gas dynamics, the equations used in DYNGEN are identical to those used in GENENG. Therefore, the reader is referred to references 3 and 4 for a detailed discussion of thermodynamic and component equations. The discussion in this report concentrates on how the programming techniques of GENENG were used to form a dynamic engine simulation and on the differential equations added to the analytical model. The modified Euler method of solving differential equations is discussed from a numerical analysis viewpoint in appendix A.

### Steady-State Balancing Technique

An example case is presented here to assist the reader in understanding how DYNGEN calculates engine steady-state operating points. For simplicity a turbojet engine is used in the example, but similar methods are used for more complicated configurations. Figure 12 shows a turbojet engine with its major components labeled. Pressures  $P$ , temperatures  $T$ , and flows  $\dot{w}$  are also labeled with appropriate station numbers. The example illustrates how the calculation of variables proceeds through the engine. DYNGEN is written so that the user can select off-design points by specifying speed  $N$ , turbine inlet temperature  $T_4$ , or fuel flow  $\dot{w}_f$ . In this example, fuel flow is assumed to be the specified variable. First, an inlet calculation is made to determine  $P_2$  and  $T_2$  from the free-stream values of pressure, temperature, and Mach number. In order to calculate  $\dot{w}_C$ ,  $P_3$ , and  $T_3$  from the compressor map (fig. 13) and thermodynamic relations, program-generated guesses are made for the values of speed  $N$  and pressure ratio  $P_3/P_2$ . Once  $\dot{w}_C$ ,  $P_3$ , and  $T_3$  are obtained, the combustor calculations for  $\dot{w}_4$ ,  $P_4$ , and  $T_4$  can be made by using the thermodynamic relations, the com-

bustor map (fig. 14), and the user-specified values for fuel flow  $\dot{w}_f$  and compressor bleed flow. In order to calculate turbine variables, the program generates another guess, this time for the value of turbine flow function  $\dot{w}_4 \sqrt{T_4}/P_4$ . Then, from the known value of  $N/\sqrt{T_4}$ , the turbine map (fig. 15) is used to calculate turbine work  $\Delta h$  and efficiency. The values of  $P_7$  and  $T_7$  are then calculated by using thermodynamic relations. Finally, the compressible-flow relations are used to calculate nozzle pressure  $P_7$  from  $\dot{w}_8$ ,  $T_7$ , and user-specified values for  $P_0$  and nozzle area.

The reader may have noticed that this calculation procedure is redundant; that is, certain variables can be calculated in more than one way. This fact is used to generate error variables, which must equal zero to yield a consistent solution of the equations. In developing a program such as DYNGEN, the analyst must choose what error variables to use. This discussion simply points out the choices which were inherited by DYNGEN from its predecessors, GENENG and SMOTE. Experience has shown that these are good choices for most engine configurations.

In the previous discussion it was stated that guesses were made for rotor speed  $N$ , compressor pressure ratio  $P_3/P_2$ , and turbine flow function  $\dot{w}_4 \sqrt{T_4}/P_4$ . From the first two guesses (and other variables) one may calculate the power absorbed by the compressor  $\dot{w}_C \Delta h_C$ . From the turbine flow function (and other variables) one may calculate the power supplied by the turbine  $\dot{w}_T \Delta h_T$ . For steady-state operation the power supplied must equal the power absorbed. Therefore, the difference  $\dot{w}_C \Delta h_C - \dot{w}_T \Delta h_T$  may be used for the first error variable.

Similarly, one can calculate a value for turbine flow function  $(\dot{w}_4 \sqrt{T_4}/P_4)'$  based only on the first two guesses, but for a consistent solution the calculated value must equal the guessed value. Hence, the difference  $(\dot{w}_4 \sqrt{T_4}/P_4) - (\dot{w}_4 \sqrt{T_4}/P_4)'$  can be used as the second error variable.

Finally, from the compressible-flow equations, we know that the variable  $P_7$  is specified by the variables  $\dot{w}_8$ ,  $T_7$ ,  $P_0$ , and nozzle area  $A_8$ . Since total conditions remain constant throughout the nozzle, this value for  $P_7$  must equal the value  $P_7'$ , which is calculated from the work and efficiency of the turbine and from adiabatic flow (with a specified pressure loss) in the duct between turbine and nozzle. Therefore, the third error variable is  $P_7 - P_7'$ .

Once three variables have been guessed and three errors have been specified, the analyst can use an iterative method to obtain a consistent solution to the equations. SMOTE, GENENG, and DYNGEN all use the Newton-Raphson technique of iteration. The details of this method are given in appendix A. Although more complicated engines will require more guesses and more error variables in the iterative procedure, the analyses will be quite similar to the one described in this example.

## Differential Equations

So far the discussion has been devoted to the methods which DYNGEN uses to obtain steady-state operating points. Now the method of implementing and solving time-dependent differential equations is discussed. DYNGEN uses a modified Euler method of solving differential equations. This method is derived, from a numerical analysis viewpoint, in appendix A. Appendix A also discusses the numerical stability of the modified Euler method and shows that it does not require extremely small time steps to obtain a stable solution. Because it uses the modified Euler method, DYNGEN does not require small time steps to obtain a stable solution. However, DYNGEN sometimes experiences convergence problems for time steps less than about 1 millisecond.

The ability to use large time steps (about 0.10 sec) is an advantage in engine simulation since in the past it has often been necessary to select integration time steps small enough to guarantee stability for high-frequency dynamics typical of mass and energy storage in unsteady flow. This can result in very long execution times even though the simulation user may only be interested in low-frequency dynamics. With the modified Euler method the user can select larger time steps without worrying about numerical stability.

The main disadvantage of the modified Euler method is that an iterative solution is required for the equations which approximate the solution to the differential equations. However, this fact turns out to be useful in DYNGEN since it means that the analyst no longer has to solve explicitly for derivatives. They may be embedded anywhere in an overall set of simultaneous algebraic equations which are to be solved by an iterative method such as Newton-Raphson. The following discussion shows how this advantage was employed in converting a steady-state simulation, GENENG, to a dynamic simulation, DYNGEN. In order to accomplish the conversion, three kinds of equations had to be modified to include dynamic terms: the power balance, continuity, and energy equations. The steady-state power balance equation simply implies that the power output of a turbine must equal the power absorbed by a fan, a compressor, and their loads

$$\dot{w}_T \Delta h_T = \dot{w}_C \Delta h_C + (HP)_{\text{ext}} \quad (1)$$

By adding a rotor acceleration term, the equation can be used to model engine dynamics: any excess power provided by the turbine will go into rotor acceleration

$$\dot{w}_T \Delta h_T = \dot{w}_C \Delta h_C + \left(\frac{2\pi}{60}\right)^2 I_N \frac{dN}{dt} + (HP)_{\text{ext}} \quad (2)$$

If the time derivative is arbitrarily set equal to zero, the dynamic equation becomes the steady-state equation. Similar considerations also hold for the continuity equation

$$\dot{w}_{out} = \dot{w}_{in} \quad (3)$$

DYNGEN treats unsteady flow dynamics in a way which has become traditional for engine simulation: a control volume is associated with each component; and pressure, temperature, and density are assumed to be constant throughout the control volume. At steady state the flow into the volume must equal the flow out; but for unsteady flow, mass can be stored in the volume at a rate proportional to the time derivative of pressure  $dP/dt$

$$\dot{w}_{out} = \dot{w}_{in} - \frac{\tilde{V}}{\gamma RT} \frac{dP}{dt} \quad (4)$$

If  $dP/dt$  is zero, the continuity equation reverts to its steady-state form. The control-volume approach is also used for the energy equation. At steady-state the rate of energy into the volume must equal the rate out

$$\dot{w}_{out} h_{out} = \dot{w}_{in} h_{in} \quad (5)$$

In unsteady flow, energy storage is accounted for by two terms: one reflecting the rate of change of specific internal energy  $du/dt$ , and another reflecting energy storage caused by mass storage

$$\dot{w}_{out} h_{out} = \dot{w}_{in} h_{in} - (\dot{w}_{in} - \dot{w}_{out})u - \frac{P\tilde{V}}{RT} \frac{du}{dt} \quad (6)$$

The following discussion shows how these equations were used in DYNGEN. DYNGEN was formed from GENENG by modifying the power balance, continuity, and energy equations for major engine components. In GENENG the steady-state power balance equation was used to form an error variable

$$E_1 = \dot{w}_C \Delta h_C - \dot{w}_T \Delta h_T + (HP)_{ext} \quad (7)$$

In DYNGEN the same error is formed with the dynamic term added

$$E_1 = \dot{w}_C \Delta h_C + \left(\frac{2\pi}{60}\right)^2 IN \frac{dN}{dt} - \dot{w}_T \Delta h_T + (HP)_{ext} \quad (8)$$

In order to implement the dynamic forms of the continuity and energy equations, a volume was associated with each component, and the flow and enthalpy out of the component were modified by the dynamic terms.

For example, if  $\dot{w}_C$  is the flow rate through the compressor specified by the compressor map and  $h_3$  is the enthalpy at the compressor exit, the flow and enthalpy enter-

ing the combustor will be given by  $\dot{w}_C^*$  and  $h_3^*$ , where

$$\dot{w}_C^* = \dot{w}_C - \frac{\tilde{V}_3}{\gamma RT_3} \frac{dP_3}{dt} \quad (9)$$

$$h_3^* = \frac{\dot{w}_C h_3 - (\dot{w}_C - \dot{w}_C^*) u_3 - \frac{P_3 \tilde{V}_3}{RT_3} \frac{du_3}{dt}}{\dot{w}_C^*} \quad (10)$$

The derivatives are calculated by the simplest possible approximation

$$\frac{dy}{dt} \approx \frac{y_i - y_{i-1}}{\Delta t} \quad (11)$$

where  $y_i$  is the current value of a variable and  $y_{i-1}$  is the value for the previous time step. This approximation is adequate provided that the time step  $\Delta t$  is no greater than one-tenth the magnitude of the smallest time constant the user wants to observe. A reasonable estimate for, say, a rotor time constant could be obtained by applying a step in main fuel flow as a disturbance. The rotor "time constant" would then be the time between the application of the step and the point when rotor speed reached  $N_0 + 0.63 \Delta N$ , where  $N_0$  is the initial speed and  $N_0 + \Delta N$  is the final speed at the end of the transient. In order to observe rotor dynamics with a time constant of 1.0 second, the user should use a  $\Delta t$  no greater than 0.10 second. In selecting a value of  $\Delta t$  for a given engine simulation, some trial and error may be necessary to determine the optimum value of  $\Delta t$ . As mentioned earlier,  $\Delta t$ 's smaller than 1 millisecond may cause convergence problems.

Adding the derivative terms to the steady-state equations did not require any change to the basic iteration scheme used in GENENG. Therefore, none of the flexibility or generality of the program was lost; its capability was simply extended to include dynamics.

## PROGRAM INPUTS

DYNGEN requires four kinds of user-supplied information:

- (1) Component maps, which are supplied in the form of BLOCK DATA subprograms
- (2) Subroutines DISTRB, FCNTRL, and NOZCTR, which are dummies unless transient operation is desired



- (3) A list of desired output variables, which is read in on data cards supplied at execution time
- (4) Engine configuration data and operating point specification, which are read in at execution time on data cards by means of NAMELIST name \$DATAIN

### Component Maps

The components which are represented by maps in DYNGEN are the fan, intermediate compressor, compressor, combustor, high-pressure turbine, intermediate-pressure turbine, low-pressure turbine, and afterburner. All these maps except the afterburner map are supplied in the form of BLOCK DATA subprograms; the afterburner map is included in subroutine ETAAB. DYNGEN is set up so that maps for all components are specified. Thus, if a single-spool turbojet is simulated, the BLOCK DATA for the components which are not used do not have to be deleted. This results in no errors in the calculations. Dummy maps for all components are supplied with the program. However, if storage space is a problem, the user may set up only the component maps which are needed and delete the space occupied by the other maps. Table I lists the component maps that must be supplied for each engine configuration.

Choice of component maps - scaling laws. - Many engines that are studied by using DYNGEN are theoretical. Therefore, actual component maps for these engines do not exist. The program, however, does require component maps in order to do off-design-point calculations. In order to alleviate this problem, DYNGEN uses scaling laws to change data from one component map into a new component map. Hopefully, a component map can be found which could be expected to perform in a similar manner to the actual map for the engine being studied. In fact, most maps that the authors have obtained are identified as to the range of pressure ratio, airflow, etc., over which they are valid. Thus, a high-bypass-ratio fan map such as that from a CF-6 could be used to simulate other high-bypass-ratio fan maps.

The scaling equations used for the compressor maps are

$$PR = \frac{(PR)_{\text{design}} - 1}{(PR)_{\text{map, design}} - 1} [(PR)_{\text{map}} - 1] + 1$$

$$WA = \frac{(WA)_{\text{design}}}{(WA)_{\text{map, design}}} \times (WA)_{\text{map}}$$

$$ETA = \frac{(ETA)_{\text{design}}}{(ETA)_{\text{map, design}}} \times (ETA)_{\text{map}}$$

In the output are printed the correction factors used in scaling the maps. The closer these values are to 1.0, the more reasonable are the simulated maps of the engine. Conversely, however, not being close to 1.0 does not necessarily mean that the simulation is poor since many maps have been shown to be typical over quite large ranges in the variables.

BLOCK DATA input. - The three compressor performance maps are entered into the code as the BLOCK DATA subprograms BLKFAN, BLKINT, and BLKCOMP. The subprograms supplied by the authors with the code and shown in appendix B are not to be taken as realistic maps. These maps are of an illustrative nature and are the ones used to run the sample calculations.

As an example, by using subprogram BLKFAN (the first nine cards of which are printed here) and referring to a typical compressor map (fig. 13), the data are programmed as follows: Card 1 reminds the reader that these maps are fictitious. Card 2

```

$IBFTC BLKFAN DECK
C THIS IS A GENERALIZED FAN MAP FOR UNREALISTIC SUPERSONIC ENGINE 1
  BLOCK DATA 2
  COMMON / FAN/CN(15),PR(15,15),WAC(15,15),ETA(15,15),N,NP(15) 3
  DATA N,NP/10,6,3*7,5*10,8,5*0/ 4
  DATA CN/0.3,0.4,0.5,0.6,0.7,0.8,0.9,1.0,1.1,1.2,5*0./ 5
  DATA (PR( 1,J),WAC( 1,J),ETA( 1,J),J=1, 6)/ 6
  1 1.03000, 243.600, 0.75592, 1.01200, 229.800, 0.76120, 7
  2 1.02800, 199.800, 0.76648, 1.03840, 166.800, 0.75592, 8
  3 1.04480, 133.200, 0.72512, 1.04800, 86.400, 0.64152/ 9

```

identifies the subprogram as BLOCK DATA. Card 3 identifies common block FAN, into which data are to be stored, and dimensions the program variables. Card 4 indicates that there are 10 speed lines N and gives the number of points NP on each line (six on the lowest speed, seven on the next three lines, etc.). Card 5 assigns the value of speed to each of the 10 lines (low to high). Cards 6 to 9 along the speed line CN=0.3 set the pressure ratio PR, corrected airflow WAC, and efficiency ETA in sets of three, going from low pressure (PR=1.0) to the surge line (PR=1.048). Note there are six sets of three values (NP(1)=6). The rest of the cards (appendix B) set the values for each speed line.

The combustor map is also a BLOCK DATA subprogram (CMBDT). It is a plot of temperature rise across the combustor against efficiency for constant input pressure. Entry to the map is through temperature rise and input pressure, with efficiency being output. The cards in the subprogram CMBDT are reproduced here; a typical combustor map is shown in figure 14. The data are programmed as follows: Card 1 identifies the common block COMB, into which data are to be stored, and dimensions each variable. Card 3 indicates that there are 15 lines of constant PSI (P3) by the value of N and that there are 15 values of DELT (DT) and ETA (ETAB) along each line of constant PSI (P3).

```

$IBFTC CMBDT DECK
BLOCK DATA
COMMON / COMB/PSI(15),DELT(15,15),ETA(15,15),N,NP(15)
DATA N,NP / 15,15*15 /
DATA PSI/4.9116,9.8232,14.735,19.646,24.558,29.470,34.381,
139.293,44.207,73.674,100.,200.,300.,400.,500./
DATA DELT/15*200.,15*300.,15*400.,15*500.,15*600.,15*700.,15*800.,
115*900.,15*1000.,15*1100.,15*1200.,15*1300.,15*1400.,15*1500.,
215*1600./
DATA ETA/
1.600,.726,.777,.806,.826,.843,.855,.865,7*.870,
2.758,.825,.858,.875,.888,.898,.906,.912,.914,6*.915,
3.868,.893,.911,.925,.935,.942,.947,.951,7*.953,
4.925,.936,.946,.955,.963,.969,.974,.977,.978,6*.979,
5.960,.966,.972,.977,.982,.985,.990,.992,.993,6*.995,
6.988,.991,.992,.994,.995,.997,.998,8*.999,
78=1.0J,7*.999,120*1.00/
END

```

Cards 4 and 5 assign values to each of the P3 lines from low to high pressure. Cards 6 to 8 assign values of  $\Delta T$  to each of the P3 lines, starting at low  $\Delta T$ . The lowest value of  $\Delta T$  on each of the P3 lines is given, starting with the lowest value of  $\Delta T$  on the lowest value of P3. Next comes the second lowest value of  $\Delta T$  on each P3, etc. Again, this map is unrealistic, being used for illustrative purposes only. Cards 9 to 16 assign the value of  $\eta_B$  in a one-to-one correspondence with the  $\Delta T$  values just assigned. The order is the same.

Also entered as BLOCK DATA subprograms are the turbine maps (HPTDAT, IPTDAT, and LPTDAT). In order to illustrate the entering of turbine data, LPTDAT is used. A typical turbine map is shown in figure 15; the data are programmed as follows: Card 1 identifies the subprogram as BLOCK DATA. Card 2 identifies common

```

$IBFTC LPTDAT DECK
BLOCK DATA
COMMON / LTURB/TFF(15),CN(15,15),DH(15,15),ETA(15,15),N,NP(15)
DATA N,NP/11,9*15,12,9,4*0/
DATA TFF / 88.470, 102.795, 116.835, 129.330, 141.045,
1 145.725, 150.000, 153.345, 156.405, 159.780, 163.170,4*0./
DATA (CN( 1,J),DH( 1,J),ETA( 1,J),J=1,15)/
1 0.3582, 0.0018, 0.7120, 0.5336, 0.0026, 0.7300,
2 0.7365, 0.0035, 0.7472, 0.9754, 0.0044, 0.7300,
3 1.2146, 0.0051, 0.7140, 1.4173, 0.0056, 0.7000,
4 1.5201, 0.0059, 0.6850, 1.7673, 0.0061, 0.6730,
5 2.3247, 0.0062, 0.6452, 2.2827, 0.0061, 0.6200,
6 2.4665, 0.0057, 0.6000, 2.6137, 0.0053, 0.5750,
7 2.9166, 0.0044, 0.5310, 2.9456, 0.0035, 0.5000,
8 3.3138, 0.0001, 0.3850/

```

block LTURB, into which data are to be loaded, and dimensions the program variables. Card 3 indicates the number of constant turbine flow function lines TFF as 11 (N) and gives the number of points on each line from low to high TFF. Cards 4 and 5 set values of corrected speed CN, work function DH, and efficiency ETA along TFF(1), starting from low CN (0.3682) and ending at high CN (3.3138). The rest of the cards set the values along higher TFF lines.

In many cases, turbine maps for high-performance engines operate at a choked condition (constant TFF). Thus, a turbine map to be represented could possibly have no lines representing constant TFF for a significant portion of the map. For complete map representation, lines of constant TFF may be estimated on the map up to the limit loading line by inputting slight changes for the values of TFF (e.g., if one line for TFF is 62.105, the next may be input as 62.108). This will eliminate computational difficulties which would arise if constant values for TFF lines were input.

Generalized afterburner performance has been programmed into subroutine COAFBN. The afterburner performance map included in the program is shown in a generalized form in figure 16(a). The performance map shows afterburner combustion efficiency as a function of fuel-air ratio. The values of the afterburner combustion efficiency correction factors  $\Delta\text{ETAA}$  during off-design operation are shown as functions of afterburner entrance Mach number (fig. 16(b)) and afterburner entrance pressure (fig. 16(c)). Other correction factors or performance maps may be added as desired. The afterburner efficiency, fuel-air ratio, inlet total pressure, and Mach number are generalized.

A specific afterburner performance map is generalized by dividing the specific off-design value by the design value, as shown below. The symbols shown are the symbols used in the ETAAB subroutine, where the generalized and specific values are input. The generalized afterburner values are obtained as follows:

$$\text{Efficiency (ETABRT)} = \frac{\text{ETAA}}{\text{ETAADS}}$$

$$\text{Fuel-air ratio (FART)} = \frac{\text{FART}}{\text{FARTDS}}$$

$$\text{Entrance total pressure (P6T)} = \frac{\text{P6}}{\text{P6DS}}$$

$$\text{Entrance Mach number (EM6T)} = \frac{\text{AM6}}{\text{AM6DS}}$$

However, the correction factor for efficiency  $\Delta\text{ETAA}$  is not a generalized value. Also input in ETAAB are the following:

(1) The change in efficiency as a function of EM6T is input as DELM6 (which is really  $\Delta\text{ETAA} = f(\text{AM6})$ ).

(2) The change in efficiency as a function of P6T is input as DELP6 (which is really  $\Delta\text{ETAA} = f(\text{P6})$ ).

At execution time for the design point, afterburner combustion efficiency ETAADS, exit total temperature T7DS, and entrance Mach number AM6DS design values are in-

put. Then design fuel-air ratio and entrance pressure ratio are calculated from the input values and the other design engine characteristics.

In order to achieve a reasonable accuracy in cycle calculations when using a generalized component map, the usage of the map should be limited within a certain range of the original design values and configuration changes. Therefore if, for example, an afterburner has a design task that differs significantly from an example used, a new performance map should be used in order to simulate the component more accurately.

DYNGEN normally uses a single-point input for the nozzle velocity coefficients (CVMNOZ, CVDWNG, and CVDNOZ) when calculating engine performance. When desired, however, a map of nozzle velocity or thrust coefficients can be readily incorporated, as in reference 3.

### Output Specification

Data cards are supplied by the user, at execution time, to specify the names of desired output variables. Any variable that is in one of the main commons (ALL1, ALL2, etc.) may be selected for output by punching, in columns 1 to 6, the name of the variable as it appears in the common. Up to 150 variables (25 lines of six variables) may be chosen for a particular run. During the output phase the name of the variable is printed out, with its value printed immediately below the name.

Another feature of the controlled output is the ability to change the name of a variable to be output; for example, it may be desired to change a station designation to one more common to a particular programmer. In this case, the variable name would be punched in columns 1 to 6 as described; but, in addition, the desired name would be punched in columns 13 to 18. Special symbols such as / may be used in the new name. The last card of the selected output must be a card with "THEEND" punched in columns 1 to 6.

### Design-Point Specification

The engine design point is specified by reading in data cards by means of NAMELIST name \$DATAIN. The design point is identified by setting IDES=1, and it must always be the first case run. Configuration specification (two-spool turbofan, one-spool turbojet, etc.) is done at the design point.

Table II contains a complete list of the variables that must be specified by the user at the design point for the 11 basic engines shown in this report. Table III contains further explanation of some of the program indices (MODE, INIT, IDUMP, etc.) which the user may employ to control the operation of the program.

One significant difference between DYNGEN and its predecessors, SMOTE and GENENG, is the ability to use the International System of Units (SI). If input variable SI is .TRUE., physical constants internal to the program will be set for SI units; if SI is .FALSE., they will be set for U.S. customary units (English units). When SI is .TRUE., most of the internal calculations are done in SI units, as opposed to simply leaving the internal calculations in English units and converting the input and output.

### Off-Design Operating Points

So far the discussion has concentrated on specifying the engine design point. Once this has been done, the user has many options for running off-design points. These may be used to study steady-state performance, or they may be the initial conditions for transients. There are four basic modes for specifying off-design points:

- (1) MODE=0, specify a new turbine inlet temperature T4
- (2) MODE=1, specify a compressor rotational speed PCNC
- (3) MODE=2, specify a fuel flow rate WFB
- (4) MODE=3, specify a fan rotational speed PCNF

The variables T4, PCNC, WFB, and PCNF have special significance because specifying any one of them also specifies the other three (assuming a fixed engine cycle). In addition to these variables, however, the user may specify any parameter which is not recalculated inside the program. Table IV contains all the variable names which may be changed for off-design points by using NAMELIST input. Table IV is not, however, an exhaustive list of variables which might be changed. For example, the user might want to vary low-pressure-turbine exit area A55 in order to determine its effect on engine performance. To do so he would only need to add A55 to NAMELIST/DATAIN/ in subroutine PUTIN. The same procedure can be used for any variable the user wants to change, provided that the variable is not recalculated inside the program. There is no restriction on the number of variables which may be changed at one time (except for afterburning cases). For example, it would be permissible to change ALTP, AM, ETAR, HPEST, A8, A28, and A38 all in one step.

When calculating off-design points, DYNGEN needs an initial guess for the values of its iteration variables. Subroutine GUESS does the job of providing the guesses. However, for some engines, GUESS will lead to trouble by causing map inputs that are out of range for the data provided or other similar problems. Variable INIT can be used to bypass GUESS. If INIT=0, GUESS will be called; if INIT=1, GUESS will be bypassed, and the last converged case will be used as the initial guess for the next case. Sometimes INIT=1 can be used to solve for a point which has been causing convergence problems.

## Transient Input

In order to use DYNGEN's transient capability, the user must provide additional NAMELIST input. Table V summarizes the variables which must be provided for each of the engine configurations discussed in this report. Except for ITRAN, the variables in table V may be input at any time; they do not affect program operation in the steady-state (ITRAN=0) mode. When the user inputs ITRAN=1, the next point will be the initial condition for a transient, and the program will print "TIME=0.0" above the output listing. From then on, until TIME exceeds TF, TIME will be incremented by DT before each point is calculated, and subroutine DISTRB will be called to provide time-varying input. The user must write subroutine DISTRB. For example, DISTRB might be used to provide a step in WFB to determine engine open-loop response. Examples of DISTRB are shown in appendixes B and C. DISTRB can be used to change any variable which is not recalculated inside the program, nor is the user restricted to the variables in NAMELIST. Table IV provides a reasonably complete list of possible time-varying inputs. The user should not, however, input a time-varying T4 (when MODE=0) unless VCOMB=0.0. If VCOMB is nonzero, T4 will be recalculated and the user-supplied value will be overridden. Similarly, a time-varying T7 should not be input unless VAFTBN=0.0, and a time-varying T24 should not be input unless VFDUCT=0.0. DISTRB should contain COMMON blocks ALL1, ALL2, etc., as required to communicate new values to the rest of the program.

DYNGEN also provides for user-written versions of subroutines FCNTRL (main fuel control) and NOZCTR (controlled A8). When ITRAN=1, FCNTRL is called by COCOMB (if MODE=2) and NOZCTR is called by COMNOZ. Appendix C contains examples of FCNTRL and NOZCTR. A set of general-purpose control system subroutines is also discussed in appendix C. The user may employ these to write his own control subroutines.

## EXAMPLE CALCULATIONS

In order to show DYNGEN's capability, three examples are presented. The first example shows the response of a three-spool, three-stream turbofan (like the one shown in fig. 1) to an open-loop step in fuel flow. Figure 17 shows time histories of fan, middle spool, and core speeds. Also shown is the response of turbine inlet temperature. All variables are presented as percentages of their design values. Complete input and output listings for this example are shown in appendix B. Apart from showing DYNGEN's capability to simulate a three-spool turbofan, figure 17 also demonstrates the effect of using different time steps in the modified Euler solution of the simulation equations. The results are shown for two time steps: 0.01 and 0.10 second. Close examination

shows some small differences between the two solutions, but they are substantially identical. There is a big difference, however, in computer execution time to run the 3-second transient shown in figure 17. With the 0.10-second time step, execution time was 1.4 minutes; with the 0.01-second time step, execution time was 12.3 minutes. This example demonstrates one of the main advantages of a modified Euler solution method: the user may select the time step to show the frequency range of interest. If low-frequency effects (less than 0.20 Hz), such as rotor dynamics, are the subject of interest, a time step of 0.10 second may be adequate. If higher frequency effects, such as temperature and pressure dynamics, are to be observed, a time step as small as 1 millisecond may be needed. Frequency ranges requiring a time step smaller than 1 millisecond may result in convergence problems in DYNGEN. In any case, execution times can be held to a minimum that is compatible with the user's interests.

The next example shows a large throttle transient for a two-spool turbofan similar to the one shown in figure 5. This engine was simulated, along with the speed control system shown in figure 18. A listing of subroutine FCNTRL for this example is shown in appendix C. The primary input to the control system is demand speed XNLDEM, which is set by the pilot's throttle lever. The only output of the control system is fuel flow WFB, which goes to the combustor. During small throttle transients the control is proportional-plus-integral on speed error, but for large transients the control is closed loop on the acceleration fuel flow schedule. Acceleration fuel flow is computed from compressor speed XNHM, compressor exit pressure P3M, and compressor inlet temperature T21M. This moderately complex control system was simulated by using subroutines that are compatible with DYNGEN's modified Euler solution method. A throttle step from 50 percent thrust to 100 percent thrust was applied to the simulation, and the results are shown in figure 19. Time histories of turbine inlet temperature and thrust are shown, with the variables expressed as percentages of their design values. This figure also presents a comparison of DYNGEN's results with those from a hybrid-computer simulation of the same engine. In figure 19, the continuous lines are the hybrid-computer solution and the discrete points are DYNGEN's solution. The hybrid-computer model is quite detailed (ref. 5), but because of differences in the simulation equations, the steady-state results of the two simulations differ by about 3 percent. The differences in the dynamic solutions are of the same order. The comparison shown in figure 19, though not perfect, tends to confirm the validity of DYNGEN's method of solving the differential equations used in modeling the engine and control system. Even though a fairly long time step of 0.10 second was used, DYNGEN's solution is quite similar to the continuous solution produced by the hybrid computer.

The final example of DYNGEN's flexibility involves a single-spool, afterburning turbojet similar to the one shown in figure 11. This type of engine requires exhaust nozzle and main fuel control subsystems as shown in figure 20. Listings of subroutines FCNTRL and NOZCTR for this engine are shown in appendix C.



The main fuel control is a simple proportional control on speed error with acceleration and deceleration fuel flow limiting. The main input is demand speed PCNFDM which is set by the pilot's throttle. The acceleration schedule is the usual WFB divided by P3 as a function of PCNF, and the deceleration schedule is obtained simply by taking one-third of the acceleration schedule. The nozzle control is used only in the afterburning mode of operation. Its purpose is to null out any change in compressor pressure ratio P3/P2 which might occur when going from nonafterburning to afterburning operation. This is accomplished by proportional-plus-integral control of nozzle area A8 in response to pressure ratio error.

This control system was simulated in connection with a turbojet engine, and a throttle slam from idle to full afterburning was applied. The results are shown in figure 21. Time histories of rotational speed, main fuel flow, afterburner fuel flow, nozzle area, and thrust are shown. All variables are presented as percentages of their design values. In order to simulate a throttle slam, afterburner fuel flow was ramped from zero to its maximum value in 2 seconds, beginning as soon as rotor speed reached 100 percent. The transient input for this example is shown in subroutine DISTRB (appendix C).

This example shows that DYNGEN can be used successfully to simulate the dynamics of an afterburning engine. Furthermore, it demonstrates that DYNGEN is not limited to small-perturbation problems. The 5-second transient shown in this example required about 2 minutes of computer execution time on the IBM 7094.

## CONCLUDING REMARKS

A generalized digital computer program for simulating the steady-state and dynamic performance of turbojet and turbofan engines has been described and discussed. This computer program, called DYNGEN, possesses significant advantages over many earlier methods of digital engine simulation. Specifically, it eliminates the need to operate two separate computer programs to obtain steady-state and dynamic results. It uses a modified Euler method for solving differential equations, which enables the user to specify long solution time steps if only low-frequency information is required. This saves computer execution time when long transients are to be run. A limitation of DYNGEN is that it sometimes experiences convergence problems when small time steps (less than 1msec) are used. Finally, DYNGEN can simulate a wide variety of engine types without reprogramming. This saves money and man-hours when new engines are to be simulated.

Lewis Research Center,  
National Aeronautics and Space Administration,  
Cleveland, Ohio, November 15, 1974,  
505-05.

## APPENDIX A

### ITERATION AND INTEGRATION TECHNIQUES

#### Steady-State Balancing Technique

The following discussion explains the iterative method which DYNGEN and its predecessor GENENG use to calculate steady-state operating points. As noted earlier, the calculation of a steady-state operating point requires solution of a system of nonlinear equations, corresponding to various engine matching constraints such as rotational speeds, airflows, compressor and turbine work functions, and nozzle flow functions. In order to satisfy these constraints, there are available an equal number of engine parameters which may be varied, such as compressor and turbine pressure ratios and flow functions. The specific number of engine parameters (independent variables) to be varied and engine error variables (dependent variables) to be satisfied depends on the type of engine configuration being studied and varies from three for a single-spool turbojet engine to nine for a three-spool engine. DYNGEN searches for the values of the engine parameters which result in the engine error variables being reduced to nearly zero.

If the independent variables are denoted by  $V_j$  and the dependent variables by  $E_i$ , the matching equations can be written as

$$E_i(V_j) = 0 \quad i = 1, 2, \dots, n$$
$$j = 1, 2, \dots, n$$

This is a set of nonlinear equations, which must be satisfied for a steady-state solution. The procedure used to satisfy these equations is the multivariable Newton-Raphson method (ref. 6). With this method, changes in  $E$  are assumed to be related to changes in  $V$  by first-order, finite-difference equations:

$$\Delta E = M \Delta V$$

where  $\Delta V$  and  $\Delta E$  are  $n$ -vectors denoting changes in  $V$  and  $E$  from some reference condition and  $M$  is an  $n \times n$  matrix of partial derivatives of  $E$  with respect to  $V$ :

$$M_{ij} = \frac{\partial E_i}{\partial V_j}$$

The matrix  $M$  is obtained by calculating a reference case and  $n$  independent perturbed cases, such that only the  $j^{\text{th}}$  variable  $V_j$  is perturbed from its reference value on the

$j^{\text{th}}$  case. Then for the  $j^{\text{th}}$  case,

$$M_{ij} \approx \frac{\Delta E_i}{\Delta V_j} \quad i = 1, 2, \dots, n$$

Once the matrix  $M$  is obtained, the reference case is improved by using

$$V = V_r - M^{-1}E_r$$

If the system of equations were linear, this process would lead to convergence in one iteration. In practice, nonlinearities in the system prevent immediate convergence. In this case, the new  $V$  and  $E$  are taken to be the reference values, and a new matrix is generated. If the system is not too nonlinear and initial guesses for  $V$  are reasonably accurate, convergence is achieved in several iterations.

### Dynamic Equations

Once an initial steady-state solution has been obtained, a time-varying solution may be generated. This requires the solution of a set of differential equations which model the system. The specific equations which are used to model the engine were discussed in the main text. In this section, the procedure used to solve the differential equations in DYNGEN is discussed.

Consider first the differential equation

$$\frac{dy}{dt} = f(y, t) \quad (\text{A1})$$

In order to obtain a numerical solution on a digital computer, this differential equation must be replaced by a difference equation in such a way that the solution of the difference equation is, in some sense, close to that of the differential equation. There are many ways in which this can be done, as discussed, for example, in reference 6. A common method is to use a difference equation of the form

$$y_{j+1} = y_j + \Delta t \left[ \epsilon f(y_j, t_j) + (1 - \epsilon) f(y_{j+1}, t_{j+1}) \right] \quad (\text{A2})$$

where

$$y_j \triangleq y(t_0 + j \Delta t)$$

and

$$0 \leq \epsilon \leq 1$$

The bracketed quantity in equation (A2) represents a weighted average of the derivative  $f(y, t)$  over the integration interval  $[t_j, t_{j+1}]$ . For  $\epsilon = 1$ , equation (A2) becomes

$$y_{j+1} = y_j + \Delta t f(y_j, t_j) \quad (\text{A3})$$

Equation (A3) is known as Euler's method and allows explicit calculation of  $y_{j+1}$  as a function of the previous values  $y_j$  and  $t_j$ . On the other hand, for  $\epsilon \neq 1$ , equation (A2) is the modified Euler method. In general, it cannot be solved explicitly for  $y_{j+1}$  because of the dependence of  $f$  on  $y_{j+1}$  which appears on the right side of the equation. In this case, some form of iteration must be used at each integration step to solve for  $y_{j+1}$ .

From the standpoint of simplicity of the integration formula, use of equation (A3) is clearly preferable to use of equation (A2). However, there are two other important considerations: accuracy and stability. As discussed in the literature (e.g., ref. 6), use of equation (A2) can lead to greater integration accuracy. Even more important for the dynamic engine simulation problem is the stability consideration.

In order to illustrate the stability consideration, consider the linear differential equation

$$\frac{dy}{dt} = ay \quad (\text{A4})$$

For this equation, equation (A2) becomes

$$y_{j+1} = y_j + a \Delta t [\epsilon y_j + (1 - \epsilon)y_{j+1}] \quad (\text{A5})$$

which can be solved for  $y_{j+1}$  to give

$$y_{j+1} = \left( \frac{1 + a\epsilon \Delta t}{1 + a\epsilon \Delta t - a \Delta t} \right) y_j \quad (\text{A6})$$

the general solution for  $y_j$  can be written

$$y_j = r^j y_0 \quad (\text{A7})$$

where

$$r = \frac{1 + a\epsilon \Delta t}{1 + a\epsilon \Delta t - a \Delta t} \quad (\text{A8})$$

The original differential equation (A4) is stable for  $a < 0$ ; the difference equation solution, equation (A7), is stable for  $|r| < 1$ . From equation (A8) the requirements for stability of equation (A7) can be established in terms of the requirements on integration step size  $\Delta t$ . Solving equation (A8) for  $\Delta t$  yields

$$\Delta t = \frac{1 - r}{a(\epsilon r - r - \epsilon)} \quad (\text{A9})$$

The upper and lower bounds for  $\Delta t$  are obtained by setting  $r = \pm 1$  in equation (A9). This results in

$$\Delta t < \frac{2}{a(1 - 2\epsilon)} \quad \epsilon > \frac{1}{2} \quad (\text{A10a})$$

$$\Delta t \text{ is unconstrained for } \epsilon < \frac{1}{2} \quad (\text{A10b})$$

In particular, for the Euler method ( $\epsilon = 1$ ) the step size must be less than  $-2/a$  in order to avoid numerically induced instability. For  $\epsilon < 1/2$  the numerical method leads to a stable solution for any value of integration step size.

These results are readily generalized to a system of linear differential equations. Consider the system of equations

$$\frac{dy}{dt} = Ay \quad (\text{A11})$$

where  $y$  is an  $n$ -vector and  $A$  is the  $n \times n$  system matrix. Use of the numerical algorithm in equation (A2) results in

$$y_{j+1} = y_j + A \Delta t [\epsilon y_j + (1 - \epsilon)y_{j+1}] \quad (\text{A12})$$

which has the general solution

$$y_j = \Phi^j y_0 \quad (\text{A13})$$

where

$$\Phi = (I + A\epsilon \Delta t - A \Delta t)^{-1} (I + A\epsilon \Delta t)$$

As shown in reference 7, equation (A11) is stable if, and only if, the eigenvalues of  $A$  all have negative real parts; the difference equation solution (A13) is stable if, and only if, all the eigenvalues of  $\Phi$  have magnitudes less than unity.

It will now be proved that if  $\lambda$  is an eigenvalue of  $A$ ,

$$\mu = \frac{1 + \lambda \epsilon \Delta t}{1 + \lambda \epsilon \Delta t - \lambda \Delta t} \quad (\text{A14})$$

is an eigenvalue of  $\Phi$ . Proof: Let  $\lambda$  be an eigenvalue of  $A$ . Then

$$|A - \lambda I| = 0$$

If  $\mu$  is an eigenvalue of  $\Phi$ ,

$$|\Phi - \mu I| = 0$$

But

$$\begin{aligned} |\Phi - \mu I| &= |(I + A \epsilon \Delta t - A \Delta t)^{-1} (I + A \epsilon \Delta t) - \mu I| \\ &= \frac{|(I + A \epsilon \Delta t) - \mu (I + A \epsilon \Delta t - A \Delta t)|}{|I + A \epsilon \Delta t - A \Delta t|} \\ &= \frac{|(1 - \mu)(I + A \epsilon \Delta t) + \mu A \Delta t|}{|I + A \epsilon \Delta t - A \Delta t|} \end{aligned}$$

But from equation (A14),

$$1 - \mu = - \frac{\lambda \Delta t}{1 + \lambda \epsilon \Delta t - \lambda \Delta t}$$

so that

$$\begin{aligned} |\Phi - \mu I| &= \frac{|-\lambda \Delta t (I + A \epsilon \Delta t) + (1 + \lambda \epsilon \Delta t) \Delta t A|}{(1 + \lambda \epsilon \Delta t - \lambda \Delta t) |I + A \epsilon \Delta t - A \Delta t|} \\ &= \frac{\Delta t |A - \lambda I|}{(1 + \lambda \epsilon \Delta t - \lambda \Delta t) |I + A \epsilon \Delta t - A \Delta t|} \\ &= 0 \end{aligned}$$

which completes the proof.

The similarity of equations (A14) and (A8), together with the requirement that all eigenvalues  $\mu$  have magnitudes less than unity, allows the conclusion, similar to equation (A10), that

$$\Delta t < \frac{2}{\lambda_{\max}(1 - 2\epsilon)} \quad \epsilon > \frac{1}{2} \quad (\text{A15a})$$

$$\Delta t \text{ is unconstrained for } \epsilon < \frac{1}{2} \quad (\text{A15b})$$

where  $\lambda_{\max}$  is the eigenvalue of  $A$  having the greatest magnitude. In particular, for the Euler method the step size is restricted by

$$\Delta t < - \frac{2}{\lambda_{\max}} \quad (\text{A16})$$

in order to avoid numerical instability.

These results are valid only for a linear system, and no such general proofs are available for nonlinear systems. However, in an intuitive sense, it seems reasonable that equation (A16) would be applicable to nonlinear systems if the matrix  $A$  and eigenvalues  $\lambda$  were interpreted as "average" values over an integration step and if the system of equations (A11) was not too nonlinear.

The significance of equation (A16), particularly for the dynamic engine simulation problem, is the following: The dynamic engine simulation generally contains a mix of high and low frequencies. The high frequencies result from the lumped-volume representation of component dynamics, which includes the storage of mass and energy. The low frequencies result, for example, from rotor dynamics and the slow motion of the exhaust nozzle and its associated control logic. Frequently, the simulation user is interested in low-frequency effects, such as overall engine spool-up time, and is not concerned with high-frequency effects. Typical transients are 5 to 10 seconds in duration.

If the simulation uses Euler's method, the integration step size is restricted by the highest frequency in the system, even though the user is not interested in high-frequency information. In this case, a step size of  $10^{-4}$  second, or smaller, is frequency required. On the other hand, if an implicit (modified Euler) technique is used ( $\epsilon < 1/2$ ), there is no upper bound on step size. It can be chosen to suit the desired frequency content of the output, which typically allows a step size of 0.1 second or larger.

### Iterative Solution Procedure

A problem which exists with the use of implicit methods, as noted previously, is that for nonlinear differential equations some iterative scheme is required to solve for the values of  $y_{j+1}$  at each integration step. The differential equations corresponding to the dynamic model of the engine may be written as

$$\frac{dy}{dt} = f(y) \quad (\text{A17})$$

where  $y$  and  $f$  are vectors. The state vector  $y$  represents pressures, temperatures, and rotor speeds. The dimension of  $y$  (and  $f$ ) depends on the type of engine configura-

tion being studied. Nine state variables are required for a single-spool turbojet engine, and a greater number for more complex engines.

The difference-equation representation used in DYNGEN utilizes  $\epsilon = 0$ , so that equation (A17) becomes

$$y_{j+1} = y_j + \Delta t f(y_{j+1}) \quad (\text{A18})$$

The discussion of the sample configuration in the main text of the report shows how the dynamic equations are incorporated into the structure of the steady-state solution. The steady-state continuity, energy, and power equations are modified to be dynamic equations. The resulting dynamic equations are then either included as error equations or are used to calculate flows and enthalpies at various stations throughout the engine.



# APPENDIX B

## DYNGEN PROGRAM

### Listing of DYNGEN

```

$IBFTC AFQUIR
      SUBROUTINE AFQUIR (X,AIND,DEPEND,ANS,AJ,TOL,DIR,ANEW,ICON)
      DIMENSION X(9)
C X(1)=NAME OF ARRAY TO USE
C AIND= INDEPENDANT VARIABLE
C DEPEND= DEPENDANT VARIABLE
C ANS=ANSWER UPON WHICH TO CONVERGE
C AJ=MAX NUMBER OF TRYS
C TOL=PERCENT TOLERANCE FOR CONVERGENCE
C DIR=DIRECTION AND PERCENTAGE FOR FIRST GUESS
C ANEW=CALCULATED VALUE OF NEXT TRY AT INDEPENDANT VARIABLE
C ICON=CONTROL =1 GO THRU LOOP AGAIN
C           =2 YOU HAVE REACHED THE ANSWER
C           =3 COUNTER HAS HIT LIMITS
C X(2)=COUNTER STORAGE
C X(3)=CHOOSES METHOD OF CONVERGENCE
C X(4)=THIRD DEPEND VAR
C X(5)=THIRD IND VAR
C X(6)=SECOND DEPEND VAR
C X(7)=SECOND IND VAR
C X(8)=FIRST DEPEND VAR
C X(9)=FIRST IND VAR
C X(3) MUST BE ZERO UPON FIRST ENTRY TO ROUTINE
      Y=0.
      IF (ANS) 1,2,1
1     DEP=DEPEND-ANS
      TOLANS=TOL*ANS
      GO TO 3
2     DEP=DEPEND
      TOLANS=TOL
3     IF (ABS(DEP)-TOLANS) 5,5,4
4     IF (X(2)-AJ) 8,8,7
5     ANEW=AIND
      X(2)=0.
      ICON=2
      RETURN
6     ANEW=Y
      X(2)=X(2)+1.
      ICON=1
      RETURN
7     ANEW=Y
      X(2)=0.
      ICON=3
      RETURN
8     IF (X(3)) 9,9,12
C *** FIRST GUESS USING DIR
9     X(3)=1.
      X(8)=DEP
      X(9)=AIND
      IF (AIND) 10,11,10
10    Y=DIR*AIND
      GO TO 6
11    Y=DIR
      GO TO 6
12    IF (X(3)-1.) 13,13,16
C *** LINEAR GUESS
13    X(3)=2.
      X(6)=DEP
      X(7)=AIND

```

	IF (X(8)-X(6)) 14,9,14	59
14	IF (X(9)-X(7)) 15,9,15	60
15	A=(X(9)-X(7))/(X(8)-X(6))	61
	Y=X(9)-A*X(8)	62
	IF (ABS(10.*X(9))-ABS(Y)) 9,9,6	63
C ***	QUADRATIC GUESS	64
16	X(4)=DEP	65
	X(5)=AIND	66
	IF (X(7)-X(5)) 18,17,18	67
17	IF (X(6)-X(4)) 13,9,13	68
18	IF (X(6)-X(4)) 19,13,19	69
19	IF (X(9)-X(5)) 23,20,23	70
20	IF (X(8)-X(4)) 21,22,21	71
21	X(9)=X(7)	72
	X(8)=X(6)	73
	GO TO 13	74
22	X(9)=X(7)	75
	X(8)=X(6)	76
	X(3)=1.	77
	IF (X(9)) 10,11,10	78
23	IF (X(8)-X(4)) 24,21,24	79
24	F=(X(6)-X(4))/(X(7)-X(5))	80
	A=(X(8)-X(4)-F*(X(9)-X(5)))/((X(9)-X(7))*(X(9)-X(5)))	81
	B=F-A*(X(5)+X(7))	82
	C=X(4)+X(5)*(A*X(7)-F)	83
	IF (A) 27,25,27	84
25	IF (B) 26,7,26	85
26	Y=-C/B	86
	GO TO 47	87
27	IF (B) 32,28,32	88
28	IF (C) 30,29,30	89
29	Y=0.	90
	GO TO 47	91
30	G=-C/A	92
	IF (G) 7,7,31	93
31	Y=SQRT(G)	94
	YY=-SQRT(G)	95
	GO TO 37	96
32	IF (C) 34,33,34	97
33	Y=-B/A	98
	YY=0.	99
	GO TO 37	100
34	D=4.*A*C/B**2	101
	IF (1.-D) 13,35,36	102
35	Y=-B/(2.*A)	103
	GO TO 47	104
36	E=SQRT(1.-D)	105
	Y=(-B/(2.*A))*(1.+E)	106
	YY=(-B/(2.*A))*(1.-E)	107
37	J=4	108
	DEPMIN=ABS(X(4))	109
	DO 39 I=6,8,2	110
	IF (DEPMIN-ABS(X(I))) 39,39,38	111
38	J=I	112
	DEPMIN=ABS(X(I))	113
39	CONTINUE	114
	K=J+1	115
	IF ((X(K)-Y)*(X(K)-YY)) 42,42,40	116
40	IF (ABS(X(K)-Y)-ABS(X(K)-YY)) 47,47,41	117
41	Y=YY	118
	GO TO 47	119
42	IF (J-6) 43,44,44	120
43	JJ=J+2	121
	KK=K+2	122
	GO TO 45	123
44	JJ=J-2	124
	KK=K-2	125
45	SLOPE=(X(KK)-X(K))/(X(JJ)-X(J))	126
	IF (SLOPE*X(J)*X(K)-Y) 46,46,47	127
46	Y=YY	128
47	X(9)=X(7)	129
	X(8)=X(6)	130
	X(7)=X(5)	131

X(6)=X(4)  
GO TO 6  
END

132  
133  
134

```

$IBFTC ATMOS
  SUBROUTINE ATMOS (ZFT, TM, SIGMA, RHO, THETA, DELTA, CA, AMU, K)
C THIS IS A SUBROUTINE TO COMPUTE CERTAIN ELEMENTS OF THE 1962
C U.S. STANDARD ATMOSPHERE UP TO 90 KILOMETERS.
C CALLING SEQUENCE...
C
C CALL ATMOS (ZFT, TM, SIGMA, RHO, THETA, DELTA, CA, AMU, K)
C   ZFT = GEOMETRIC ALTITUDE (FEET)
C   TM = MOLECULAR SCALE TEMPERATURE (DEGREES RANKINE)
C   SIGMA = RATIO OF DENSITY TO THAT AT SEA LEVEL
C   RHO = DENSITY(LB-SEC**2-FT**(-4) OR SLUG-FT**(-3))
C   THETA = RATIO OF TEMPERATURE TO THAT AT SEA LEVEL
C   DELTA = RATIO OF PRESSURE TO THAT AT SEA LEVEL
C   CA = SPEED OF SOUND (FT/SEC)
C   AMU = VISCOSITY COEFFICIENT (LB-SEC/FT**2)
C
C   K = 1 NORMAL
C       = 2 ALTITUDE LESS THAN -5000 METERS OR GREATER THAN 90 KM
C       = 3 FLOATING POINT OVERFLOW
C
C ALL DATA AND FUNDAMENTAL CONSTANTS ARE IN THE METRIC SYSTEM AS
C THESE QUANTITIES ARE DEFINED AS EXACT IN THIS SYSTEM.
C
C THE RADIUS OF THE EARTH (REFT59) IS THE VALUE ASSOCIATED WITH THE
C 1959 ARDC ATMOSPHERE SO THAT PROGRAMS CURRENTLY USING THE LIBRARY
C ROUTINE WILL NOT REQUIRE ALTERATION TO USE THIS ROUTINE.
COMMON/UNITS/SI
LOGICAL SI
DIMENSION HB(10), TMB(10), DELTAB(10), ALM(10)
DATA(HB(I), TMB(I), DELTAB(I), ALM(I), I=1,10)/
1 -5.0, 320.65, 1.75363E 00, -6.5,
2 0.0, 288.15, 1.00000E 00, -6.5,
3 11.0, 216.65, 2.23361E-01, 0.0,
4 20.0, 216.65, 5.40328E-02, 1.0,
5 32.0, 228.65, 8.56663E-03, 2.8,
6 47.0, 270.65, 1.09455E-03, 0.0,
7 52.0, 270.65, 5.82289E-04, -2.0,
8 61.0, 252.65, 1.79718E-04, -4.0,
9 79.0, 180.65, 1.0241 E-05, 0.0,
$ 88.743, 180.65, 1.6223 E-06, 0.0/
DATA REFT59/2.0855531E 07/, GZ /9.80665/,
1 AMZ /28.9644 /, RSTAR /8.31432/,
2 FTTOKM/3.048E-04 /, S /110.4 /,
3 AMUZ /1.2024E-05 /, CAZ /1116.45/,
4 RHOZ /0.076474 /, GZENG /32.1741/
C CONVERT GEOMETRIC ALTITUDE TO GEOPOTENTIAL ALTITUDE
C IF IN SI UNITS, CHANGE ZFT TO FEET
IF (SI) ZFT=ZFT*3.280833
HFT=(REFT59/(REFT59+ZFT))*ZFT
C CONVERT HFT AND ZFT TO KILOMETERS
Z=FTTOKM*ZFT
H=FTTOKM*HFT
K=1
TMZ=TMB(2)
IF (H.LT.-5.0.OR.Z.GT.90.0) GO TO 7
DO 1 M=1,10
IF (H-HB(M)) 2,3,1
1 CONTINUE
GO TO 7
2 M=M-1
3 DELH=H-HB(M)
IF (ALM(M).EQ.0.0) GO TO 4
TMK=TMB(M)+ALM(M)*DELH
C GRADIENT IS NON ZERO, PAGE 10, EQUATION 1.2.10-(3)

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        DELTA=DELTAB(M)*((TMB(M)/TMK)**(GZ*AMZ/(RSTAR*ALM(M))))
        GO TO 5
4      TMK=TMB(M)
C      GRADIENT IS ZERO, PAGE 10, EQUATION I.2.10-(4)
        DELTA=DELTAB(M)*EXP(-GZ*AMZ*DELH/(RSTAR*TMB(M)))
5      THETA=TMK/TMZ
        SIGMA=DELTA/THETA
        ALPHA=SQRT(THETA**3)*((TMZ+S)/(TMK+S))
C      CONVERSION TO ENGLISH UNITS
        TM=1.8*TMK
        RHO=RHOZ*SIGMA/GZENG
        CA=CAZ*SQRT(THETA)
        AMU=AMUZ*ALPHA/GZENG
        IF (SI) GO TO 100
        GO TO 101
100    TM=TM/1.8
        RHO=RHO*515.379
        CA=CA*.3048
        AMU=AMU*47.880258
        ZFT=ZFT/3.280833
C      IF IN SI UNITS*
C      TM          DEGREES KELVIN
C      RHO         KG/M**2
C      CA          M/SEC
C      AMU         (N-SEC)/M**2
C      ZFT        M
101    CONTINUE
        CALL OVERFL (J)
        GO TO (6,8),J
6      K=K+2
        GO TO 8
7      K=2
8      RETURN
        END

```

```

$IBFTC COAFBN
SUBROUTINE COAFBN
COMMON /WORDS/ WORD
COMMON /DESIGN/
1IDES ,JDES ,KDES ,MODE ,INIT ,IDUMP ,IAMTP ,IGASM,
2IDBURN,IAFTBN,IOCD ,IMCD ,IDSHOC,IMSHOC,NOZFLT,ITRYS ,
3LOOPER,NOMAP ,NUMMAP,MAPEDG,TCLALL,ERR(9)
COMMON /ALL1/
1PCNFGU,PCNCGU,T4GU ,DUMD1 ,DUMD2 ,DELFG ,DELFN ,DELSFC,
2ZFDS ,PCNFDS,PRFDS ,ETAFDS,WAFDS ,PRFCF ,ETAFCF,WAFCF ,
3ZCDS ,PCNCDS,PRCDS ,ETACDS,WACDS ,PRCCF ,ETACCF,WACCF ,
4T4DS ,WFBDS ,DTCODS,ETABDS,WA3CDS ,DPCODS,DTCCF,ETABCF,
5TFHPDS,CNHPDS,ETHPDS,TFHPCF,CNHPCF,ETHPCF,DHHPCF,T2DS ,
6TFLPDS,CNLPDS,ETL PDS,TFLPCF,CNLP CF,ETLPCF,DHLP CF,T21DS ,
7T24DS ,WFDS ,DTUDS,ETADS,WA23DS ,DPDUDS,DTDUCF,ETADCF,
8T7DS ,WFADS ,DTAFDS,ETAADS,WG6CDS ,DPAFDS,DTAF CF,ETAACF,
9A55 ,A25 ,A6 ,A7 ,A8 ,A9 ,A28 ,A29 ,
$PS55 ,AM55 ,CVDNOZ,CVMNOZ,A8SAV ,A9SAV ,A28SAV,A29SAV
COMMON /ALL2/
1T1 ,P1 ,H1 ,S1 ,T2 ,P2 ,H2 ,S2 ,
2T21 ,P21 ,H21 ,S21 ,T3 ,P3 ,H3 ,S3 ,
3T4 ,P4 ,H4 ,S4 ,T5 ,P5 ,H5 ,S5 ,
4T55 ,P55 ,H55 ,S55 ,BLF ,BLC ,BLDU ,BLOB ,
5CNF ,PRF ,ETAF ,WAF ,WAF ,WA3 ,WG4 ,FAR4 ,
6CNC ,PRC ,ETAC ,WACC ,WAC ,ETAB ,DPCOM ,DUMP ,
7CNHP ,ETATHP,DHTCHP,DHTC ,BLHP ,WG5 ,FAR5 ,CS ,
8CNLP ,ETATLP,DHTCLP,DHTF ,BLLP ,WG55 ,FAR55 ,HPEXT ,
9AM ,ALTP ,ETAR ,ZF ,PCNF ,ZC ,PCNC ,WFB ,
$TFFHP ,TFFLP ,PCBLF ,PCBLC ,PCBLDU,PCBLOB,PCBLHP,PCBLLP
COMMON /ALL3/
1XP1 ,XWAF ,XWAC ,XBLF ,XBLDU ,XH3 ,DUMS1 ,DUMS2 ,
2XT21 ,XP21 ,XH21 ,XS21 ,T23 ,P23 ,H23 ,S23 ,
3T24 ,P24 ,H24 ,S24 ,T25 ,P25 ,H25 ,S25 ,
4T28 ,P28 ,H28 ,S28 ,T29 ,P29 ,H29 ,S29 ,
5WAD ,WFD ,WG24 ,FAR24 ,ETAC ,DPDUC ,BYPASS,DUMS3 ,

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6TS28 ,PS28 ,V28 ,AM28 ,TS29 ,PS29 ,V29 ,AM29 , 35
7XT55 ,XP55 ,XH55 ,XS55 ,XT25 ,XP25 ,XH25 ,XS25 , 36
8XWFB ,XWG55 ,XFAR55,XWFD ,XWG24 ,XFAR24,XXP1 ,DUMB , 37
9T6 ,P6 ,H6 ,S6 ,T7 ,P7 ,H7 ,S7 , 38
,T8 ,P8 ,H8 ,S8 ,T9 ,P9 ,H9 ,S9 , 39
COMMON /ALL4/ 40
1WG6 ,WFA ,WG7 ,FAR7 ,ETAA ,DPAFT ,V55 ,V25 , 41
2PS6 ,V6 ,AM6 ,TS7 ,PS7 ,V7 ,AM7 ,AM25 , 42
3TS8 ,PS8 ,V8 ,AM8 ,TS9 ,PS9 ,V9 ,AM9 , 43
4VA ,FRD ,VJD ,FGMD ,VJM ,FGMM ,FGPD ,FGPM , 44
5FGM ,FGP ,WFT ,WGT ,FART ,FG ,FN ,SFC , 45
6WA32 ,DPWGD,DPWING,WA32DS,A38 ,AM38 ,V38 ,T38 , 46
7H38 ,P38 ,TS38 ,PS38 ,T39 ,H39 ,P39 ,TS39 , 47
8V39 ,AM39 ,A39 ,BPRINT,WG37 ,CVDWNG,FGMWNG,FGPWNG, 48
9FNWING,FNMAIN,FWOVFN,PS39 ,FFQVFN,FCOVFN,FMNOFN,FNOVFD, 49
,VJW ,T22 ,P22 ,H22 ,S22 ,T50 ,P50 ,H50 50
COMMON /ALL5/ 51
1S50 ,WA22 ,ZI ,PCNI ,CNI ,PRI ,ETAI ,WACI , 52
2TFFIP ,CNIP ,ETATIP,DMTCIP,DMTI ,BLIP ,PCBLIP,PCNIGU, 53
3ZIDS ,PCNIDS,PRI DS ,ETAIDS,WAIDS ,PRICF ,ETAICF,WAICF , 54
4TFIPDS,CNIPDS,ETIPDS,TFIPCF,CNIPCF,ETIPCF,DMIPCF,WAICDS, 55
5WAI ,PCBLI,BLI ,T22DS ,WA21 ,WG50 ,FAR50 ,A24 , 56
6AM23 ,DUMSPL,FXFN2M,FXM2CP,AFTFAN,PUNT ,PCBLID,P6DSAV, 57
7AM6DSV,ETAASV,FAR7SV,T4PBL ,T41 ,FAN ,ISPOOL 58
COMMON /VOLS/ VFAN,VINTC,VCOMP,VCOMB,VHPTRB,VIPTRB,VLPTRB,VAFTBN, 59
1 VFDUCT,VMDUCT 60
COMMON/UNITS/SI 61
LOGICAL SI 62
COMMON/WHRERR/ICOFB,ICODUC,ICOMIX 63
DIMENSION Q(9) 64
DATA AWORD/6HCOAFBN/ 65
WORD=AWORD 66
Q(2)=0. 67
Q(3)=0. 68
IF (SI) GO TO 100 69
AJ=778.26 70
AJX=2.719 71
CAPSF=2116.2170 72
G=32.174049 73
PRATM=14.696 74
TDEL=2000.0 75
T7MAX=4000.0 76
RA=.0252 77
GO TO 101 78
100 AJ=1.0 79
AJX=1.0 80
CAPSF=101325.0 81
G=1.0 82
PRATM=14.696/101324.6 83
TDEL=1111.0 84
T7MAX=2222.0 85
RA=286.9 86
101 CONTINUE 87
ICOFB=0 88
C*** P6DS AND AM6DS ARE SET FOR GENERALIZATION OF AFTERBURNER 89
C*** EFFICIENCY MAP GENERALIZATION 90
IF (IDES.EQ.1) P6DS=P6*PRATM 91
IF (IDES.EQ.1) AM6DS=AM6 92
WF6 = FAR55*WG55/(FAR55+1.) 93
IF(IGASMX.GT.0) WF6 = WF6 + FAR24*WG24/(FAR24+1.) 94
WA6=WF6-WF6 95
C *** DRY LOSS 96
WG6C=WG6*SQRT(T6)/P6 97
IF (IDES.EQ.1) WG6CDS=WG6C 98
DPAFT=DPAFDS*(WG6C/WG6CDS) 99
IF (DPAFT.GT.1.) DPAFT=1. 100
P7=P6*(1.-DPAFT) 101
A7=A6 102
FAR6=WF6/WA6 103
CALL PROCOM (FAR6,T6,XX1,XX2,XX3,XX4,PHI6,XX6) 104
WQA=WG6/A7 105
C1=P7*SQRT(G/(T6*AJ))*CAPSF 106
AM7=AM6 107

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	TS7=0.875*T6	108
1	DO 2 I=1,15	109
	CALL PROCOM (FAR6,TS7,CS7,AK7,CP7,REX7,PHIS7,HS7)	110
	V7=AM7*CS7	111
	HSCAL=H6-V7**2/(2.*G*AJ)	112
	DELHS=HSCAL-HS7	113
	IF (ABS(DELHS).LE.0.0005*HSCAL) GO TO 3	114
2	TS7=TS7+DELHS/CP7	115
	ICDAFB=1	116
	GO TO 14	117
3	WQAT=C1*SQRT(AK7/REX7)*AM7/(1.+(AK7-1.)*AM7**2/2.)*((AK7+1.)/(2.*	118
	1(AK7-1.)))	119
	DIR=WQA/WQAT	120
	EW=(WQA-WQAT)/WQA	121
	CALL AFQUIR (Q(1),AM7,EW,0.,40.,.001,DIR,AM7T,IGD)	122
	ICDAFB=2	123
	GO TO (4,5,14),IGD	124
4	AM7=AM7T	125
	IF (AM7.GE.1.0) AM7=0.9	126
	GO TO 1	127
5	PS7=P7/EXP((PHI6-PHIS7)/REX7)	128
	IF (IAFTBN.GT.0) GO TO 7	129
C ***	NON-AFTERBURNING	130
6	T7=T6	131
	WFA=0.0	132
	FAR7=FAR6	133
	WG7=WG6	134
	IF (IDES.EQ.1.AND.T7DS.NE.0.) GO TO 7	135
	GO TO 20	136
C ***	AFTERBURNING	137
7	IF (IAFTBN .EQ. 2) T7=T6+TDEL	138
	IF (IDES.EQ.1) T7=T7DS	139
	IF (T7.LE.T6) GO TO 6	140
	RH065=CAPSF*PS7/(AJ*REX7*TS7)	141
	PS65=PS7	142
	V65=V7	143
	Q(2)=0.	144
	Q(3)=0.	145
8	IF (T7 .GT. T7MAX) T7=T7MAX	146
	IF (T7 .LT. T6) T7=T6*1.001	147
	IF (SI) T7=T7*9.0/5.0	148
	HV=((((( (-.4594317E-19*T7)-.2034116E-15)*T7+.2783643E-11)*T7+.2051	149
	1501E-07)*T7-.2453116E-03)*T7-.9433296E-01)*T7+.1845537E+05	150
	IF (SI) T7=T7*5.0/9.0	151
	IF (SI) HV=HV*2325.4295	152
	CALL THERMO (P7,HA,T7,XX1,XX2,1,FAR6,0)	153
C ***	TO ALTER DESIGN ABETAA MAP FROM GENERAL TO SPECIFIC MAP	154
	IF (IDES.NE.1) GO TO 9	155
	FAR7DS=(HA-H6)/(HV*ETAADS)	156
	CALL ETAAB (0.,0.,0.,0.,ETAADS,ETAASV,P6DS,P6DSAV,AM6DS,AM6DSV,IDE	157
	IS,FAR7DS,FAR7SV)	158
	T7=T6	159
	GO TO 20	160
9	P6GS=P6*PRATM	161
	FAR7GS=(HA-H6)/(HV*ETAADS)	162
	DO 10 II=1,15	163
	CALL ETAAB (FAR7GS,AM6,P6GS,ETAA,ETAADS,ETAASV,P6DS,P6DSAV,AM6DS,A	164
	IM6DSV,IDES,FAR7DS,FAR7SV)	165
	FAR7=(HA-H6)/(HV*ETAA)	166
	DELFA7=ABS(FAR7-FAR7GS)	167
	IF (DELFA7.LE.0.01*FAR7) GO TO 11	168
10	FAR7GS=FAR7	169
11	CONTINUE	170
	IF (FAR7.GT.0.) GO TO 12	171
	ICDAFB=3	172
	CALL ERROR	173
12	WFA=FAR7*WG6	174
	IF (IAFTBN.EQ.1) GO TO 15	175
	ERRW=(WFA-WFAX)/WFA	176
	DIR=SQRT(WFA/WFAX)	177
	CALL AFQUIR (Q(1),T7,ERRW,0.,30.,.0005,DIR,T7T,IGD)	178
	ICDAFB=4	179
	GO TO (13,16,14),IGD	180
13	T7=T7T	181

	GO TO 8	182
14	CALL ERROR	183
15	WFA=WFA	184
16	FAR7=(WF6+WFA)/WA6	185
	WG7=WG6+WFA	186
C ***	MOMENTUM LOSS	187
	CALL PROCOM (FAR7,T7,XX1,XX2,XX3,REX7,PHI7,H7)	188
	RHO7=CAPSF*P7/(AJ*REX7*T7)	189
	V7=WG7/(RHO7*A7)	190
	Q(2)=0.	191
	Q(3)=0.	192
	PS7=PS65-0.01	193
17	RHO7=WG7/(V7*A7)	194
	HS7=H7-V7**2/(2.*G*AJ)	195
	CALL THERMO (1.0,HS7,TS7,PHIS7,XX2,1,FAR7,1)	196
	IF (TS7.GE.301.) GO TO 18	197
	CALL THERMO (1.0,HS7,400.,PHIS7,XX2,1,FAR7,0)	198
	V7=SQRT(2.*G*AJ*(H7-HS7))	199
	GO TO 17	200
18	PS7=RHO7*AJ*REX7*TS7/CAPSF	201
	PS7A=PS65+(RHO65*V65**2-RHO7*V7**2)/(G*CAPSF)	202
	DIR=SQRT(ABS(PS7/PS7A))	203
	EP=(PS7-PS7A)/PS7	204
	CALL AFQUIR (Q(1),V7,EP,0.,50.,.001,DIR,V7T,IGO)	205
	V7=V7T	206
	IF (V7.LT.100.) V7=100.	207
	ICOFB=5	208
	GO TO (17,19,14), IGO	209
19	P7=PS7*EXP((PHI7-PHIS7)/REX7)	210
	CALL PROCOM (FAR7,TS7,CS7,XX2,XX3,XX4,XX5,XX6)	211
	AM7=V7/CS7	212
20	CALL THERMO (P7,H7,T7,S7,XX2,1,FAR7,0)	213
	IF(VAFTBN.EQ.0.0) GO TO 31	214
	Q(2)=0.0	215
	Q(3)=0.0	216
	WG7P=WG7	217
	H7P=H7	218
	P7DOT=DERIV(18,P7)	219
28	CONTINUE	220
	CALL THERMO(P7,H7,T7,S7,XX2,1,FAR7,0)	221
	WG7=WG7P-P7DOT*VAFTBN/T7/(1.4*RA)	222
	U7=H7-AJX*RA*T7	223
	U7DOT=DERIV(19,U7)	224
	H7X=(WG7P*H7P-(WG7P-WG7)*U7-U7DOT*P7*VAFTBN/T7/RA )/WG7	225
	ERRW=(H7-H7X)/H7	226
	DIR=SQRT(ABS(H7/H7X))	227
	CALL AFQUIR(Q(1),T7,ERRW,0.,20.,0.0001,DIR,T7T,IGO)	228
	ICOFB=6	229
	GO TO (29,31,30), IGO	230
29	T7=T7T	231
	GO TO 28	232
30	CALL ERROR	233
31	CONTINUE	234
	ICOFB=0	235
	CALL COMNOZ	236
	RETURN	237
C		238
C		239
	END	240

\$IBFTC	COCOMB	1
	SUBROUTINE COCOMB	2
	COMMON /WORDS/ WORD	3
	COMMON /DESIGN/	4
	1IDES ,JDES ,KDES ,MODE ,INIT ,IDUMP ,IAHTP ,IGASMX,	5
	2IDBURN,IAFTBN,IDCD ,IMCD ,IDSHOC,IMSHOC,NOZFLT,ITRYS ,	6
	3LOOPER,NOMAP ,NUMMAP,MAPEDG,TOLALL,ERR(9)	7
	COMMON /ALL1/	8
	1PCNFGU,PCNCGU,T4GU ,DUMD1 ,DUMD2 ,DELFG ,DELFN ,DELSFC,	

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2ZFDS ,PCNFDS,PRFDS ,ETAFDS,WAFDS ,PRFCF ,ETAFCF,WAFCF ,
3ZCDS ,PCNCDS,PRCDS ,ETACDS,WACDS ,PRCCF ,ETACCF,WACCF ,
4T4DS ,WFBDS ,DTCODS,ETABDS,WA3CDS,DPCODS,DTCCOF,ETABCF,
5TFHPDS,CNHPDS,ETHPDS,TFHPCF,CNHPCF,ETHPCF,DHHPCF,T2DS ,
6TFLPDS,CNLPDS,ETLPDS,TFLPCF,CNLPFC,ETLPCF,DHLPFC,T21DS ,
7T24DS ,WFDDSD,DTDUOS,ETADDS,WA23DS,DPDUOS,DTDUFC,ETADCF,
8T7DS ,WFADS ,DTAFDS,ETAADS,WG6CDS,DPAFDS,DTAFCF,ETAACF,
9A55 ,A25 ,A6 ,A7 ,A8 ,A9 ,A28 ,A29 ,
$PS55 ,AM55 ,CVDNOZ,CVMNOZ,ABS AV ,A9SAV ,A28SAV,A29SAV
COMMON /ALL2/
1T1 ,P1 ,H1 ,S1 ,T2 ,P2 ,H2 ,S2 ,
2T21 ,P21 ,H21 ,S21 ,T3 ,P3 ,H3 ,S3 ,
3T4 ,P4 ,H4 ,S4 ,T5 ,P5 ,H5 ,S5 ,
4T55 ,P55 ,H55 ,S55 ,BLF ,BLC ,BLDU ,BLOB ,
5CNF ,PRF ,ETAF ,WAF ,WAF ,WA3 ,WG4 ,FAR4 ,
6CNC ,PRC ,ETAC ,WACC ,WAC ,ETAB ,DPCOM ,DUMP ,
7CNHP ,ETATHP,DHTCHP,DHTC ,BLHP ,WG5 ,FAR5 ,CS ,
8CNLP ,ETATLP,DHTCLP,DHTF ,BLLP ,WG55 ,FAR55 ,HPEXT ,
9AM ,ALTP ,ETAR ,ZF ,PCNF ,ZC ,PCNC ,WFB ,
$TFFHP ,TFFLP ,PCBLF ,PCBLC ,PCBLDU,PCBLOB,PCBLHP,PCBLLP
COMMON /ALL3/
1XP1 ,XWAF ,XWAC ,XBLF ,XBLDU ,XH3 ,DUMS1 ,DUMS2 ,
2XT21 ,XP21 ,XH21 ,XS21 ,T23 ,P23 ,H23 ,S23 ,
3T24 ,P24 ,H24 ,S24 ,T25 ,P25 ,H25 ,S25 ,
4T28 ,P28 ,H28 ,S28 ,T29 ,P29 ,H29 ,S29 ,
5WAD ,WFD ,WG24 ,FAR24 ,ETAD ,DPOUC ,BYPASS,DUMS3 ,
6TS28 ,PS28 ,V28 ,AM28 ,TS29 ,PS29 ,V29 ,AM29 ,
7XT55 ,XP55 ,XH55 ,XS55 ,XT25 ,XP25 ,XH25 ,XS25 ,
8XWFB ,XWG55 ,XFAR55,XWFD ,XWG24 ,XFAR24,XXP1 ,DUMB ,
9T6 ,P6 ,H6 ,S6 ,T7 ,P7 ,H7 ,S7 ,
$T8 ,P8 ,H8 ,S8 ,T9 ,P9 ,H9 ,S9
COMMON /ALL4/
1WG6 ,WFA ,WG7 ,FAR7 ,ETAA ,DPAFT ,V55 ,V25 ,
2PS6 ,V6 ,AM6 ,TS7 ,PS7 ,V7 ,AM7 ,AM25 ,
3TS8 ,PS8 ,V8 ,AM8 ,TS9 ,PS9 ,V9 ,AM9 ,
4VA ,FRD ,VJD ,FGMD ,VJM ,FGMM ,FGPD ,FGPM ,
5FGM ,FGP ,WFT ,WGT ,FART ,FG ,FN ,SFC ,
6WA32 ,DPWGDS,DPWING,WA32DS,A38 ,AM38 ,V38 ,T38 ,
7M38 ,P38 ,TS38 ,PS38 ,T39 ,H39 ,P39 ,TS39 ,
8V39 ,AM39 ,A39 ,BPRINT,WG37 ,CVDWNG,FGMWNG,FGPWNG,
9FNWING,FNMAIN,FMOVFN,PS39 ,FFOVFN,FCOVFN,FMNOFN,FNOVFD,
$VJW ,T22 ,P22 ,H22 ,S22 ,T50 ,P50 ,H50
COMMON /ALL5/
1S50 ,WA22 ,ZI ,PCNI ,CNI ,PRI ,ETAI ,WACI ,
2TFFIP ,CNIP ,ETATIP,DHTCIP,DHTI ,BLIP ,PCBLIP,PCNIGU,
3ZIDS ,PCNIDS,PRIDS ,ETAIOS,WAIDS ,PRICF ,ETAI CF,WAICF ,
4TFIPDS,CNIPDS,ETIPDS,TFIPCF,CNIPCF,ETIPCF,DHIPCFC,WAICDS,
5WAI ,PCBLI ,BLI ,T22DS ,WA21 ,WG50 ,FAR50 ,A24 ,
6AM23 ,DUMSPL,FXFN2M,FXM2CP,AFTFAN,PUNT ,PCBLID,P6DSAV,
7AM6DSV,ETAASV,FAR7SV,T4PBL ,T41 ,FAN ,ISPOOL
COMMON /DYN/ ITRAN,TIME,DT,TF ,JTRAN,NSTEP ,TPRINT,OTPRNT
COMMON /VOLS/ VFAN,VINTC,VCOMP,VCOMB,VHPTRB,VIPTRB,VLPTRB,VAFTBN,
1 VFDUCT,VWDUCT
COMMON /UNITS/ SI
LOGICAL FXFN2M,FXM2CP,SI
COMMON / COMB/PSI(15),DELT(15,15),ETA(15,15),NPS,NPT(15)
DIMENSION Q(9),DUMBO(15,15)
DATA AWORD/6HCOCOMB/
WORD=AWORD
IF(SI) GO TO 100
RA=.0252
AJ=2.719
TMAX=4000.
TMIN=1000.
GO TO 101
100 RA=286.9
AJ=1.0
TMAX=2222.
TMIN=555.5
101 CONTINUE
Q(2)=0.
Q(3)=0.
P3PSI=14.696*P3
IF(SI) P3PSI=.14504E-3*P3

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	WA3C=WA3*SQRT(T3)/P3PSI	83
	IF(SI) WA3C=WA3*SQRT(T3)/P3	84
	IF (IDES.EQ.1) WA3CDS=WA3C	85
	DPCOM=DPCODS*(WA3C/WA3CDS)	86
	IF (DPCOM.GT.1.) DPCOM=1.	87
	P4=P3*(1.-DPCOM)	88
	IF(IDES.EQ.1.AND.MODE.EQ.2) T4=(TMAX+TMIN)/2.	89
	IF(ITRAN.EQ.1.AND.MODE.EQ.2) CALL FCNTRL	90
1	IF(T4.GT.TMAX) T4=TMAX	91
	IF(T4.GE.TMIN) GO TO 2	92
	T4=TMIN	93
	IF (MODE.EQ.1) MAPEDG=1	94
2	DTCO=T4-T3	95
	IF(SI) DTCO=DTCO*9.0/5.0	96
	P3PSIN=P3PSI	97
	CALL SEARCH (-1.,P3PSIN,DTCO,ETAB,DUMMY,PSI(1),NPS,DELT(1,1),ETA(1	98
	1,1),DUMBO(1,1),NPT(1),15,15,IGO)	99
	IF (IGO.EQ.7) CALL ERROR	100
	IF (IDES.NE.1) GO TO 4	101
	ETABCF=ETABDS/ETAB	102
4	ETAB=ETABCF*ETAB	103
	IF (SI) T4=T4*9.0/5.0	104
	HV=(((((-.4594317E-19*T4)-.2034116E-15)*T4+.2783643E-11)*T4+.2051	105
	1501E-07)*T4-.2453116E-03)*T4-.9433296E-01)*T4+.1845537E+05	106
	IF (SI) T4=T4*5.0/9.0	107
	IF (SI) HV=HV*2325.4295	108
	CALL THERMO (P4,HA,T4,XX1,XX2,0,0,0,0)	109
	FAR4=(HA-H3)/(HV*ETAB)	110
	IF (FAR4.LT.0.) FAR4=0.	111
	WFBX=FAR4*WA3	112
	IF (MODE.NE.2) GO TO 7	113
	ERRW=(WFB-WFBX)/WFB	114
	DIR=SQRT(WFB/WFBX)	115
	CALL AFQUIR (Q(1),T4,ERRW,0.,20.,0.0001,DIR,T4T,IGO)	116
	GO TO (5,8,6),IGO	117
5	T4=T4T	118
	GO TO 1	119
6	CALL ERROR	120
7	WFB=WFBX	121
	IF (IDES.EQ.1) WFBDS=WFB	122
8	CALL THERMO (P4,H4,T4,S4,XX2,1,FAR4,0)	123
	WG4=WFB+WA3	124
	IF(VCOMB.EQ.0.0) GO TO 21	125
	Q(2)=0.0	126
	Q(3)=0.0	127
	WG4P=WG4	128
	H4P=H4	129
	P4DOT=DERIV(10,P4)	130
18	CONTINUE	131
	CALL THERMO(P4,H4,T4,S4,XX2,1,FAR4,0)	132
	WG4=WG4P-P4DOT*VCOMB/T4/1.4/RA	133
	U4=H4-AJ*RA*T4	134
	U4DOT=DERIV(11,U4)	135
	H4X=(WG4P*H4P-(WG4P-WG4)*U4-U4DOT*P4*VCOMB/T4/RA)/WG4	136
	ERRW=(H4-H4X)/H4	137
	DIR=SQRT(ABS(H4/H4X))	138
	CALL AFQUIR(Q(1),T4,ERRW,0.,20.,0.0001,DIR,T4T,IGO)	139
	GO TO (19,21,20),IGO	140
19	T4=T4T	141
	GO TO 18	142
20	CALL ERROR	143
21	CONTINUE	144
	IF (IDES.EQ.1) WRITE(6,10) WA3CDS,ETABCF	145
	IF (FXM2CP.OR.ISPOOL.EQ.1) GO TO 9	146
	CALL COMPTB	147
	RETURN	148
9	P50=P4	149
	H50=H4	150
	T50=T4	151
	S50=S4	152
	FAR50=FAR4	153
	WG50=WG4	154
C	SET HIGH PRESSURE TURBINE PARAMETERS TO ZERO, NOT USED	155

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TFFHP=0.
CNHP=0.
DHTC=0.
DHTCHP=0.
ETATHP=0.
IF (FXM2CP) CALL COIPTB
IF (FXM2CP) RETURN
C IF RUNNING 1 SPOOL TJ GO TO COHPTB TO ZERO OUT COIPTB
CALL COHPTB
RETURN
C
C
C
10 FORMAT (17HOCOMBUSTOR DESIGN,7X8H WA3CDS=,E15.8,8H ETABCF=,E15.8)
END

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\$IBFTC COCOMP

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SUBROUTINE COCOMP
COMMON /WORDS/ WORD
COMMON /DESIGN/
1IDES ,JDES ,KDES ,MODE ,INIT ,IDUMP ,IAMTP ,IGSMX,
2IDBURN,IAFTBN,IDCD ,IMCO ,IDSHOC,IMSHOC,NOZFLT,I TRYS ,
3LOOPER,NOMAP ,NUMMAP,MAPEOG,TOLALL,ERR(9)
COMMON /ALL1/
1PCNFGU,PCNCGU,T4GU ,DUMD1 ,DUMD2 ,DELFG ,DELFN ,DELSFC,
2ZFDS ,PCNFDS,PRFDS ,ETAFDS,WA FDS ,PRFCF ,ETAFCF,WAFCF ,
3ZCDS ,PCNCDS,PRCDS ,ETACDS,WACDS ,PRCCF ,ETACCF,WACCF ,
4T4DS ,WFBDS ,DTCODS,ETABDS,WA3CDS,CPCODS,DTCCOF,ETABCF,
5TFHPDS,CNHPDS,ETHPDS,TFHPCF,CNHPCF,ETHPCF,DHHPCF,T2DS ,
6TFLPDS,CNLPDS,ETLPDS,TFLPCF,CNLP CF,ETLPCF,DHLP CF,T21DS ,
7T24DS ,WFDD S ,DTODS,ETADS,WA23DS,DPDUDS,DTDU CF,ETADCF,
8T7DS ,WFADS ,DTAFDS,ETAADS,WG6CDS,DPAFDS,DTAFCF,ETAACF,
9A55 ,A25 ,A6 ,A7 ,A8 ,A9 ,A28 ,A29 ,
10$PS55 ,AM55 ,CVDNDZ,CVMNDZ,A8SAV ,A9SAV ,A28SAV,A29SAV
COMMON /ALL2/
1T1 ,P1 ,H1 ,S1 ,T2 ,P2 ,H2 ,S2 ,
2T21 ,P21 ,H21 ,S21 ,T3 ,P3 ,H3 ,S3 ,
3T4 ,P4 ,H4 ,S4 ,T5 ,P5 ,H5 ,S5 ,
4T55 ,P55 ,H55 ,S55 ,BLF ,BLC ,BLDU ,BLOB ,
5CNF ,PRF ,ETAF ,WAF ,WAF ,WA3 ,WG4 ,FAR4 ,
6CNC ,PRC ,ETAC ,WACC ,WAC ,ETAB ,DPCOM ,DUMP ,
7CNHP ,ETATHP,DHTCHP,DHTC ,BLHP ,WG5 ,FAR5 ,CS ,
8CNLP ,ETATLP,DHTCLP,DHTF ,BLLP ,WG55 ,FAR55 ,HPEXT ,
9AM ,ALTP ,ETAR ,ZF ,PCNF ,ZC ,PCNC ,WFB ,
10$TFFHP ,TFFLP ,PCBLF ,PCBLC ,PCBLDU,PCBLOB,PCBLHP,PCBLLP
COMMON /ALL3/
1XP1 ,XWAF ,XWAC ,XBLF ,XBLDU ,XH3 ,DUMS1 ,DUMS2 ,
2XT21 ,XP21 ,XH21 ,XS21 ,T23 ,P23 ,H23 ,S23 ,
3T24 ,P24 ,H24 ,S24 ,T25 ,P25 ,H25 ,S25 ,
4T28 ,P28 ,H28 ,S28 ,T29 ,P29 ,H29 ,S29 ,
5WAD ,WFD ,WG24 ,FAR24 ,ETAC ,DPDUC ,BYPASS,DUMS3 ,
6TS28 ,PS28 ,V28 ,AM28 ,TS29 ,PS29 ,V29 ,AM29 ,
7XT55 ,XP55 ,XH55 ,XS55 ,XT25 ,XP25 ,XH25 ,XS25 ,
8XWFB ,XWG55 ,XFAR55,XWFD ,XWG24 ,XFAR24,XXP1 ,DUMB ,
9T6 ,P6 ,H6 ,S6 ,T7 ,P7 ,H7 ,S7 ,
10$T8 ,P8 ,H8 ,S8 ,T9 ,P9 ,H9 ,S9
COMMON /ALL4/
1WG6 ,WFA ,WG7 ,FAR7 ,ETAA ,DPAFT ,V55 ,V25 ,
2PS6 ,V6 ,AM6 ,TS7 ,PS7 ,V7 ,AM7 ,AM25 ,
3TS8 ,PS8 ,V8 ,AM8 ,TS9 ,PS9 ,V9 ,AM9 ,
4VA ,FRD ,VJD ,FGMD ,VJM ,FGMM ,FGPD ,FGPM ,
5FGM ,FGP ,WFT ,WGT ,FART ,FG ,FN ,SFC ,
6WA32 ,DPWGDS,DPWING,WA32DS,A38 ,AM38 ,V38 ,T38 ,
7H38 ,P38 ,TS38 ,PS38 ,T39 ,H39 ,P39 ,TS39 ,
8V39 ,AM39 ,A39 ,BPRINT,WG37 ,CVDWNG,FGMWNG,FGPWNG,
9FNWING,FNMAIN,FNOVFN,PS39 ,FFOVFN,FCOVFN,FMNOFN,FNOVFD,
10$VJW ,T22 ,P22 ,H22 ,S22 ,T50 ,P50 ,H50
COMMON /ALL5/
1S50 ,WA22 ,ZI ,PCNI ,CNI ,PRI ,ETAI ,WACI ,
2TFFIP ,CNIP ,ETATIP,DHTCIP,DHTI ,BLIP ,PCBLIP,PCNIGU,

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	3ZIDS ,PCNIDS,PRIDS ,ETAIDS,WAIDS ,PRICF ,ETAICF,WAICF ,	54
	4TFIPDS,CNIPDS,ETIPDS,TFIPCF,CNIPCF,ETIPCF,DHIFCF,WAICDS,	55
	5WAI ,PCBLI ,BLI ,T22DS ,WA21 ,WG50 ,FAR50 ,A24 ,	56
	6AM23 ,DUMSPL,FXFN2M,FXM2CP,AFTFAN,PUNT ,PCBLID,P6DSAV,	57
	7AM6DSV,ETAASV,FAR7SV,T4PBL ,T41 ,FAN ,ISPOOL	58
	COMMON /VOLS/ VFAN,VINTC,VCOMP,VCOMB,VHPTRB,VIPTRB,VLPTRB,VAFTBN,	59
	1 VFDUCT,VWDUCT	60
	COMMON /FLOWS/ WAFP,WAIP,WACP	61
	COMMON /UNITS/ SI	62
	LOGICAL FXFN2M,FXM2CP,DUMSPL-FAN,SI	63
	COMMON / COMP/CNX(15),PRX(15,15),WACX(15,15),ETAX(15,15),	64
	1NCN,NPT(15)	65
	DIMENSION Q(9),WLH(2)	66
	DATA AWORD,WLH/6HCOCOMP,6H (LO) ,6H (HI) /	67
	WORD=AWORD	68
	IF (SI) GO TO 100	69
	TSTD=518.668	70
	PSTD=1.0	71
	RA=.0252	72
	AJ=2.719	73
	GO TO 101	74
100	TSTD=288.149	75
	PSTD=101325.	76
	RA=286.9	77
	AJ=1.0	78
101	THETA=SQRT(T21/TSTD)	79
	DELTA=P21/PSTD	80
	IF (IDES.NE.1) GO TO 1	81
	THETAD=THETA	82
	WACDS=WAC	83
	WACC=WAC*THETA/DELTA	84
	IF (.NOT.FXM2CP) PCNC=PCNCDS	85
1	IF (.NOT.FXM2CP) GO TO 2	86
C	SPEEDS OF MIDDLE AND INNER SPOOL ARE THE SAME	87
	SPDMID=CNI*SQRT(T22/TSTD)	88
	CNC=SPDMID/THETA	89
	PCNC=100.*CNC*THETA/THETAD	90
	IF (IDES.EQ.1) PCNCDS=PCNC	91
2	CNC=PCNC*THETAD/(100.*THETA)	92
	IF (ZC.LT.0.) ZC=0.	93
	IF (ZC.GT.1.) ZC=1.	94
	CNCS=CNC	95
	IF (ISPOOL.EQ.1) GO TO 12	96
	CALL SEARCH (ZC,CNC,PRC,WACC,ETAC,CNX(1),NCN,PRX(1,1),WACX(1,1),ET	97
	LAX(1,1),NPT(1),15,15,IGO)	98
	GO TO 13	99
12	PRC=1.	100
	ETAC=1.	101
	WAC=WA21	102
	WACC=WAC*THETA/DELTA	103
	CNC=1.	104
	PRCCF=1.	105
13	IF (MODE.EQ.1) GO TO 4	106
	IF ((CNC-CNCS).GT.0.0005*CNC) MAPEDG=1	107
4	IF (IGO.EQ.1.OR.IGO.EQ.2) WRITE (8,9) CNCS,WLH(IGO)	108
	WAC=WACC*DELTA/THETA	109
	IF (IDES.NE.1) GO TO 5	110
	T21DS=T21	111
	IF (ISPOOL.GE.2) PRCCF=(PRCDS-1.)/(PRC-1.)	112
	ETACCF=ETACDS/ETAC	113
	IF (ISPOOL.EQ.1) ETACCF=1.0	114
	WACCF=WACDS/WAC	115
	WRITE (6,10) PRCCF,ETACCF,WACCF,T21DS	116
5	PRC=PRCCF*(PRC-1.)+1.	117
	ETAC=ETACCF*ETAC	118
	WAC=WACCF*WAC	119
	WACP=WAC	120
	IF (.NOT.DUMSPL.OR.PCBLID.NE.0..OR..NOT.FAN) GO TO 6	121
	WA22=WAC	122
	WAI=WA22	123
	WACI=WACC*WACCF	124
6	WA32=WAI-WAC	125
	BLI=WA32	126
	WA21=WAC	127

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WACC=WACC*WACCF
PCBLI=BLI/WAI
CALL WDUCT1
IF (PCBLID.EQ.0.) ERR(7)=(WAC-WAI)/WAC
IF (.NOT.FAN) ERR(5)=(WAF-WAC-BLF)/WAC
IF (IDES.EQ.1.AND.PCBLID.EQ.0.) ERR(7)=1.E-4
CALL THCOMP (PRC,ETAC,T21,H21,S21,P21,T3,H3,S3,P3)
IF(VCOMP.EQ.0.0) GO TO 21
Q(2)=0.0
Q(3)=0.0
H3P=H3
P3DOT=DERIV(8,P3)
18 CONTINUE
CALL THERMO(P3,H3,T3,S3,XX2,0,0,0,0)
WAC=WAC-P3DOT*VCOMP/T3/1.4/RA
U3=H3-AJ*RA*T3
U3DOT=DERIV(9,U3)
H3X=(WAC*H3P-(WAC-P*WAC)*U3-U3DOT*P3*VCOMP/T3/RA)/WAC
ERRW=(H3-H3X)/H3
DIR=SQRT(ABS(H3/H3X))
CALL AFQUIR(Q(1),T3,ERRW,0.,20.,0.0001,DIR,T3T,IGO)
GO TO (19,21,20), IGO
19 T3=T3T
GO TO 18
20 CALL ERROR
21 CONTINUE
IF (PCBLC.GT.0.) BLC=PCBLC*WAC
WA3=WAC-BLC
BLDU=PCBLDU*BLC
BLOB=PCBLOB*BLC
BLHP=PCBLHP*BLC
BLIP=PCBLIP*BLC
BLLP=PCBLLP*BLC
IF (MODE.NE.1) GO TO 7
IF (ABS(CNC-CNCS).LE.0.001*CNCS) GO TO 8
WRITE (8,11) CNCS,CNC
CALL ERROR
7 PCNC=100.*THETA*CNC/THETAD
8 CALL COCOMB
RETURN
C
C
C
9 FORMAT (19H0* * * CNC OFF MAP,F10.4,2XA6,11H* * *$$$$$)
10 FORMAT (18HOCOMPRESSOR DESIGN,6X8H PRCCF=,E15.8,8H ETACCF=,E15.8,
18H WACCF=,E15.8,8H T21DS=,E15.8)
11 FORMAT (10HOCNC WAS= ,E15.8,11H AND NOW= ,E15.8,24H CHECK PCNC I
INPUT$$$$$)
END

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\$IBFTC CODUCT

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SUBROUTINE CODUCT
COMMON /WORDS/ WORD
COMMON /DESIGN/
1IDES ,JDES ,KDES ,MODE ,INIT ,IDUMP ,IAMTP ,IGSMX,
2IDURN,IAFTBN,IDCD ,IMCD ,IDSHOC,IMSHOC,NOZFLT,ITRYS ,
3BLOOPER,NOMAP ,NUMMAP,MAPEDG,TOLALL,ERR(9)
COMMON /ALL1/
4IPCNGU,PCNCGU,T4GU ,DUMD1 ,DUMD2 ,DELFG ,DELFN ,DELSFC,
5ZFDS ,PCNFDS,PRFDS ,ETAFDS,WAFDS ,PRFCF ,ETAFCF,WAFCF ,
6ZCDS ,PCNCDS,PRCDS ,ETACDS,WACDS ,PRCCF ,ETACCF,WACCF ,
74T4DS ,WFBDS ,DTCODS,ETABDS,WA3CDS,DPCODS,DTCCF,ETABCF,
85TFHPDS,CNHPS,ETHPDS,TFHPCF,CNHPCF,ETMPCF,DHHPCF,T2DS ,
96TFLPDS,CNLPDS,ETLPDS,TFLPCF,CNLPDF,ETLPCF,DHLPDF,T21DS ,
107T24DS ,WFDD ,DTDUDS,ETADD,WA23DS,DPDUDS,DTDUCF,ETAOCF,
118T7DS ,WFADS ,DTAFDS,ETAADS,WG6CDS,DPAFDS,DTAFCF,ETAACF,
129A55 ,A25 ,A6 ,A7 ,A8 ,A9 ,A28 ,A29 ,
13$PS55 ,AM55 ,CVDNOZ,CVMNOZ,ABSVA ,A9SAV ,A28SAV,A29SAV
COMMON /ALL2/

```

1T1	,P1	,H1	,S1	,T2	,P2	,H2	,S2		19
2T21	,P21	,H21	,S21	,T3	,P3	,H3	,S3		20
3T4	,P4	,H4	,S4	,T5	,P5	,H5	,S5		21
4T55	,P55	,H55	,S55	,BLF	,BLC	,BLDU	,BLOB		22
5CNF	,PRF	,ETAF	,WAF	,WAF	,WAF	,WAF	,WAF		23
6CNC	,PRC	,ETAC	,WACC	,WAC	,ETAB	,DPCOM	,DUMP		24
7CNHP	,ETATHP	,DHTCHP	,DHTC	,BLHP	,WG5	,FAR5	,CS		25
8CNLP	,ETATLP	,DHTCLP	,DHTF	,BLLP	,WG55	,FAR55	,HPEXT		26
9AM	,ALTP	,ETAR	,ZF	,PCNF	,ZC	,PCNC	,WFB		27
\$TFFHP	,TFFLP	,PCBLF	,PCBLC	,PCBLDU	,PCBLOB	,PCBLHP	,PCBLLP		28
COMMON /ALL3/									29
1XP1	,XWAF	,XWAC	,XBLF	,XBLDU	,XH3	,DUMS1	,DUMS2		30
2XT21	,XP21	,XH21	,XS21	,T23	,P23	,H23	,S23		31
3T24	,P24	,H24	,S24	,T25	,P25	,H25	,S25		32
4T28	,P28	,H28	,S28	,T29	,P29	,H29	,S29		33
5WAD	,WFD	,WG24	,FAR24	,ETAD	,DPDUC	,BYPASS	,DUMS3		34
6TS28	,PS28	,V28	,AM28	,TS29	,PS29	,V29	,AM29		35
7XT55	,XP55	,XH55	,XS55	,XT25	,XP25	,XH25	,XS25		36
8XWFB	,XWG55	,XFAR55	,XWFD	,XWG24	,XFAR24	,XXP1	,DUMB		37
9T6	,P6	,H6	,S6	,T7	,P7	,H7	,S7		38
\$T8	,P8	,H8	,S8	,T9	,P9	,H9	,S9		39
COMMON /ALL4/									40
1WG6	,WFA	,WG7	,FAR7	,ETAA	,DPAFT	,V55	,V25		41
2PS6	,V6	,AM6	,TS7	,PS7	,V7	,AM7	,AM25		42
3TS8	,PS8	,V8	,AM8	,TS9	,PS9	,V9	,AM9		43
4VA	,FRD	,VJD	,FGMD	,VJM	,FGMM	,FGPD	,FGPM		44
5FGM	,FGP	,WFT	,WGT	,FART	,FG	,FN	,SFC		45
6WA32	,DPWGD	,DPWING	,WA32DS	,A38	,AM38	,V38	,T38		46
7H38	,P38	,TS38	,PS38	,T39	,H39	,P39	,TS39		47
8V39	,AM39	,A39	,BPRINT	,WG37	,CVDWNG	,FGMWNG	,FGPWNG		48
9FNWING	,FNMAIN	,FNOVFN	,PS39	,FFOVFN	,FCOVFN	,FMNOFN	,FNOVFD		49
\$VJW	,T22	,P22	,H22	,S22	,T50	,P50	,H50		50
COMMON /ALL5/									51
1S50	,WA22	,ZI	,PCNI	,CNI	,PRI	,ETAI	,WACI		52
2YFFIP	,CNIP	,ETATIP	,DHTCIP	,DHTI	,BLIP	,PCBLIP	,PCNIGU		53
3ZIDS	,PCNIDS	,PRI DS	,ETAIDS	,WAIDS	,PRICF	,ETAICF	,WAICF		54
4TFIPDS	,CNIPDS	,ETIPDS	,TFIPCF	,CNIPCF	,ETIPCF	,DHIPCF	,WAICDS		55
5WAI	,PCBLI	,BLI	,T22DS	,WA21	,WG50	,FAR50	,A24		56
6AM23	,DUMSPL	,FXFN2M	,FXM2CP	,AFTFAN	,PUNT	,PCBLID	,P6DSAV		57
7AM6DSV	,ETAASV	,FAR7SV	,T4PBL	,T41	,FAN	,ISPOOL			58
COMMON /DYN/	ITRAN	,TIME	,DT	,TF	,JTRAN	,NSTEP	,TPRINT	,DTPRNT	59
COMMON /VOLS/	VFAN	,VINTC	,VCOMP	,VCOMB	,VHPTRB	,VI PTRB	,VLPTRB	,VAFTBN	60
1	VFDUCT	,VWDUCT							61
COMMON /WHRERR/	ICOAFB	,ICODUC	,ICCMIX						62
COMMON /UNITS/	SI								63
LOGICAL	SI								64
LOGICAL	AFTFAN								65
DIMENSION	Q(9)								66
DATA	AWORD1	,AWORD2	,6HCODUCT	,6HONOZZL					67
WORD	=AWORD1								68
Q(2)	=0.								69
Q(3)	=0.								70
GOGO	=0.0								71
IF (SI)	GO TO 100								72
AJ	=778.26								73
AJX	=2.719								74
CAPSF	=2116.2170								75
G	=32.174049								76
TSTD	=518.67								77
TDEL	=2000.0								78
TMAX	=4000.0								79
RA	=0.0252								80
GO TO	101								81
100	AJ=1.0								82
	AJX=1.0								83
	CAPSF=101325.0								84
	G=1.0								85
	TSTD=288.15								86
	TDEL=1111.0								87
	TMAX=2222.0								88
	RA=286.9								89
101	CONTINUE								90
	ICODUC=0								91
	MAX=WAF-WAI-BLF								92

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IF (PCBLID.EQ.0.) MAX=WAF-WAC-BLF 93
IF (AFTFAN) MAX=WAF-BLF 94
WAD=WAX+BLDU 95
P23=P22 96
C*** DRY LOSS 97
H23=(BLDU*H3+WAX*H22)/WAD 98
CALL THERMO (P23,H23,T23,S23,XX2,1,0.0,1) 99
WA23C=WAD*SQR(T23)/P23 100
IF (IDES.EQ.1) WA23DS=WA23C 101
BYPASS=(WAF-WAI)/WAI 102
IF (AFTFAN) BYPASS=WAF/WAI 103
DPDUC=DPDUCS*(WA23C/WA23DS) 104
IF (DPDUC.GT.1.) DPDUC=1.0 105
P24=P23*(1.-DPDUC) 106
CALL PROCOM (0.,T23,XX1,XX2,XX3,XX4,PHI23,XX6) 107
IF (IGASHX.GT.0) IDBURN=0 108
AM24=AM23 109
TS24=T23*0.875 110
1 DO 2 I=1,15 111
CALL PROCOM (0.,TS24,CS24,AK24,CP24,REX24,PHIS24,HS24) 112
V24=AM24*CS24 113
HSCAL=H23-V24**2/(2.*G*AJ) 114
DELHS=HSCAL-HS24 115
IF (ABS(DELHS).LE.0.001*HSCAL) GO TO 3 116
2 TS24=TS24+DELHS/CP24 117
ICODUC=1 118
GO TO 11 119
3 C1=P24*SQR(G/(T23*AJ))*CAPSF 120
IF (IDES.NE.1) GO TO 4 121
IF (GOGO.GT.0.) GO TO 4 122
ASTOA=((AK24+1.)/2.)*((AK24+1.)/(2.*(AK24-1.)))*AM24*(1.+(((AK24-
1 1.)/2.)*AM24**2))*(-AK24+1.)/(2.*(AK24-1.)) 123
EQWCR=SQR(G*AK24/REX24/AJ)/(SQR(TSTD)/CAPSF)*(2.0/(AK24+1.))* 124
1*((AK24+1.)/2./AK24-1.)) 125
WA23CC=WA23C/SQR(TSTD) 126
A24=1./ASTOA*WA23CC/EQWCR 127
GOGO=1.0 128
4 WQA=WAD/A24 129
WQAT=C1*SQR(AK24/REX24)*AM24/(1.+(AK24-1.)*AM24**2/2.)*((AK24+1.
1)/(2.*(AK24-1.))) 130
DIR=WQA/WQAT 131
EW=(WQA-WQAT)/WQA 132
CALL AFQUIR (Q(1),AM24,EW,0.,30.,0.001,DIR,AM24T,IGO) 133
ICODUC=2 134
GO TO (5,6,11),IGO 135
5 AM24=AM24T 136
IF (AM24.GT.1.0) AM24=0.5 137
GO TO 1 138
6 PS24=P24/EXP((PHI23-PHIS24)/REX24) 139
7 IF (IDBURN.GT.0) GO TO 8 140
C*** NON-DUCT BURNING 141
T24=T23 142
WFD=0. 143
FAR24=0 144
GO TO 17 145
8 IF (IDBURN .EQ. 2) T24=T23+TDEL 146
9 IF (T24 .GT. TMAX) T24=TMAX 147
IF (T24.LT.T23) T24=T23 148
C*** DUCT BURNING 149
RHO42=CAPSF*PS24/(AJ*REX24*TS24) 150
PS42=PS24 151
V42=V24 152
Q(2)=0. 153
Q(3)=0. 154
IF (T24 .LT. T23) T24 = T23*1.001 155
C *** IF DESIRED, ENTER CALCULATIONS FOR ETAD HERE 156
IF (SI) T24=T24*9.0/5.0 157
HV=(((((-.4594317E-19*T24)-.2034116E-15)*T24+.2783643E-11)*T24+.2
1051501E-07)*T24-.2453116E-03)*T24-.9433296E-01)*T24+.1845537E+05 160
IF (SI) T24=T24*5.0/9.0 161
IF (SI) HV=HV*2325.4295 162
CALL THERMO (P24,HA,T24,XX1,XX2,0,0.0,0) 163
FAR24=(HA-H23)/(HV*ETAD) 164
IF (FAR24.LT.0.) FAR24=0. 165
166

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	WFDX=FAR24*WAD	167
	IF (IOBURN.NE.2) GO TO 12	168
	ERRW=(WFD-WFOX)/WFD	169
	DIR=SQRT(WFD/WFOX)	170
	CALL AFQUIR(Q(1),T24,ERRW,0.,20.,0.0001,DIR,T24T,IGO)	171
	ICODUC=3	172
	GO TO (10,13,11), IGO	173
10	T24=T24T	174
	GO TO 9	175
11	CALL ERROR	176
12	WFD=WFDX	177
13	CONTINUE	178
C**	MOMENTUM LOSS	179
	WG24=WFD+WAD	180
	CALL PROCOM (FAR24,T24,XX1,XX2,XX3,REX24,PHI24,H24)	181
	RHO24=CAPSF*P24/(AJ*REX24*T24)	182
	V24=WG24/(RHO24*A24)	183
	Q(2)=0.	184
	Q(3)=0.	185
	PS24=PS42-0.01	186
14	RHO24=WG24/(V24*A24)	187
	HS24=H24-V24**2/(2.*G*AJ)	188
	CALL THERMO (1.0,HS24,TS24,PHIS24,XX2,1,FAR24,1)	189
	IF (TS24.GE.301.) GO TO 15	190
	CALL THERMO (1.0,HS24,400.,PHIS24,XX2,1,FAR24,1)	191
	V24=SQRT(2.*G*AJ*(H24-HS24))	192
	GO TO 14	193
15	PS24=RHO24*AJ*REX24*TS24/CAPSF	194
	PS24A=PS42+(RHO42*V42**2-RHO24*V24**2)/(G*CAPSF)	195
	DIR=SQRT(ABS(PS24/PS24A))	196
	EP=(PS24-PS24A)/PS24	197
	CALL AFQUIR(Q(1),V24,EP,0.,50.,0.001,DIR,V24T,IGO)	198
	V24=V24T	199
	IF (V24.LT.25.) V24=25.	200
	ICODUC=4	201
	GO TO (14,16,11), IGO	202
16	P24=PS24*EXP((PHI24-PHIS24)/REX24)	203
	CALL PROCOM (FAR24,TS24,CS24,XX2,XX3,XX4,XX5,XX6)	204
	AM24=V24/CS24	205
17	CALL THERMO (P24,H24,T24,S24,XXI,1,FAR24,0)	206
	WG24=WFD+WAD	207
	IF(VFDUCT.EQ.0.0) GO TO 31	208
	Q(2)=0.0	209
	Q(3)=0.0	210
	WG24P=WG24	211
	H24P=H24	212
	P24DOT=DERIV(20,P24)	213
28	CONTINUE	214
	CALL THERMO(P24,H24,T24,S24,XX2,1,FAR24,0)	215
	WG24=WG24P-P24DOT*VFDUCT/T24/(1.4*RA)	216
	U24=H24-AJX*RA*T24	217
	U24DOT=DERIV(21,U24)	218
	H24X=(WG24P*H24P-(WG24P-WG24)*U24-U24DOT*P24*VFDUCT/T24/RA )/	219
	1 WG24	220
	ERRW=(H24-H24X)/H24	221
	DIR=SQRT(ABS(H24/H24X))	222
	CALL AFQUIR(Q(1),T24,ERRW,0.,20.,0.0001,DIR,T24T,IGO)	223
	ICODUC=5	224
	GO TO (29,31,30), IGO	225
29	T24=T24T	226
	GO TO 28	227
30	CALL ERROR	228
31	CONTINUE	229
	T25=T24	230
	P25=P24	231
	H25=H24	232
	S25=S24	233
	AM25=AM24	234
	IF (IGSMX.GT.0) GO TO 21	235
	WORD=AWORD2	236
	AZ9SAV=AZ8	237
	AZ9SAV=AZ9	238
	NOZD=0	239
	IDNOZ=0	240

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IF (NOZFLT.EQ.2.OR.NOZFLT.EQ.3) NOZD=1
IF (IDES.EQ.1.OR.IDBURN.GT.0.OR.NOZD.EQ.1) IDNOZ=1
IF (ITRAN.EQ.1) IDNOZ=0
IF (IDCD.EQ.1) GO TO 18
CALL CONVRG (T25,H25,P25,S25,FAR24,WG24,P1,IDNOZ,A28,P25R,T28,H28,
1P28,S28,TS28,PS28,V28,AM28,ICON)
GO TO (19,19,19,11),ICON
18 CALL CONDIV (T25,H25,P25,S25,FAR24,WG24,P1,IDNOZ,A28,A29,P25R,T28,
1H28,P28,S28,T29,H29,P29,S29,TS28,TS29,PS28,PS29,V28,V29,AM28,AM29,
2ICON)
IDSHOC=ICON
ICODUC=6
GO TO (20,20,20,11),ICON
19 T29=T28
H29=H28
P29=P28
S29=S28
TS29=TS28
PS29=PS28
V29=V28
AM29=AM28
A29=A28
IDSHOC=ICON+3
20 ERR(5)=(P25R-P25)/P25R
IF (IDNOZ.EQ.1) WRITE (6,22) A28,AM28,A29,AM29
21 ICODUC=0
CALL FASTBK
RETURN
C
C
22 FORMAT (19HODUCT NOZZLE DESIGN,5X8H A28=,E15.8,8H AM28=,E15.8
1,8H A29=,E15.8,8H AM29=,E15.8)
END

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$IBFTC COFAN
SUBROUTINE COFAN
COMMON /WORDS/ WORD
COMMON /DESIGN/
1IDES ,JDES ,KDES ,MODE ,INIT ,IDUMP ,IAMTP ,IGASMX,
2IDBURN,IAFTBN,IDCD ,IMCD ,IDSHOC,IMSHOC,NOZFLT,ITRYS ,
3LOOPER,NOMAP ,NUMMAP,MAPEDG,TOLALL,ERR(9)
COMMON /ALL1/
1PCNFGU,PCNCGU,T4GU ,DUMD1 ,DUMD2 ,DELFG ,DELFN ,DELSFC,
2ZFDS ,PCNFDS,PRFDS ,ETAFDS,WAFDS ,PRFCF ,ETAFCF,WAFCF ,
3ZCDS ,PCNCDS,PRCDS ,ETACDS,WACDS ,PRCCF ,ETACCF,WACCF ,
4T4DS ,WFBDS ,DTCODS,ETABDS,WA3CDS,DPCODS,DTCCCF,ETABCF,
5TFHPDS,CNHPDS,ETHPDS,TFHPCF,CNHPCF,ETHPCF,DHHPCF,T2DS ,
6TFLPDS,CNLPDS,ETLPDS,TFLPCF,CNLPFC,ETLPCF,DHLPFC,T21DS ,
7T24DS ,WFDSD ,DTDUDS,ETADDS,WA23DS,DPOUDS,DTDUCF,ETADCF,
8T7DS ,WFAOS ,DTAFOS,ETAADS,WG6CDS,DPAFDS,DTAFCF,ETAACF,
9A55 ,A25 ,A6 ,A7 ,A8 ,A9 ,A28 ,A29 ,
10PS55 ,AM55 ,CVDNOZ,CVMNOZ,A8SAV ,A9SAV ,A28SAV ,A29SAV
COMMON /ALL2/
1T1 ,P1 ,H1 ,S1 ,T2 ,P2 ,H2 ,S2 ,
2T21 ,P21 ,H21 ,S21 ,T3 ,P3 ,H3 ,S3 ,
3T4 ,P4 ,H4 ,S4 ,T5 ,P5 ,H5 ,S5 ,
4T55 ,P55 ,H55 ,S55 ,BLF ,BLC ,BLDU ,BLOB ,
5SCNF ,PRF ,ETAF ,WAF ,WAF ,WAF ,WA3 ,WG4 ,FAR4 ,
6CNC ,PRC ,ETAC ,WACC ,WAC ,ETAB ,OPCOM ,DUMP ,
7CNHP ,ETATLP,DHTCLP,DHTC ,BLHP ,WG5 ,FAR5 ,CS ,
8CNLP ,ETATLP,DHTCLP,DHTF ,BLLP ,WG55 ,FAR55 ,HPEXT ,
9AM ,ALTP ,ETAR ,ZF ,PCNF ,ZC ,PCNC ,WFB ,
10$TFFHP ,TFFLP ,PCBLF ,PCBLC ,PCBLDU,PCBLOB,PCBLHP,PCBLP
COMMON /ALL3/
1XPI ,XWAF ,XWAC ,XBLF ,XBLDU ,XH3 ,DUMS1 ,DUMS2 ,
2XT21 ,XP21 ,XH21 ,XS21 ,T23 ,P23 ,H23 ,S23 ,
3T24 ,P24 ,H24 ,S24 ,T25 ,P25 ,H25 ,S25 ,
4T28 ,P28 ,H28 ,S28 ,T29 ,P29 ,H29 ,S29 ,
5SWAD ,WFD ,WG24 ,FAR24 ,ETAD ,DPOUC ,BYPASS,DUMS3 ,
6TS28 ,PS28 ,V28 ,AM28 ,TS29 ,PS29 ,V29 ,AM29 ,

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7XT55 ,XP55 ,XH55 ,XS55 ,XT25 ,XP25 ,XH25 ,XS25 , 36
8XWFB ,XWG55 ,XFAR55 ,XWFD ,XWG24 ,XFAR24 ,XXP1 ,DUMB , 37
9T6 ,P6 ,H6 ,S6 ,T7 ,P7 ,H7 ,S7 , 38
$T8 ,P8 ,H8 ,S8 ,T9 ,P9 ,H9 ,S9 , 39
COMMON /ALL4/ 40
1WG6 ,WFA ,WG7 ,FAR7 ,ETA A ,DPAFT ,V55 ,V25 , 41
2PS6 ,V6 ,AM6 ,TS7 ,PS7 ,V7 ,AM7 ,AM25 , 42
3TS8 ,PS8 ,V8 ,AM8 ,TS9 ,PS9 ,V9 ,AM9 , 43
4VA ,FRD ,VJD ,FGMD ,VJM ,FGMM ,FGPD ,FGPM , 44
5FGM ,FGP ,WFT ,WGT ,FART ,FG ,FN ,SFC , 45
6WA32 ,DPWGDS ,DPW ING ,WA32DS ,A38 ,AM38 ,V38 ,T38 , 46
7H38 ,P38 ,TS38 ,PS38 ,T39 ,H39 ,P39 ,TS39 , 47
8V39 ,AM39 ,A39 ,BPRINT ,WG37 ,CVDWNG ,FGMNG ,FGPMNG , 48
9FNWING ,FNMAIN ,FNOVFN ,PS39 ,FFOVFN ,FCOVFN ,FMNOFN ,FNOVFD , 49
$VJW ,T22 ,P22 ,H22 ,S22 ,T50 ,P50 ,H50 50
COMMON /ALL5/ 51
1S50 ,WA22 ,Z1 ,PCNI ,CNI ,PRI ,ETAI ,WACI , 52
2TFFIP ,CNIP ,ETATIP ,DHTCIP ,DHTI ,BLIP ,PCBLIP ,PCNIGU , 53
3ZIDS ,PCNIDS ,PRIDS ,ETAIDS ,WAIDS ,PRICF ,ETAICF ,WAICF , 54
4TFIPDS ,CNIPDS ,ETIPDS ,TFIPCF ,CNIPCF ,ETIPCF ,DHIPCF ,WAICDS , 55
5WAI ,PCBLI ,BLI ,T22DS ,WA21 ,WG50 ,FAR50 ,A24 , 56
6AM23 ,DUMSPL ,FXFN2M ,FXM2CP ,AFTFAN ,PUNT ,PCBLID ,P6DSAV , 57
7AM6DSV ,ETAASV ,FAR7SV ,T4PBL ,T41 ,FAN ,ISPOOL 58
COMMON /DYN/ ITRAN ,TIME ,DT ,TF ,JTRAN ,NSTEP ,TPRINT ,DTPRNT 59
COMMON /VOL/ VFAN ,VINTC ,VCOMP ,VCOMB ,VHPTRB ,VIPTRB ,VLPTRB ,VAFTBN , 60
1 VFDUCT ,VWDOCT 61
COMMON /FLOWS/ WAFP ,WAIP ,WACP 62
COMMON /UNITS/ SI 63
LOGICAL SI 64
LOGICAL FXM2CP 65
COMMON / FAN/CNX(15) ,PRX(15,15) ,WACX(15,15) ,ETAX(15,15) , 66
INCN ,NPT(15) 67
DIMENSION Q(9) ,WLH(2) 68
DATA AWORD ,WLH/6H COFAN ,6H (LO) ,6H (HI) / 69
WORD=AWORD 70
IF (SI) GO TO 100 71
TSTD=518.668 72
PSTD=1.0 73
RA=.0252 74
AJ=2.719 75
GO TO 101 76
100 TSTD=288.149 77
PSTD=101325. 78
RA=286.9 79
AJ=1.0 80
101 THETA=SQRT(T2/TSTD) 81
DELTA=P2/PSTD 82
IF (IDES.NE.1) GO TO 1 83
THETAD=THETA 84
WAFDS=W AFC*DELTA/THETA 85
CNF=PCNF*THETAD/(100.*THETA) 86
IF (ZF.LT.0.) ZF=0. 87
IF (ZF.GT.1.) ZF=1. 88
CNFS=CNF 89
CALL SEARCH (ZF ,CNF ,PRF ,W AFC ,ETA F ,CNX(1) ,NCN ,PRX(1,1) ,WACX(1,1) ,ET 90
IAX(1,1) ,NPT(1) ,15,15 ,IGO) 91
IF ((CNF-CNFS).GT.0.0005*CNF) MAPEDG=1 92
IF (IGO.EQ.1.OR.IGO.EQ.2) WRITE (8,12) CNFS ,WLH(IGO) 93
WAF=W AFC*DELTA/THETA 94
IF (IDES.NE.1) GO TO 2 95
PRFCF=(PRFDS-1.)/(PRF-1.) 96
ETAFCF=ETA FDS/ETA F 97
W AFCF=W AFC/W AF 98
WRITE (6,13) PRFCF ,ETAFCF ,W AFCF ,T2DS 99
2 PRF=PRFCF*(PRF-1.)+1. 100
ETA F=ETAFCF*ETA F 101
W AF=W AFCF*W AF 102
W AFP=W AF 103
W AFC=W AFC*W AFCF 104
PCNF=100.*THETA*CNF/THETAD 105
DUMD1=PCNF 106
CALL THCOMP (PRF ,ETA F ,T2 ,H2 ,S2 ,P2 ,T22 ,H22 ,S22 ,P22) 107
IF (VFAN.EQ.0.0) GO TO 21 108
Q(2)=0.0 109

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	Q(3)=0.0	110
	H22P=H22	111
	P22DOT=DERIV(4,P22)	112
18	CONTINUE	113
	CALL THERMO(P22,H22,T22,S22,XX2,0,0,0,0)	114
	WAF=WAFP-P22DOT*VFAN/T22/1.4/RA	115
	U22=H22-AJ*RA*T22	116
	U22DOT=DERIV(5,U22)	117
	H22X=(WAFP*H22P-(WAFP-WAF)*U22-U22DOT*P22*VFAN/T22/RA)/WAF	118
	ERRW=(H22-H22X)/H22	119
	DIR=SQRT(ABS(H22/H22X))	120
	CALL AFQUIR(Q(1),T22,ERRW,0.,20.,0.0001,DIR,T22T,IGO)	121
	GO TO (19,21,20),IGO	122
19	T22=T22T	123
	GO TO 18	124
20	CALL ERROR	125
21	CONTINUE	126
	IF (PCBLF.GT.0.) BLF=PCBLF*WAF	127
	IF (JDES.EQ.1) GO TO 9	128
	JDES=1	129
	IF (INIT.EQ.1) GO TO 8	130
	IF (IDES.EQ.1) GO TO 6	131
	IF (JTRAN.EQ.1) GO TO 8	132
	IF (MODE.NE.2) GO TO 3	133
	T4=GUESS(3,Y1,Y2,PCNF,PCNFDS,WFB,WFBDS,Y7,Y8,T4DS)	134
	PCNI=GUESS(8,T4,T4DS,Y3,Y4,Y5,Y6,T22,T22DS,PCNIDS)	135
	PCNC=GUESS(4,Y1,Y2,PCNI,PCNIDS,WFB,WFBDS,Y7,Y8,PCNCDS)	136
	GO TO 7	137
3	IF (MODE.EQ.1) GO TO 5	138
	IF (MODE.EQ.0) GO TO 4	139
	T4=GUESS(7,Y1,Y2,PCNF,PCNFDS,Y5,Y6,T2,T2DS,T4DS)	140
4	CONTINUE	141
	PCNC=GUESS(5,T4,T4DS,Y3,Y4,Y5,Y6,T22,T22DS,PCNCDS)	142
	IF (FXM2CP) PCNC=PCNCDS*.99	143
	PCNCG1=PCNC	144
	PCNCG2=PCNCDS	145
	PCNI=GUESS(9,Y1,Y2,PCNCG1,PCNCG2,Y5,Y6,T22,T22DS,PCNIDS)	146
	GO TO 7	147
5	T4=GUESS(6,Y1,Y2,PCNC,PCNCDS,Y5,Y6,T22,T22DS,T4DS)	148
	PCNI=GUESS(8,T4,T4DS,Y3,Y4,Y5,Y6,T22,T22DS,PCNIDS)	149
	GO TO 7	150
6	PCNC=PCNCDS	151
	PCNI=PCNIDS	152
	T4=T4DS	153
	WFB=WFBDS	154
	T21DS=T21	155
7	ZC=ZCDS	156
	ZI=ZIDS	157
	PCNIGU=PCNI	158
	PCNCGU=PCNC	159
	T4GU=T4	160
8	INIT=0	161
9	IF (MODE.NE.3) GO TO 10	162
	IF (ABS(CNF-CNFS).LE.0.001*CNFS) GO TO 11	163
	WRITE (8,14) CNFS,CNF	164
	CALL ERROR	165
10	PCNF=100.*THETA*CNF/THETA0	166
11	CALL COINTC	167
	RETURN	168
C		169
C		170
12	FORMAT (19H0* * * CNF OFF MAP,F10.4,2XA6,11H* * *\$\$\$\$\$)	171
13	FORMAT (11HOFAN DESIGN,13X8H PRFCF=,E15.8,8H ETAFCF=,E15.8,8H WA	172
	IFCF=,E15.8,8H T2DS=,E15.8)	173
14	FORMAT (10HOCNF WAS= ,E15.8,11H AND NOW= ,E15.8,24H CHECK PCNF I	174
	INPUT\$\$\$\$\$)	175
	END	176

```

$IBFTC COMPTB
SUBROUTINE COMPTB
COMMON /WORDS/ WORD
COMMON /DESIGN/
1IDES ,JDES ,KDES ,MODE ,INIT ,IDUMP ,IAMTP ,IGASMX,
2IDBURN,I AFTBN, I DCD ,IMCD ,IDSHOC,IMSHOC,NOZFLT,I TRYS ,
3LOOPER,NOMAP ,NUMMAP ,MAPEDG,TOLALL ,ERR(9)
COMMON /ALL1/
1PCNFGU,PCNCGU,T4GU ,DUMD1 ,DUMD2 ,DELFG ,DELFN ,DELSFC,
2ZFDS ,PCNFDS,PRFDS ,ETAFDS,WAFDS ,PRFCF ,ETAFCF,WAFCF ,
3ZCDS ,PCNCDS,PRCDS ,ETACDS,WACDS ,PRCCF ,ETACCF,WACCF ,
4T4DS ,WFBDS ,DTCODS,ETABDS,WA3CDS ,DPCODS ,DTCOCF,ETABCF,
5TFHPDS ,CNHPDS,ETHPDS ,TFHPCF,CNHPCF,ETHPCF,DHHPCF,T2DS ,
6TFLPDS ,CNLPDS,ETLPDS ,TFLPCF,CNLPDF,ETLPCF,DHLPDF,T2LDS ,
7T24DS ,WFDD ,DTDUDS,ETADDS,WA23DS ,DPDUDS ,DTDUCF,ETADCF,
8BTDS ,WFA DS ,DTAFDS,ETAADS,WG6CDS ,DPAFDS ,DTAFCF,ETAACF,
9A55 ,A25 ,A6 ,A7 ,A8 ,A9 ,A28 ,A29 ,
10$PS55 ,AM55 ,CVDNOZ ,CVMNOZ,A8SAV ,A9SAV ,A28SAV,A29SAV
COMMON /ALL2/
1T1 ,P1 ,H1 ,S1 ,T2 ,P2 ,H2 ,S2 ,
2T21 ,P21 ,H21 ,S21 ,T3 ,P3 ,H3 ,S3 ,
3T4 ,P4 ,H4 ,S4 ,T5 ,P5 ,H5 ,S5 ,
4T55 ,P55 ,H55 ,S55 ,BLF ,BLC ,BLDU ,BLOB ,
5CNF ,PRF ,ETAF ,WAF ,WAF ,WAF ,WAF ,WAF ,WAF ,WAF ,
6CNC ,PRC ,ETAC ,WACC ,WAC ,ETAB ,DPCOM ,DUMP ,
7CNHP ,ETATHP,DHTCHP,DHTC ,BLHP ,WG5 ,FAR5 ,CS ,
8CNLP ,ETATLP,DHTCLP,DHTF ,BLLP ,WG55 ,FAR55 ,HPEXT ,
9AM ,ALTP ,ETAR ,ZF ,PCNF ,ZC ,PCNC ,WFB ,
$TFFHP ,TFFLP ,PCBLF ,PCBLC ,PCBLDU,PCBLOB,PCBLHP,PCBLLP
COMMON /ALL3/
1XP1 ,XWAF ,XWAC ,XBLF ,XBLDU ,XH3 ,DUMS1 ,DUMS2 ,
2XT21 ,XP21 ,XH21 ,XS21 ,T23 ,P23 ,H23 ,S23 ,
3T24 ,P24 ,H24 ,S24 ,T25 ,P25 ,H25 ,S25 ,
4T28 ,P28 ,H28 ,S28 ,T29 ,P29 ,H29 ,S29 ,
5WAD ,WFD ,WG24 ,FAR24 ,ETAD ,DPDUC ,BYPASS ,DUMS3 ,
6TS28 ,PS28 ,V28 ,AM28 ,TS29 ,PS29 ,V29 ,AM29 ,
7XT55 ,XP55 ,XH55 ,XS55 ,XT25 ,XP25 ,XH25 ,XS25 ,
8XWFB ,XWG55 ,XFAR55 ,XWFD ,XWG24 ,XFAR24 ,XXP1 ,DUMB ,
9T6 ,P6 ,H6 ,S6 ,T7 ,P7 ,H7 ,S7 ,
10$T8 ,P8 ,H8 ,S8 ,T9 ,P9 ,H9 ,S9
COMMON /ALL4/
1WG6 ,WFA ,WG7 ,FAR7 ,ETAA ,DPAFT ,V55 ,V25 ,
2PS6 ,V6 ,AM6 ,TS7 ,PS7 ,V7 ,AM7 ,AM25 ,
3TS8 ,PS8 ,V8 ,AM8 ,TS9 ,PS9 ,V9 ,AM9 ,
4VA ,FRD ,VJD ,FGMD ,VJM ,FGMM ,FGPD ,FGPM ,
5FGM ,FGP ,WFT ,WGT ,FART ,FG ,FN ,SFC ,
6WA32 ,DPWGDS,DPWING,WA32DS,A38 ,AM38 ,V38 ,T38 ,
7H38 ,P38 ,TS38 ,PS38 ,T39 ,H39 ,P39 ,TS39 ,
8V39 ,AM39 ,A39 ,BPRINT,WG37 ,CVDWNG,FGMWNG,FGPWNG,
9FNWING,FNMAIN,FWOVFN,PS39 ,FFOVFN,FCOVFN,FMNOFN,FNOVFD,
10$VJW ,T22 ,P22 ,H22 ,S22 ,T50 ,P50 ,H50
COMMON /ALL5/
1S50 ,WA22 ,ZI ,PCNI ,CNI ,PRI ,ETAI ,WACI ,
2TFFIP ,CNIP ,ETATIP,DHTCIP,DHTI ,BLIP ,PCBLIP,PCNIGU,
3ZIDS ,PCNIDS,PRIDS ,ETAIDS,WAIDS ,PRICF ,ETAICF,WAICF ,
4TFIPDS ,CNIPDS,ETIPDS ,TFIPCF,CNIPCF,ETIPCF,DHIPCF,WAICDS,
5WAI ,PCBLI ,BLI ,T22DS ,WA21 ,WG50 ,FAR50 ,A24 ,
6AM23 ,DUMSPL,FXFN2M,FXM2CP,AFTFAN,PUNT ,PCBLID,P6DSAV,
7AM6DSV,ETAASV,FAR7SV,T4PBL ,T41 ,FAN ,ISPOOL
COMMON /RPMS/ XNHPDS,XNIPDS,XNLPDS,PMIHP,PMIIP,PMILP
COMMON /VOLS/ VFAN,VINTC,VCOMP,VCOMB,VHPTRB,VIPTRB,VLPTRB,VAFTBN,
1 VFDUCT,VMDUCT
COMMON /FLOWS/ WAFP,WAIP,WACP
COMMON /UNITS/ SI
LOGICAL SI
DIMENSION Q(9)
LOGICAL FXFN2M,FXM2CP,DUMSPL
COMMON /HTURB/TFX(15),CNX(15,15),DHTCX(15,15),ETATX(15,15),
1NTFFS,NPTTFF(15)
DATA AWORD,WLO,WHI/6HCOMPTB,6H(LO),6H(HI) /
WORD=AWORD
IF(SI) GO TO 100
RA=.0252
AJ=2.719

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	CONFAC=1.4091E-5	74
	GO TO 101	75
100	RA=286.9	76
	AJ=1.0	77
	CONFAC=1.0966E-2	78
101	CONTINUE	79
	IF (ISPOOL.EQ.1) GO TO 8	80
	IF (IDES.EQ.0) GO TO 1	81
	CNHPCF=CNHPDS*SQRT(T4)/PCNC	82
1	CNHP=CNHPCF*PCNC/SQRT(T4)	83
	CNHPS=CNHP	84
	TFFHPS=TFFHP	85
	CALL SEARCH (-1.,TFFHP,CNHP,DHTCHP,ETATHP,TFFX(1),NTFFS,CNX(1,1),D	86
	IHTCX(1,1),ETATX(1,1),NPTTF(1),15,15,IGO)	87
	IF (IGO.EQ.1.OR.IGO.EQ.11.OR.IGO.EQ.21) WRITE (8,9) TFFHPS,WLO	88
	IF (IGO.EQ.2.OR.IGO.EQ.12.OR.IGO.EQ.22) WRITE (8,9) TFFHPS,WHI	89
	IF (IGO.EQ.10.OR.IGO.EQ.11.OR.IGO.EQ.12) WRITE (8,10) CNHPS,WLO	90
	IF (IGO.EQ.20.OR.IGO.EQ.21.OR.IGO.EQ.22) WRITE (8,10) CNHPS,WHI	91
	IF (IGO.NE.7) GO TO 2	92
	CALL ERROR	93
	RETURN	94
2	NOMAP=0	95
	TFHCAL=WG4*SQRT(T4)/(14.696*P4)	96
	BTUEXT=0.706705*HPEXT	97
	IF(SI) TFHCAL=WG4*SQRT(T4)/P4	98
	IF(SI) BTUEXT=HPEXT	99
	XNHP=XNHPDS*PCNC/100.	100
	XNHDDT=DERIV(1,XNHP)	101
	DHTCC=(BTUEXT+WACP*(H3-H21)+CONFAC*PMIHP*XNHP*XNHDDT)/(WG4*T4)	102
	IF (IDES.EQ.0) GO TO 5	103
	TFHPCF=TFHPDS/TFHCAL	104
	DHPCF=DHTCC/DHTCHP	105
	ETHPCF=ETHPDS/ETATHP	106
	WRITE (6,11) CNHPCF,TFHPCF,ETHPCF,DHPCF	107
5	TFHCAL=TFHPCF*TFHCAL	108
	DHTCHP=DHPCF*DHTCHP	109
	ETATHP=ETHPCF*ETATHP	110
	DHTC=DHTCC*T4	111
	ERR(1)=(TFHCAL-TFFHP)/TFHCAL	112
	ERR(2)=(DHTCC-DHTCHP)/DHTCC	113
	CALL THTURB (DHTC,ETATHP,FAR4,H4,S4,P4,T50,H50,S50,P50)	114
	IF (BLHP.LE.0.0) GO TO 6	115
	FAR50=FAR4*WG4/(WG4+BLHP*(FAR4+1.))	116
	WG50=WG4+BLHP	117
	H50=(BLHP*H3+WG4*H50)/WG50	118
	CALL THERMO(P50,H50,T50,S50,XX2,1,FAR50,1)	119
	GO TO 7	120
6	FAR50=FAR4	121
	WG50=WG4	122
7	CONTINUE	123
	IF (VHPTRB.EQ.0.0) GO TO 21	124
	Q(2)=0.0	125
	Q(3)=0.0	126
	WG50P=WG50	127
	H50P=H50	128
	P50DOT=DERIV(12,P50)	129
18	CONTINUE	130
	CALL THERMO(P50,H50,T50,S50,XX2,1,FAR50,0)	131
	WG50=WG50P-P50DOT*VHPTRB/T50/1.4/RA	132
	U50=H50-RA*AJ*T50	133
	U50DOT=DERIV(13,U50)	134
	H50X=(WG50P*H50P-(WG50P-WG50)*U50-U50DOT*P50*VHPTRB/T50/RA)/WG50	135
	ERRW=(H50-H50X)/H50	136
	DIR=SQRT(ABS(H50/H50X))	137
	CALL AFQUIR(Q(1),T50,ERRW,0.,20.,0.0001,DIR,T50T,IGO)	138
	GO TO (19,21,20), IGO	139
19	T50=T50T	140
	GO TO 18	141
20	CALL ERROR	142
21	CONTINUE	143
	IF (FXFN2M.OR.DUMSPL) GO TO 8	144
	CALL COIPTB	145
	RETURN	146
8	P5=P50	147

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H5=H50 148
T5=T50 149
S5=S50 150
FAR5=FAR50 151
WG5=WG50 152
C SET MIDDLE TURBINE PARAMETERS TO ZERO, NOT USED 153
TFFIP=0. 154
CNIP=0. 155
DHTI=0. 156
DHTCIP=0. 157
ETATIP=0. 158
CALL COLPTB 159
RETURN 160
C 161
C 162
C 163
9 FORMAT (19H0*****TFFHP OFF MAP,F10.4,2XA6,11H*****$$$$$$) 164
10 FORMAT (19H0***** CNHP OFF MAP,F10.4,2XA6,11H*****$$$$$$) 165
11 FORMAT (20H0.P. TURBINE DESIGN,5X7HCNHPCF=,E15.8,8H TFHPCF=,E15.8 166
1,8H ETHPCF=,E15.8,8H DHHPCF=,E15.8) 167
END 168

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$IBFTC COINLT 1
SUBROUTINE COINLT 2
COMMON /WORDS/ WORD 3
COMMON /DESIGN/ 4
1IDES ,JDES ,KDES ,MODE ,INIT ,IDUMP ,IAMTP ,IGASMX, 5
2IDBURN,IAFTBN,ICD ,IMCD ,IDSHOC,IMSHOC,NOZFLT,ITRYS , 6
3LOOPER,NOMAP , NUMMAP,MAPEDG,TOLALL,ERR(9) 7
COMMON /ALL1/ 8
1PCNFGU,PCNCGU,T4GU ,DUMD1 ,DUMD2 ,DELFG ,DELFN ,DELSFC, 9
2ZFDS ,PCNFDS,PRFDS ,ETAFDS,WAFDS ,PRFCF ,ETAFCF,WAFCF , 10
3ZCDS ,PCNCDS,PRCDS ,ETACDS,WACDS ,PRCCF ,ETACCF,WACCF , 11
4T4DS ,WFBDS ,DTCODS,ETABDS,WA3CDS ,DPCODS,DTCCOF,ETABCF , 12
5TFHPDS,CNHPS,ETHPOS,TFHPCF,CNHPCF,ETHPCF,DHHPCF,T2DS , 13
6TFLPDS,CNLPDS,ETLPDS,TFLPCF,CNLPFC,ETLPCF,DHLPFC,T2LDS , 14
7T24DS ,WFDD ,DTDUDS,ETAADS,WA23DS ,DPDUDS,DTDUCF,ETAOCF, 15
8T7DS ,WFADS ,DTAFDS,ETAADS,WG6CDS ,DPAFDS,DTAFCF,ETAACF, 16
9A55 ,A25 ,A6 ,A7 ,A8 ,A9 ,A28 ,A29 , 17
$PS55 ,AM55 ,CVDNOZ,CVMNOZ,A8SAV ,A9SAV ,A28SAV,A29SAV 18
COMMON /ALL2/ 19
1T1 ,P1 ,H1 ,S1 ,T2 ,P2 ,H2 ,S2 , 20
2T21 ,P21 ,H21 ,S21 ,T3 ,P3 ,H3 ,S3 , 21
3T4 ,P4 ,H4 ,S4 ,T5 ,P5 ,H5 ,S5 , 22
4T55 ,P55 ,H55 ,S55 ,BLF ,BLC ,BLDU ,BLOB , 23
5CNF ,PRF ,ETAF ,WAF ,WAF ,WA3 ,WG4 ,FAR4 , 24
6CNC ,PRC ,ETAC ,WACC ,WAC ,ETAB ,DPCOM ,DUMP , 25
7CNHP ,ETATHP,DHTCHP,DHTC ,BLHP ,WG5 ,FAR5 ,CS , 26
8CNLP ,ETATLP,DHTCLP,DHTF ,BLLP ,WG55 ,FAR55 ,HPEXT , 27
9AM ,ALTP ,ETAR ,ZF ,PCNF ,ZC ,PCNC ,WFB , 28
$TFFHP ,TFFLP ,PCBLF ,PCBLC ,PCBLDU,PCBLOB,PCBLHP,PCBLLP 29
COMMON /ALL3/ 30
1XP1 ,XWAF ,XWAC ,XBLF ,XBLDU ,XH3 ,DUMS1 ,DUMS2 , 31
2XT21 ,XP21 ,XM21 ,XS21 ,T23 ,P23 ,H23 ,S23 , 32
3T24 ,P24 ,H24 ,S24 ,T25 ,P25 ,H25 ,S25 , 33
4T28 ,P28 ,H28 ,S28 ,T29 ,P29 ,H29 ,S29 , 34
5WAD ,WFD ,WG24 ,FAR24 ,ETAC ,DPDUC ,BYPASS,DUMS3 , 35
6TS28 ,PS28 ,V28 ,AM28 ,TS29 ,PS29 ,V29 ,AM29 , 36
7XT55 ,XP55 ,XH55 ,XS55 ,XT25 ,XP25 ,XH25 ,XS25 , 37
8XWFB ,XWG55 ,XFAR55,XWFD ,XWG24 ,XFAR24,XXP1 ,DUMB , 38
9T6 ,P6 ,H6 ,S6 ,T7 ,P7 ,H7 ,S7 , 39
$T8 ,P8 ,H8 ,S8 ,T9 ,P9 ,H9 ,S9 , 40
COMMON /ALL4/ 41
1WG6 ,WFA ,WG7 ,FAR7 ,ETAA ,DPAFT ,V55 ,V25 , 42
2PS6 ,V6 ,AM6 ,TS7 ,PS7 ,V7 ,AM7 ,AM25 , 43
3TS8 ,PS8 ,V8 ,AM8 ,TS9 ,PS9 ,V9 ,AM9 , 44
4VA ,FRD ,VJD ,FGMD ,VJM ,FGMM ,FGPD ,FGPM , 45
5FGM ,FGP ,WFT ,WGT ,FART ,FG ,FN ,SFC , 46
6WA32 ,DPWGDS,DPWING,WA32DS,A38 ,AM38 ,V38 ,T38 , 46
7H38 ,P38 ,TS38 ,PS38 ,T39 ,H39 ,P39 ,TS39 , 47

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BV39 ,AM39 ,A39 ,BPRINT,WG37 ,CVDWNG,FGMWNG,FGPWNG, 48
9FNHNG,FNMAIN,FMOVFN,PS39 ,FFOVFN,FCOVFN,FMNOFN,FNOVFD, 49
$VJW ,T22 ,P22 ,H22 ,S22 ,T50 ,P50 ,H50 50
COMMON /ALL5/ 51
IS50 ,WA22 ,ZI ,PCNI ,CNI ,PRI ,ETAI ,WACI , 52
2TFFIP ,CNIP ,ETATIP,DHTCIP,DHTI ,BLIP ,PCBLIP,PCNIGU, 53
3ZIDS ,PCNIDS,PRIDS ,ETAIDS,WAIDS ,PRICF ,ETAICF,WAICF, 54
4TFIPDS,CNIPDS,ETIPDS,TFIPCF,CNIPCF,ETIPCF,DHIPCFC,WAICDS, 55
5WAI ,PCBLI ,BLI ,T22DS ,WA21 ,WG50 ,FAR50 ,A24 , 56
6AM23 ,DUMSPL,FXFN2M,FXM2CP,AFTFAN,PUNT ,PCBLID,P6DSAV, 57
7AM6DSV,ETAASV,FAR7SV,T4PBL ,T41 ,FAN ,ISPOOL 58
COMMON /DELCH/ DELT1 59
COMMON /UNITS/ SI 60
LOGICAL SI 61
DATA AWORD/6HCOINLT/ 62
WORD=AWORD 63
IF(SI) GO TO 10 64
AJ=778.26 65
G=32.174049 66
REF59=2.0855531E07 67
R=1.986375 68
GO TO 11 69
10 AJ=1.0 70
G=1.0 71
REF59=6.3567658E06 72
R=8314.34 73
11 ALT=ALTP*REF59/(REF59-ALTP) 74
CALL ATMOS(ALT,T1STD,XX1,XX2,XX3,DELTA,CS,XX4,IIER) 75
P1=DELTA 76
IF(SI) P1=101325.*DELTA 77
T1=T1STD 78
IF(IAMTP.EQ.2) T1=T1STD+DELT1 79
IF (IAMTP.EQ.5) CALL RAM2 (AM,ETAR) 80
IF (IAMTP.NE.1.AND.IAMTP.NE.5) CALL RAM (AM,ETAR) 81
FAR=0.0 82
CALL PROCOM (FAR,T1,CS,XX2,XX3,R1,PHI1,H1) 83
S1=PHI1-R1*ALOG(DELTA) 84
H2=H1+(AM*CS)**2/(2.*AJ*G) 85
P2T=1. 86
IF(SI) P2T=101325. 87
DO 1 I=1,10 88
CALL THERMO (P2T,H2,T2T,S2T,AW,0,0,0,1) 89
IF (ABS(S2T-S1).LE.0.0001*S1) GO TO 2 90
1 P2T=P1*EXP((AW/R)*((S2T-S1)+(R/AW)*ALOG(P2T/P1))) 91
CALL ERROR 92
RETURN 93
2 IF (IAMTP.EQ.3.OR.IAMTP.EQ.4) ETAR=P2/P2T 94
P2=ETAR*P2T 95
IF (IAMTP.NE.4) CALL THERMO (P2,H2,T2,S2,XX5,0,0,0,1) 96
IF (IAMTP.EQ.4) CALL THERMO (P2,H2,T2,S2,XX5,0,0,0,0) 97
IF (INIT.EQ.1) GO TO 5 98
IF (IDES.EQ.1) GO TO 3 99
IF (MODE.EQ.3) GO TO 4 100
PCNF=GUESS(MODE,T4,T4DS,PCNC,PCNCDS,WFB,WFBDS,T2,T2DS,PCNFDS) 101
PCNFGU=PCNF 102
GO TO 4 103
3 PCNF=PCNFDS 104
PCNFGU=PCNF 105
T2DS=T2 106
4 ZF=ZFDS 107
5 RETURN 108
END 109

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\$IBFTC COINTC

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SUBROUTINE COINTC 1
COMMON /WORDS/ WORD 2
COMMON /DESIGN/ 3
IIDES ,JDES ,KDES ,MODE ,INIT ,IDUMP ,IAMTP ,IGASMX, 4
2IDBURN,IAFTBN,IOCD ,IMCD ,IDSHOC ,IMSHOC,MOZFLT,ITRYS , 5
3LOOPER,NOMAP ,NUMMAP,MAPEDG,TOLALL,ERR(9) 6

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COMMON /ALL1/
1PCNFGU,PCNCGU,T4GU ,DUMD1 ,DUMD2 ,DELFG ,DELFN ,DELSFC,
27FDS ,PCNFDS,PRFDS ,ETAFDS,WFADS ,PRFCF ,ETAFCF,WFACF ,
3ZCDS ,PCNCDS,PRCDS ,ETACDS,WACDS ,PRCCF ,ETACCF,WACCF ,
4T4DS ,WFBDS ,DTCODS,ETABDS,WA3CDS ,DPCODS,DTCCCF,ETABCF,
5TFHPDS,CNHPDS,ETHPDS,TFHPCF,CNHPCF,EJHPCF,DHHPCF,T2DS ,
6TFLPDS,CNLPDS,ETLPDS,TFLPCF,CNLPFC,ETLPFC,DHLPFC,T21DS ,
7T24DS ,WFDDSD,DTDUDS,ETADDS,WA23DS,DPDUDS,DTDUCF,ETADCF,
8T7DS ,WFADS ,DTAFDS,ETAADS,WG6CDS,DPAFDS,DTAFCF,ETAACF,
9A55 ,A25 ,A6 ,A7 ,A8 ,A9 ,A28 ,A29 ,
$PS55 ,AM55 ,CVDNOZ,CVMNOZ,A8SAV ,A9SAV ,A28SAV,A29SAV
COMMON /ALL2/
1T1 ,P1 ,H1 ,S1 ,T2 ,P2 ,H2 ,S2 ,
2T21 ,P21 ,H21 ,S21 ,T3 ,P3 ,H3 ,S3 ,
3T4 ,P4 ,H4 ,S4 ,T5 ,P5 ,H5 ,S5 ,
4T55 ,P55 ,H55 ,S55 ,BLF ,BLC ,BLDU ,BLOB ,
5CNF ,PRF ,ETAF ,WAF ,WAF ,WA3 ,WG4 ,FAR4 ,
6CNC ,PRC ,ETAC ,WACC ,WAC ,ETAB ,DPCDM ,DUMP ,
7CNHP ,ETATHP,DHTCHP,DHTC ,BLHP ,WG5 ,FAR5 ,CS ,
8CNLP ,ETATLP,DHTCLP,DHTF ,BLLP ,WG55 ,FAR55 ,HPEXT ,
9AM ,ALTP ,ETAR ,ZF ,PCNF ,ZC ,PCNC ,WFB ,
$TFFHP ,TFFLP ,PCBLF ,PCBLC ,PCBLDU,PCBLOB,PCBLHP,PCBLLP
COMMON /ALL3/
1XP1 ,XWAF ,XWAC ,XBLF ,XBLDU ,XH3 ,DUMS1 ,DUMS2 ,
2XT21 ,XP21 ,XH21 ,XS21 ,T23 ,P23 ,H23 ,S23 ,
3T24 ,P24 ,H24 ,S24 ,T25 ,P25 ,H25 ,S25 ,
4T28 ,P28 ,H28 ,S28 ,T29 ,P29 ,H29 ,S29 ,
5WAD ,WFD ,WG24 ,FAR24 ,ETAC ,DPDUC ,BYPASS,DUMS3 ,
6TS28 ,PS28 ,V28 ,AM28 ,TS29 ,PS29 ,V29 ,AM29 ,
7XT55 ,XP55 ,XH55 ,XS55 ,XT25 ,XP25 ,XH25 ,XS25 ,
8XWFB ,XWG55 ,XFAR55,XWFD ,XWG24 ,XFAR24,XXP1 ,DUMB ,
9T6 ,P6 ,H6 ,S6 ,T7 ,P7 ,H7 ,S7 ,
$T8 ,P8 ,H8 ,S8 ,T9 ,P9 ,H9 ,S9
COMMON /ALL4/
1WG6 ,WFA ,WG7 ,FAR7 ,ETAA ,DPAFT ,V55 ,V25 ,
2PS6 ,V6 ,AM6 ,TS7 ,PS7 ,V7 ,AM7 ,AM25 ,
3TS8 ,PS8 ,V8 ,AMB ,TS9 ,PS9 ,V9 ,AM9 ,
4VA ,FRD ,VJD ,FGMD ,VJM ,FGMM ,FGPD ,FGPM ,
5FGM ,FGP ,WFT ,WGT ,FART ,FG ,FN ,SFC ,
6WA32 ,DPWGDS,DPWING,WA32DS,A38 ,AM38 ,V38 ,T38 ,
7H38 ,P38 ,TS38 ,PS38 ,T39 ,H39 ,P39 ,TS39 ,
8V39 ,AM39 ,A39 ,BPRINT,WG37 ,CVDWNG,FGMWNG,FGPWNG,
9FNWING,FNMAIN,FNOVFN,PS39 ,FFOVFN,FCOVFN,FMNOFN,FNOVFD,
$VJW ,T22 ,P22 ,H22 ,S22 ,T50 ,P50 ,H50
COMMON /ALL5/
1S50 ,WA22 ,ZI ,PCNI ,CNI ,PRI ,ETAI ,WACI ,
2TFFIP ,CNIP ,ETATIP,DHTCIP,DHTI ,BLIP ,PCBLIP,PCNIGU,
3ZIDS ,PCNIDS,PRIDS ,ETAIDS,WAIDS ,PRICF ,ETAICF,WAICF ,
4TFIPDS,CNIPDS,ETIPDS,TFIPCF,CNIPCF,ETIPCF,DHIPCFC,WAICDS,
5WAI ,PCBLI ,BLI ,T22DS ,WA21 ,WG50 ,FAR50 ,A24 ,
6AM23 ,DUMSPL,FXFN2M,FXM2CP,AFTFAN,PUNT ,PCBLID,P6DSAV,
7AM6DSV,ETAASV,FAR7SV,T4PBL ,T41 ,FAN ,ISPOOL
COMMON /VOLS/ VFAN,VINTC,VCOMP,VCCMB,VHPTRB,VIPTRB,VLPTRB,VAFTBN,
1 VFDUCT,VWDUCT
COMMON /FLOWS/ WAFP,WAIP,WACP
COMMON /UNITS/ SI
COMMON /INT/CNX(15),PRX(15,15),WACX(15,15),ETAX(15,15),
INCN,NPT(15)
COMMON/DUMINT/CNX(15),PRXX(15,15),WACXX(15,15),ETAXX(15,15),
INCNX,NPTX(15)
LOGICAL FXFN2M,FXM2CP,AFTFAN,DLMSPL,FAN,SI
DIMENSION Q(9),WLH(2)
DATA AMORD,WLH/6HCOINTC,6H(LO),6H(HI) /
WORD=AMORD
IF (SI) GO TO 100
TSTD=518.668
PSTD=1.0
RA=.0252
AJ=2.719
GO TO 101
TSTD=288.149
PSTD=101325.
RA=286.9
AJ=1.0

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101	CONTINUE	81
	IF (.NOT.AFTFAN) GO TO 1	82
	T22S=T22	83
	H22S=H22	84
	S22S=S22	85
	P22S=P22	86
	T22=T2	87
	H22=H2	88
	S22=S2	89
	P22=P2	90
1	THETA=SQRT(T22/TSTD)	91
	DELTA=P22/PSTD	92
	IF (.NOT.FAN) WAI=WAF-BLF	93
	IF (IDES.NE.1) GO TO 2	94
	PRI=PRIDS	95
	PCBLI=PCBLID	96
	IF (.NOT.FAN) WAICDS=WAI*THETA/DELTA	97
	IF (.NOT.FAN) DUMSPL=.TRUE.	98
	WAI=WAICDS	99
	THETAD=THETA	100
	WAIDS=WAI*DELTA/THETA	101
	ETAI=ETAIDS	102
2	IF (.NOT.FXFN2M) GO TO 3	103
C	FAN AND MIDDLE SPOOL ROTATE AT SAME SPEED	104
	SPDFAN=CNF*SQRT(T2/TSTD)	105
	CNI=SPDFAN/THETA	106
	PCNI=100.*CNI*THETA/THETAD	107
	IF (IDES.EQ.1) PCNIDS=PCNI	108
3	CNI=PCNI*THETAD/(100.*THETA)	109
	ZI=AMAX1(ZI,0.)	110
	ZI=AMIN1(ZI,1.)	111
	CNIS=CNI	112
	IF (.NOT.DUMSPL) GO TO 4	113
	CALL INDUMY (CNI,ZI,WAICDS,IDES)	114
	CALL SEARCH (ZI,CNI,PRI,WACI,ETAI,CNXX,NCNX,PRXX,WACXX,ETAXX,NPTX,	115
	115,15,IGO)	116
	GO TO 5	117
4	CONTINUE	118
	CALL SEARCH (ZI,CNI,PRI,WACI,ETAI,CNX(1),NCN,PRX(1,1),WACX(1,1),ET	119
	LAX(1,1),NPT(1),15,15,IGO)	120
5	CONTINUE	121
	IF ((CNI-CNIS).GT..0005*CNI) MAPEDG=1	122
	IF (IGO.EQ.1.OR.IGO.EQ.2) WRITE (8,12) CNIS,WLH(IGO)	123
	IF (.NOT.FAN) WAI=WAI*THETA/DELTA	124
	WAI=WAI*DELTA/THETA	125
	WA22=WAI	126
	IF (IDES.NE.1) GO TO 7	127
	T22DS=T22	128
	IF (AFTFAN) T22DS=T22S	129
	IF (.NOT.DUMSPL) PRICF=(PRIDS-1.)/(PRI-1.)	130
	ETAICF=ETAIDS/ETAI	131
	WAICF=WAIDS/WAI	132
	IF (.NOT.DUMSPL) GO TO 6	133
	PRICF=1.	134
	ETAICF=1.	135
	WAICF=1.	136
6	CONTINUE	137
	WRITE (6,13) PRICF,ETAICF,WAICF,T22DS	138
7	PRI=PRICF*(PRI-1.)+1.	139
	ETAI=ETAICF*ETAI	140
	WAI=WAICF*WAI	141
	WAIP=WAI	142
	WACI=WACI*WAICF	143
	WA22=WAI	144
	CALL THCOMP (PRI,ETAI,T22,H22,S22,P22,T21,H21,S21,P21)	145
	IF(VINTC.EQ.0.0) GO TO 21	146
	Q(2)=0.0	147
	Q(3)=0.0	148
	H21P=H21	149
	P21DOT=DERIV(6,P21)	150
18	CONTINUE	151
	CALL THERMO(P21,H21,T21,S21,XX2,0,0,0,0)	152
	WAI=WAIP-P21DOT*VINTC/T21/1.4/RA	153
	U21=H21-AJ*RA*T21	154



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U21DOT=DERIV(7,U21)
H21X=(WAIP*H21P-(WAIP-WAI)*U21-U21DOT*P21*VINTC/T21/RA)/WAI
ERRW=(H21-H21X)/H21
DIR=SQRT(ABS(H21/H21X))
CALL AFQUIR(Q(1),T21,ERRW,0.,20.,0.0001,DIR,T21T,IGO)
GO TO (19,21,20),IGO
19 T21=T21T
GO TO 18
20 CALL ERROR
21 CONTINUE
IF (.NOT.DUMSPL) GO TO 8
PRI=1.
ETAI=1.
T21=T22
H21=H22
S21=S22
P21=P22
IF (ISPOOL.EQ.1) WA21=WAI
8 CONTINUE
IF (IDES.NE.1) GO TO 9
BLI=PCBLI*WAI
WA21=WA21-BLI
WA32=BLI
IF (FAN.OR.IDES.EQ.1) WAC=WA21
9 CONTINUE
IF (ABS(CNI-CNIS).LE.0.001*CNIS) GO TO 10
WRITE (8,14) CNIS,CNI
CALL ERROR
PCNI=100.*THETA*CNI/THETAD
10 IF (.NOT.AFTFAN) GO TO 11
T22=T22S
H22=H22S
S22=S22S
P22=P22S
11 CALL COCOMP
RETURN
C
C
C
12 FORMAT (19H0* * * CNI OFF MAP,F10.4,2XA6,11H* * *$$$$$)
13 FORMAT (20H/MIDDLE SPOOL DESIGN,4X8H PRICF=,E15.8,8H ETAICF=,E15.
18,8H WAICF=,E15.8,8H T22DS=,E15.8)
14 FORMAT (10HOCNI WAS= ,E15.8,11H AND NOW= ,E15.8,24H CHECK PCNI I
INPUT$$$$$)
END

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\$IBFTC COIPTB

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SUBROUTINE COIPTB
COMMON /WORDS/ WORD
COMMON /DESIGN/
1IDES ,JDES ,KDES ,MODE ,INIT ,IDUMP ,IAMTP ,IGASM,
2IDBURN,IAFTBN,IDCD ,IMCD ,IDSHOC,IMSHOC,NOZFLT,ITRYS ,
3LOOPER,NOMAP ,NUMMAP,MAPELG,TOLALL,ERR(9)
COMMON /ALL1/
1PCNFGU,PCNCGU,T4GU ,DUMD1 ,DUMD2 ,DELFG ,DELFN ,DELSFC,
2ZFDS ,PCNFDS,PRFDS ,ETAFDS,MAFDS ,PRCF ,ETACCF,MAFCF ,
3ZCDS ,PCNCDS,PRCDS ,ETACDS,WACDS ,PRCCF ,ETACCF,WACCF ,
4T4DS ,WFBS ,DTCODS,ETABDS,WA3CDS,OPCODS,OTCCCF,ETABCF,
5TFHPDS,CNHPDS,ETHPDS,TFHPCF,CNHPCF,ETHPCF,DHMPCF,T2DS ,
6TFLPDS,CNLPDS,ETLPDS,TFLPCF,CNLPDF,ETLPDF,DHLPDF,T21DS ,
7T24DS ,WFDD ,DTDUDS,ETADD,WA23DS,DPDUDS,DTDUCF,ETAOCF,
8T7DS ,WFAOS ,DTAFDS,ETAADS,WG&CDS,DPAFDS,DTAFCF,ETAACF,
9A55 ,A25 ,A6 ,A7 ,A8 ,A9 ,A28 ,A29 ,
$PS55 ,AM55 ,CVDNOZ,CVMNOZ,A8SAV ,A9SAV ,A28SAV,A29SAV
COMMON /ALL2/
1T1 ,P1 ,H1 ,S1 ,T2 ,P2 ,H2 ,S2 ,
2T21 ,P21 ,H21 ,S21 ,T3 ,P3 ,H3 ,S3 ,
3T4 ,P4 ,H4 ,S4 ,T5 ,P5 ,H5 ,S5 ,
4T55 ,P55 ,H55 ,S55 ,BLF ,BLC ,BLOU ,BLOB .

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5CNF ,PRF ,ETAF ,WAF ,WAF ,WA3 ,WG4 ,FAR4 ,
6CNC ,PRC ,ETAC ,WACC ,WAC ,ETAB ,DPCOM ,DUMP , 23
7CNHP ,ETATHP,DHTCHP,DHTC ,BLHP ,WG5 ,FAR5 ,CS , 24
8CNLP ,ETATLP,DHTCLP,DHTF ,BLLP ,WG55 ,FAR55 ,HPEXT , 25
9AM ,ALTP ,ETAR ,ZF ,PCNF ,ZC ,PCNC ,WFB , 26
$TFFHP ,TFFLP ,PCBLF ,PCBLC ,PCBLDU,PCBLOB,PCBLHP,PCBLLP , 27
COMMON /ALL3/ 28
1XP1 ,XWAF ,XWAC ,XBLF ,XBLDU ,XH3 ,DUMS1 ,DUMS2 , 29
2XT21 ,XP21 ,XH21 ,XS21 ,T23 ,P23 ,H23 ,S23 , 30
3T24 ,P24 ,H24 ,S24 ,T25 ,P25 ,H25 ,S25 , 31
4T28 ,P28 ,H28 ,S28 ,T29 ,P29 ,H29 ,S29 , 32
5WAD ,WFD ,WG24 ,FAR24 ,ETAC ,DPDUC ,BYPASS,DUMS3 , 33
6TS28 ,PS28 ,V28 ,AM28 ,TS29 ,PS29 ,V29 ,AM29 , 34
7XT55 ,XP55 ,XH55 ,XS55 ,XT25 ,XP25 ,XH25 ,XS25 , 35
8XWFB ,XWG55 ,XFAR55,XWFD ,XWG24 ,XFAR24,XXP1 ,DUMB , 36
9T6 ,P6 ,H6 ,S6 ,T7 ,P7 ,H7 ,S7 , 37
$T8 ,P8 ,H8 ,S8 ,T9 ,P9 ,H9 ,S9 , 38
COMMON /ALL4/ 39
1WG6 ,WFA ,WG7 ,FAR7 ,ETAA ,DPAFT ,V55 ,V25 , 40
2PS6 ,V6 ,AM6 ,TS7 ,PS7 ,V7 ,AM7 ,AM25 , 41
3TS8 ,PS8 ,V8 ,AM8 ,TS9 ,PS9 ,V9 ,AM9 , 42
4VA ,FRD ,VJD ,FGMD ,VJM ,FGMM ,FGPD ,FGPM , 43
5FGM ,FGP ,WFT ,WGT ,FART ,FG ,FN ,SFC , 44
6WA32 ,DPWGDS,DPWING,WA32DS,A38 ,AM38 ,V38 ,T38 , 45
7H38 ,P38 ,TS38 ,PS38 ,T39 ,H39 ,P39 ,TS39 , 46
8V39 ,AM39 ,A39 ,BPRINT,WG37 ,CVDWNG,FGMWNG,FGPWNG, 47
9FNWING,FNMAIN,FWOVFN,PS39 ,FFCVFN,FCOVFN,FMNOFN,FNOVFD, 48
$VJW ,T22 ,P22 ,H22 ,S22 ,T50 ,P50 ,H50 , 49
COMMON /ALL5/ 50
1S50 ,WA22 ,ZI ,PCNI ,CNI ,PRI ,ETAI ,WACI , 51
2TFFIP ,CNIP ,ETATIP,DHTCIP,DHTI ,BLIP ,PCBLIP,PCNIGU, 52
3ZIDS ,PCNIDS,PRIDS ,ETAIDS,WAIDS ,PRICF ,ETAICF,WAICF , 53
4TFIPDS,CNIPDS,ETIPDS,TFIPCF,CNIPCF,ETIPCF,DHIPCFC,WAICDS, 54
5WAI ,PCBLI ,BLI ,T22DS ,WA21 ,WG50 ,FAR50 ,A24 , 55
6AM23 ,DUMSPL,FXFN2M,FXM2CP,AFTFAN,PUNT ,PCBLID,P6DSAV, 56
7AM6DSV,ETAASV,FAR7SV,T4PBL ,T41 ,FAN ,ISPOOL 57
COMMON /RPM/ XNHPDS,XNIPDS,XNLPDS,PMIHP,PMIIP,PMILP 58
COMMON /VOLS/ VFAN,VINTC,VCOMP,VCOMB,VHPTRB,VIPTRB,VLPTRB,VAFTBN, 59
1 VFDUCT,VWDUCT 60
COMMON /FLOWS/ WAFP,WAIP,WACP 61
COMMON /UNITS/ SI 62
DIMENSION Q(9) 63
COMMON /ITURB/TFFX(15),CNX(15,15),DHTCX(15,15),ETATX(15,15), 64
INTFFS,NPTTFF(15) 65
LOGICAL AFTFAN,FXFN2M,FXM2CP,SI 66
COMMON /HTURB/TFFY(15),CNY(15,15),DHTCY(15,15),ETATY(15,15),NTFYS, 67
INPTTSF(15) 68
DATA AWORD,WLO,WHI/6HCOIPTB,6H(LO),6H(HI) / 69
IF(SI) GO TO 100 70
RA=.0252 71
AJ=2.719 72
CONFAC=1.4091E-5 73
GO TO 101 74
100 RA=286.9 75
AJ=1.0 76
CONFAC=1.0966E-2 77
101 CONTINUE 78
H22SAV=H22 79
IF (AFTFAN) H22=H2 80
WORD=AWORD 81
IF (IDES.EQ.0) GO TO 1 82
CNIPCF=CNIPDS*SQRT(T50)/PCNI 83
IF (FXM2CP) CNIPCF=CNHPDS*SQRT(T50)/PCNI 84
1 CNIP=CNIPCF*PCNI/SQRT(T50) 85
CNIPS=CNIP 86
TFFIPS=TFFIP 87
IF (FXM2CP) GO TO 2 88
CALL SEARCH (-1.,TFFIP,CNIP,DHTCIP,ETATIP,TFFX(1),NTFFS,CNX(1,1),D 89
HTCX(1,1),ETATX(1,1),NPTTFF(1),15,15,IGO) 90
IF (FXM2CP) CALL SEARCH (-1.,TFFIP,CNIP,DHTCIP,ETATIP,TFFY(1),NTFY 91
IS,CNY(1,1),DHTCY(1,1),ETATY(1,1),NPTTSF(1),15,15,IGO) 92
IF (IGO.EQ.1.OR.IGO.EQ.11.OR.IGO.EQ.21) WRITE (8,9) TFFIPS,WLO 93
IF (IGO.EQ.2.OR.IGO.EQ.12.OR.IGO.EQ.22) WRITE (8,9) TFFIPS,WHI 94
IF (IGO.EQ.10.OR.IGO.EQ.11.OR.IGO.EQ.12) WRITE (8,9) CNIPS,WLO 95
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IF (IGO.EQ.20.OR.IGO.EQ.21.OR.IGO.EQ.22) WRITE (8,10) CNIPS,WHI      97
IF (IGO.NE.7) GO TO 3                                                  98
CALL ERROR                                                             99
RETURN                                                                  100
NOMAP=0                                                                101
TFICAL=WG50*SQRT(T50)/(14.696*P50)                                    102
IF(SI) TFICAL=WG50*SQRT(T50)/P50                                     103
XNIP=XNIPDS*PCNI/100.                                                104
XNIDOT=DERIV(2,XNIP)                                                 105
BTUEXT=.706705*HPEXT                                                106
IF(SI) BTUEXT=HPEXT                                                 107
DHACEL=CONFAC*PMIIP*XNIP*XNIDOT                                     108
DHTIC=(WAIP*(H21-H22)+DHACEL)/(WG50*T50)                            109
IF(FXM2CP) DHTIC=(BTUEXT+WACP*(H3-H21)+WAIP*(H21-H22)+DHACEL)/  110
1 (WG50*T50)                                                           111
IF (IDES.EQ.0) GO TO 6                                               112
TFIPCF=TFIPDS/TFICAL                                                 113
DHIPCF=DHTIC/DHTCIP                                                 114
ETIPCF=ETIPDS/ETATIP                                                115
IF (FXM2CP) TFIPCF=TFHPDS/TFICAL                                    116
IF (FXM2CP) ETIPCF=ETHPDS/ETATIP                                    117
WRITE (6,11) CNIPCF,TFIPCF,ETIPCF,DHIPCF                            118
6 TFICAL=TFIPCF*TFICAL                                               119
DHTCIP=DHIPCF*DHTCIP                                                 120
ETATIP=ETIPCF*ETATIP                                                121
DHTI=DHTIC*T50                                                       122
N1=8                                                                    123
N2=9                                                                    124
IF (FXM2CP) N1=1                                                       125
IF (FXM2CP) N2=2                                                       126
ERR(N1)=(TFICAL-TFFIP)/TFICAL                                       127
ERR(N2)=(DHTIC-DHTCIP)/DHTIC                                         128
CALL THTURB (DHTI,ETATIP,FAR50,H50,S50,P50,T5,H5,S5,P5)           129
IF(BLIP.LE.0.0) GO TO 7                                              130
FAR5=FAR50*WG50/(WG50+BLIP*(FAR50+1.))                               131
WG5=WG50+BLIP                                                         132
H5=(BLIP*H3+WG50*H5)/WG5                                             133
CALL THERMO(P5,H5,T5,S5,XX2,1,FAR5,1)                                134
GO TO 8                                                                135
7 FAR5=FAR50                                                           136
WG5=WG50                                                                137
8 CONTINUE                                                             138
IF(VIPTRB.EQ.0.0) GO TO 21                                           139
Q(2)=0.0                                                                140
Q(3)=0.0                                                                141
WG5P=WG5                                                                142
H5P=H5                                                                143
P5DOT=DERIV(14,P5)                                                   144
18 CONTINUE                                                            145
CALL THERMO(P5,H5,T5,S5,XX2,1,FAR5,0)                                146
WG5=WG5P-P5DOT*VIPTRB/T5/1.4/RA                                       147
U5=H5-RA*AJ*T5                                                         148
U5DOT=DERIV(15,U5)                                                    149
H5X=(WG5P*H5P-(WG5P-WG5)*U5-U5DOT*P5*VIPTRB/T5/RA)/WG5           150
ERRW=(H5-H5X)/H5                                                       151
DIR=SQRT(ABS(H5/H5X))                                                  152
CALL AFQUIR(Q(1),T5,ERRW,0.,20.,0.0001,DIR,T5T,IGO)                 153
GO TO (19,21,20),IGO                                                  154
19 T5=T5T                                                              155
GO TO 18                                                                156
20 CALL ERROR                                                           157
21 CONTINUE                                                             158
H22=H22SAV                                                             159
CALL COLPTB                                                             160
RETURN                                                                  161
C                                                                        162
C                                                                        163
C                                                                        164
9 FORMAT (19H0*****TFFIP OFF MAP,F10.4,2XA6,11H*****$$$$$$)     165
10 FORMAT (19H0***** CNIP OFF MAP,F10.4,2XA6,11H*****$$$$$$)     166
11 FORMAT (20H01-P. TURBINE DESIGN,5X7HCNIPCF=,E15.8,8H TFIPCF=,E15.8  167
1,8H ETIPCF=,E15.8,8H DHIPCF=,E15.8)                                  168
END                                                                      169

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$IBFTC COLPT8
SUBROUTINE COLPT8
COMMON /WORDS/ WORD
COMMON /DESIGN/
1IDES ,JDES ,KDES ,MODE ,INIT ,IDUMP ,IAMTP ,IGASMX,
2IDBURN ,IAFTBN ,IDCD ,IMCD ,IDSHOC ,IMSHOC ,NOZFLT ,ITRYS ,
3LOOPER ,NOMAP ,NUMMAP ,MAPEDG ,TOLALL ,ERR (9)
COMMON /ALL1/
4IPCNGU ,PCNGU ,T4GU ,DUMD1 ,DUMD2 ,DELFG ,DELFN ,DELSFC,
5ZFDS ,PCNFDS ,PRFDS ,ETAFDS ,WAFDS ,PRFCF ,ETAFCF ,WAFCF ,
63ZCOS ,PCNCOS ,PRCOS ,ETACOS ,WACOS ,PRCCF ,ETACCF ,WACCF ,
74T4DS ,WFBDS ,DTCOS ,ETABDS ,WA3COS ,DPCOS ,DTCOCF ,ETABCF ,
85TFHPDS ,CNHPDS ,ETHPDS ,TFHPCF ,CNHPCF ,ETHPCF ,DHHPCF ,T2DS ,
96TFLPDS ,CNLPDS ,ETLPDS ,TFLPCF ,CNLPCF ,ETLPCF ,DHLPCF ,T21DS ,
107T24DS ,WFDS ,DTODS ,ETADDS ,WA23DS ,DPDUDS ,DTDUCF ,ETADCF ,
118T7DS ,WFADS ,DTAFDS ,ETAADS ,WG6CDS ,DPAFDS ,DTAFCF ,ETAACF ,
129A55 ,A25 ,A6 ,A7 ,A8 ,A9 ,A28 ,A29 ,
13$PS55 ,AM55 ,CVDNOZ ,CVMNOZ ,A8SAV ,A9SAV ,A28SAV ,A29SAV
COMMON /ALL2/
14IT1 ,P1 ,H1 ,S1 ,T2 ,P2 ,H2 ,S2 ,
152T21 ,P21 ,H21 ,S21 ,T3 ,P3 ,H3 ,S3 ,
163T4 ,P4 ,H4 ,S4 ,T5 ,P5 ,H5 ,S5 ,
174T55 ,P55 ,H55 ,S55 ,BLF ,BLC ,BLDU ,BLOB ,
185CNF ,PRF ,ETAF ,WAF ,WAF ,WA3 ,WG4 ,FAR4 ,
196CNC ,PRC ,ETAC ,WACC ,WAC ,ETAB ,DPCOM ,DUMP ,
207CNHP ,ETATHP ,DHTCHP ,DHTC ,BLHP ,WG5 ,FAR5 ,CS ,
218CNLP ,ETATLP ,DHTCLP ,DHTF ,BLLP ,WG55 ,FAR55 ,HPEXT ,
229AM ,ALTP ,ETAR ,ZF ,PCNF ,ZC ,PCNC ,WFB ,
23$TFFHP ,TFFLP ,PCBLF ,PCBLC ,PCBLDU ,PCBLOB ,PCBLHP ,PCBLLP
COMMON /ALL3/
241XP1 ,XWAF ,XWAC ,XBLF ,XBLDU ,XH3 ,DUMS1 ,DUMS2 ,
252XT21 ,XP21 ,XH21 ,XS21 ,T23 ,P23 ,H23 ,S23 ,
263T24 ,P24 ,H24 ,S24 ,T25 ,P25 ,H25 ,S25 ,
274T28 ,P28 ,H28 ,S28 ,T29 ,P29 ,H29 ,S29 ,
285WAD ,WFD ,WG24 ,FAR24 ,ETAD ,DPDUC ,BYPASS ,DUMS3 ,
296TS28 ,PS28 ,V28 ,AM28 ,TS29 ,PS29 ,V29 ,AM29 ,
307XT55 ,XP55 ,XH55 ,XS55 ,XT25 ,XP25 ,XH25 ,XS25 ,
318XWFB ,XWG55 ,XFAR55 ,XWFD ,XWG24 ,XFAR24 ,XFP1 ,DUMB ,
329T6 ,P6 ,H6 ,S6 ,T7 ,P7 ,H7 ,S7 ,
33$T8 ,P8 ,H8 ,S8 ,T9 ,P9 ,H9 ,S9
COMMON /ALL4/
341WG6 ,WFA ,WG7 ,FAR7 ,ETAA ,DPAFT ,V55 ,V25 ,
352PS6 ,V6 ,AM6 ,TS7 ,PS7 ,V7 ,AM7 ,AM25 ,
363TS8 ,PS8 ,V8 ,AM8 ,TS9 ,PS9 ,V9 ,AM9 ,
374VA ,FRD ,VJD ,FGMD ,VJM ,FGMM ,FGPD ,FGPM ,
385FGM ,FGP ,WFT ,WGT ,FART ,FG ,FN ,SFC ,
396WA32 ,DPWGDS ,DPWING ,WA32DS ,A38 ,AM38 ,V38 ,T38 ,
407H38 ,P38 ,TS38 ,PS38 ,T39 ,H39 ,P39 ,TS39 ,
418V39 ,AM39 ,A39 ,BPRINT ,WG37 ,CVDWNG ,FGMWNG ,FGPWNG ,
429FNWING ,FNMAIN ,FWOVN ,PS39 ,FFOVN ,FCOVN ,FMNOFN ,FNOVFD ,
43$VJW ,T22 ,P22 ,H22 ,S22 ,T50 ,P50 ,H50
COMMON /ALL5/
441S50 ,WA22 ,ZI ,PCNI ,CNI ,PRI ,ETAI ,WACI ,
452TFFIP ,CNIP ,ETATIP ,DHTCIP ,DHTI ,BLIP ,PCBLIP ,PCNIGU ,
463ZIDS ,PCNIDS ,PRIDS ,ETAIDS ,WAIDS ,PRICF ,ETAICF ,WAICF ,
474TFIPDS ,CNIPDS ,ETIPDS ,TFIPCF ,CNIPCF ,ETIPCF ,DHIPCF ,WAICDS ,
485WAI ,PCBLI ,BLI ,T22DS ,WA21 ,WG50 ,FAR50 ,A24 ,
496AM23 ,DUMSPL ,FXFN2M ,FXM2CP ,AFTFAN ,PUNT ,PCBLID ,P6DSAV ,
507AM6DSV ,ETAASV ,FAR7SV ,T4PBL ,T41 ,FAN ,ISPOOL
COMMON /RPM/ XNHPDS ,XNIPDS ,XNLPDS ,PMIHP ,PMIIP ,PMILP
COMMON /VOLS/ VFAN ,VINTC ,VCOMP ,VCOMB ,VHPTRB ,VIPTRB ,VLPTRB ,VAFTBN ,
511 VFDUCT ,VWDUCT
COMMON /FLOWS/ WAFP ,WAIP ,WACP
COMMON /UNITS/ SI
LOGICAL AFTFAN ,FXFN2M ,FXM2CP ,SI
COMMON /LTURB/TFFX(15) ,CNX(15,15) ,DHTCX(15,15) ,ETATX(15,15) ,
52INTFFS ,NPTTFF(15)
DIMENSION Q(9)
DATA ANORD ,WLO ,WHI /6HCOLPT8 ,6H (LO) ,6H (HI) /
WORD=ANORD
IF(SI) GO TO 100.
RA=.0252
AJ=2.719

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	CONFAC=1.4091E-5	73
	GO TO 101	74
100	RA=286.9	75
	AJ=1.0	76
	CONFAC=1.0966E-2	77
101	CONTINUE	78
	IF (IDES.EQ.0) GO TO 1	79
	CNLPCF=CNL PDS*SQRT(T5)/PCNF	80
1	CNLP=CNLPCF*PCNF/SQRT(T5)	81
	CNLPS=CNLP	82
	TFFLPS=TFFLP	83
	CALL SEARCH (-1.,TFFLP,CNLP,DHTCLP,ETATLP,TFFX(1),NTFFS,CNX(1,1),D	84
	IHTCX(1,1),ETATX(1,1),NPTTFF(1),15,15,IGO)	85
	IF (IGO.EQ.1.OR.IGO.EQ.11.OR.IGO.EQ.21) WRITE (8,8) TFFLPS,WLO	86
	IF (IGO.EQ.2.OR.IGO.EQ.12.OR.IGO.EQ.22) WRITE (8,8) TFFLPS,WHI	87
	IF (IGO.EQ.10.OR.IGO.EQ.11.OR.IGO.EQ.12) WRITE (8,9) CNLPS,WLO	88
	IF (IGO.EQ.20.OR.IGO.EQ.21.OR.IGO.EQ.22) WRITE (8,9) CNLPS,WHI	89
	IF (IGO.NE.7) GO TO 2	90
	CALL ERROR	91
	RETURN	92
2	NOMAP=0	93
	TFLCAL=WG5*SQRT(T5)/(14.696*P5)	94
	IF(S1) TFLCAL=WG5*SQRT(T5)/P5	95
	XNLP=XNLPDS*PCNF/100.	96
	XNLDOT=DERIV(3,XNLP)	97
	DHACEL=CONFAC*PMILP*XNLP*XNLDOT	98
	DHTCF=(WAFP*(H22-H2)+DHACEL)/(WG5*T5)	99
	IF(FXFN2M) DHTCF=(WAFP*(H22-H2)+WAI P*(H21-H22)+DHACEL)/(WG5*T5)	100
	IF(FXFN2M.AND.AFTFAN) DHTCF=(WAFP*(H22-H2)+WAI P*(H21-H2)+DHACEL)	101
	1/(WG5*T5)	102
	IF (ISPOOL.GE.2) GO TO 11	103
	BTUEXT=0.706706*HPEXT	104
	IF(S1) BTUEXT=HPEXT	105
	DHTCF=(BTUEXT+WAFP*(H22-H2)+DHACEL)/(WG5*T5)	106
11	IF (IDES.EQ.0) GO TO 5	107
	TFLPCF=TFLPDS/TFLCAL	108
	DHLPCF=DHTCF/DHTCLP	109
	ETLPCF=ETLPDS/ETATLP	110
	WRITE (6,10) CNLPCF,TFLPCF,ETLPCF,DHLPCF	111
5	TFLCAL=TFLPCF*TFLCAL	112
	DHTCLP=DHLPCF*DHTCLP	113
	ETATLP=ETLPCF*ETATLP	114
	DHTF=DHTCF*T5	115
	I1=3	116
	I2=4	117
	IF (ISPOOL.EQ.1) I1=1	118
	IF (ISPOOL.EQ.1) I2=2	119
	ERR(I1)=(TFLCAL-TFFLP)/TFLCAL	120
	ERR(I2)=(DHTCF-DHTCLP)/DHTCF	121
	CALL THTURB (DHTF,ETATLP,FAR5,H5,S5,P5,T55,H55,S55,P55)	122
	IF(BLLP.LE.0.) GO TO 6	123
	FAR55 = FAR5*WG5/(WG5+BLLP*(1.+FAR5))	124
	WG55=WG5+BLLP	125
	H55=(BLLP*H3+WG5*H55)/WG55	126
	CALL THERMO(P55,H55,T55,S55,XX2,1,FAR55,1)	127
	GO TO 7	128
6	FAR55=FAR5	129
	WG55=WG5	130
7	CONTINUE	131
	IF(VLPTRB.EQ.0.0) GO TO 21	132
	Q(2)=0.0	133
	Q(3)=0.0	134
	WG55P=WG55	135
	H55P=H55	136
	P55DOT=DERIV(16,P55)	137
18	CONTINUE	138
	CALL THERMO(P55,H55,T55,S55,XX2,1,FAR55,0)	139
	WG55=WG55P-P55DOT*VLPTRB/T55/1.4/RA	140
	U55=H55-RA*AJ*T55	141
	U55DOT=DERIV(17,U55)	142
	H55X=(WG55P*H55P-(WG55P-WG55)*U55-U55DOT*P55*VLPTRB/T55/RA)/WG55	143
	ERRW=(H55-H55X)/H55	144
	DIR=SQRT(ABS(H55/H55X))	145

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	CALL AFQUIR(Q(1),T55,ERRW,0.,20.,0.0001,DIR,T55T,IGO)	146
	GO TO (19,21,20),IGO	147
19	T55=T55T	148
	GO TO 18	149
20	CALL ERROR	150
21	CONTINUE	151
	CALL FRTOSD	152
	RETURN	153
C		154
C		155
8	FORMAT (19HO****TFFLP OFF MAP,F10.4,2XA6,11H*****\$\$\$\$\$)	156
9	FORMAT (19HO****CNLP OFF MAP,F10.4,2XA6,11H*****\$\$\$\$\$)	157
10	FORMAT (20HOL.P. TURBINE DESIGN,5X7HCNLPF=,E15.8,8H TFLPCF=,E15.8	158
	1,8H ETLPCF=,E15.8,8H DHLPCF=,E15.8)	159
	END	160

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$IBFTC COMIX
SUBROUTINE COMIX
COMMON /WORDS/ WORD
COMMON /DESIGN/
1IDES ,JDES ,KDES ,MODE ,INIT ,IDUMP ,IAMTP ,IGSMX,
2IDBURN,IAFTBN,IDCD ,IMCD ,IDSHOC,IMSHOC,NOZFLT,ITRYS ,
3LOOPER,NOMAP ,NUMMAP,MAPEDG,TOLALL,ERR(9)
COMMON /ALL1/
4IPCNGU,PCNCGU,T4GU ,DUMD1 ,DUMD2 ,DELFG ,DELFN ,DELSFC,
5ZFDS ,PCNFDS,PRFDS ,ETAFDS,WAFFDS ,PRFCF ,ETAFCF,WAFCF ,
63ZCDS ,PCNCDS,PRCDS ,ETACDS,WACDS ,PRCCF ,ETACCF,WACCF ,
74T4DS ,WFBDs ,DTCODS,ETABDS,WA3CDS,DPCODS,DTCCOF,ETABCF,
85TFHPDS,CNHPDS,ETHPDS,TFHPCF,CNHPCF,ETHPCF,DHHPCF,T2DS ,
96TFLPDS,CNLPDS,ETL PDS,TFLPCF,CNLPFC,ETLPCF,DHLPFC,T21DS ,
107T24DS ,WFDDs ,DTDUOS,ETAADS,WA23DS,DPDUOS,DTDUFC,ETADCF,
118T7DS ,WFADS ,DTAFDS,ETAADS,WG6CDS,DPAFDS,DTAFCF,ETAACF,
129A55 ,A25 ,A6 ,A7 ,A8 ,A9 ,A28 ,A29 ,
13$PS55 ,AM55 ,CVDNOZ,CVMNOZ,A8SAV ,A9SAV ,A28SAV,A29SAV
COMMON /ALL2/
14IT1 ,P1 ,H1 ,S1 ,T2 ,P2 ,H2 ,S2 ,
152T21 ,P21 ,H21 ,S21 ,T3 ,P3 ,H3 ,S3 ,
163T4 ,P4 ,H4 ,S4 ,T5 ,P5 ,H5 ,S5 ,
174T55 ,P55 ,H55 ,S55 ,BLF ,BLC ,BLDU ,BLOB ,
185CNF ,PRF ,ETAF ,WAF ,WAF ,MA3 ,WG4 ,FAR4 ,
196CNC ,PRC ,ETAC ,WACC ,WAC ,ETAB ,DPCOM ,DUMP ,
207CNHP ,ETATHP,DHTCHP,DHTC ,BLHP ,WG5 ,FAR5 ,CS ,
218CNLP ,ETATLP,DHTCLP,DHTF ,BLLP ,WG55 ,FAR55 ,HPEXT ,
229AM ,ALTP ,ETAR ,ZF ,PCNF ,ZC ,PCNC ,WFB ,
23$TFFHP ,TFFLP ,PCBLF ,PCBLC ,PCBLDU,PCBLOB,PCBLHP,PCBLLP
COMMON /ALL3/
241XP1 ,XWAF ,XWAC ,XBLF ,XBLOU ,XH3 ,DUMS1 ,DUMS2 ,
252XT21 ,XP21 ,XH21 ,XS21 ,T23 ,P23 ,H23 ,S23 ,
263T24 ,P24 ,H24 ,S24 ,T25 ,P25 ,H25 ,S25 ,
274T28 ,P28 ,H28 ,S28 ,T29 ,P29 ,H29 ,S29 ,
285WAD ,WFD ,WG24 ,FAR24 ,ETAD ,DPDUC ,BYPASS,DUMS3 ,
296TS28 ,PS28 ,V28 ,AM28 ,TS29 ,PS29 ,V29 ,AM29 ,
307XT55 ,XP55 ,XH55 ,XS55 ,XT25 ,XP25 ,XH25 ,XS25 ,
318XWFB ,XWG55 ,XFAR55,XWFD ,XWG24 ,XFAR24,XXP1 ,DUMB ,
329T6 ,P6 ,H6 ,S6 ,T7 ,P7 ,H7 ,S7 ,
33$T8 ,P8 ,H8 ,S8 ,T9 ,P9 ,H9 ,S9
COMMON /ALL4/
341WG6 ,WFA ,WG7 ,FAR7 ,ETAA ,DPAFT ,V55 ,V25 ,
352PS6 ,V6 ,AM6 ,TS7 ,PS7 ,V7 ,AM7 ,AM25 ,
363TS8 ,PS8 ,V8 ,AM8 ,TS9 ,PS9 ,V9 ,AM9 ,
374VA ,FRD ,VJD ,FGMD ,VJM ,FGMM ,FGPD ,FGPM ,
385FGM ,FGP ,WFT ,WGT ,FART ,FG ,FN ,SFC ,
396WA32 ,DPWGDs,DPWING,WA32DS,A38 ,AM38 ,V38 ,T38 ,
407H38 ,P38 ,TS38 ,PS38 ,T39 ,H39 ,P39 ,TS39 ,
418V39 ,AM39 ,A39 ,BPRINT,WG37 ,CVDWNG,FGMWNG,FGPWNG,
429FNWING,FNMAIN,FWOVFN,PS39 ,FFOVFN,FCOVFN,FMNOFN,FNOVFD,
43$VJW ,T22 ,P22 ,H22 ,S22 ,T50 ,P50 ,H50
COMMON /ALL5/
441S50 ,WA22 ,ZI ,PCNI ,CNI ,PRI ,ETAI ,MACI ,
452TFFIP ,CNIP ,ETATIP,DHTCIP,DHTI ,BLIP ,PCBLIP,PCNIGU,
46

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	3ZIDS ,PCNIDS,PRIDS ,EYIDS,WYIDS ,PRICF ,EYICF,WAICF ,	54
	4TFIPDS,CNIPDS,ETIPDS,TFIPCF,CNIPCF,ETIPCF,DMIPCF,WAICDS,	55
	5WAI ,PCBLI ,BLI ,T22DS ,WA21 ,WG50 ,FAR50 ,A24 ,	56
	6AM23 ,DUMSPL,FXFN2M,FXN2CP,AFYFAN,PUNT ,PCBLID,P6DSAV,	57
	7AM6DSV,EYASV,FAR7SV,T4PBL ,T41 ,FAN ,ISPOOL	58
	COMMON/WHRERR/ICDAFB,ICODUC,ICOMIX	59
	COMMON/UNITS/SI	60
	LOGICAL SI	61
	COMMON/LOOPPR/KKGO,PRFNEW,PRCNEW	62
	DATA AWORD/6H COMIX/	63
	DIMENSION QQ(9)	64
	WORD=AWORD	65
	IF (SI) GO TO 100	66
	AJ=778.26	67
	CAPSF=2116.2170	68
	G=32.17049	69
	RDEM=1.986375	70
	GO TO 101	71
100	AJ=1.0	72
	CAPSF=1.0	73
	G=1.0	74
	RDEM=8316.41	75
101	CONTINUE	76
	ICOMIX=0	77
	CALL PROCOM (FAR55,T55,XX1,XX2,XX3,XX4,PHI55,XX5)	78
	CALL PROCOM (FAR24,T25,XX1,XX2,XX3,XX4,PHI25,XX5)	79
	IF (IDES.EQ.0) GO TO 12	80
C ***	CALCULATE A55 AND A25 WITH PS25=PS55	81
	IF (PS55.EQ.0.) GO TO 3	82
	TS55=T55*(PS55/P55)**0.286	83
	DO 1 I=1,15	84
	CALL PROCOM (FAR55,TS55,CS55,AK55,CP55,REX55,PHI55,HS55)	85
	PHIS=PHI55-REX55*ALOG(P55/PS55)	86
	DELPHI=PHIS-PHI55	87
	IF (ABS(DELPHI).LE.0.0001*PHIS) GO TO 6	88
1	TS55=TS55*EXP(4.0*DELPHI)	89
	ICOMIX=1	90
2	CALL ERROR	91
	RETURN	92
3	TS55=0.875*T55	93
	DO 4 I=1,15	94
	CALL PROCOM (FAR55,TS55,CS55,AK55,CP55,REX55,PHI55,HS55)	95
	V55=AM55*CS55	96
	HSCAL=H55-V55**2/(2.*G*AJ)	97
	DELHS=HSCAL-H55	98
	IF (ABS(DELHS).LE.0.0005*HSCAL) GO TO 5	99
4	TS55=TS55+DELHS/CP55	100
	ICOMIX=2	101
	GO TO 2	102
5	PS55=P55/EXP((PHI55-PHI55)/REX55)	103
	IF (PS55.GT.P25.AND.IDES.EQ.1.AND.IGASMX.GT.0) GO TO 45	104
6	IF (H55.GT.HS55) GO TO 7	105
	WRITE (8,46) P55,PS55,T55,TS55,H55,HS55	106
	ICOMIX=3	107
	CALL ERROR	108
7	V55=SQRT(2.*G*AJ*(H55-HS55))	109
	RHD=CAPSF*PS55/(AJ*REX55*TS55)	110
	A55=WG55/(RHD*V55)	111
	AM55=V55/CS55	112
	IF (IGASMX.GT.0) GO TO 8	113
	WRITE (6,47) A55,AM55	114
	IF (IGASMX .EQ. 0) GO TO 41	115
	IF (IGASMX .EQ. -1) GO TO 35	116
8	PS25=PS55	117
	TS25=T25*(PS25/P25)**0.286	118
	DO 9 I=1,15	119
	CALL PROCOM (FAR24,TS25,CS25,AK25,CP25,REX25,PHI25,HS25)	120
	PHIS=PHI25-REX25*ALOG(P25/PS25)	121
	DELPHI=PHIS-PHI25	122
	IF (ABS(DELPHI).LE.0.0001*PHIS) GO TO 10	123
9	TS25=TS25*EXP(4.0*DELPHI)	124
	ICOMIX=4	125
	GO TO 2	126

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10	IF (H25.GT.HS25) GO TO 11	127
	WRITE (8,48) P25,PS25,T25,TS25,H25,HS25	128
	ICOMIX=5	129
	CALL ERROR	130
11	V25=SQRT(2.*G*AJ*(H25-HS25))	131
	RHO=CAPSF*PS25/(AJ*REX25*TS25)	132
	A25=WG24/(RHO*V25)	133
	AM25=V25/CS25	134
	WRITE (6,49) A55,AM55,A25,AM25	135
	GO TO 27	136
C ***	CALCULATE PS55 AND PS25	137
12	WQA=WG55/A55	138
	C1=P55*SQRT(G/(T55*AJ))*CAPSF	139
	MCON=0	140
	QQ(2)=0.	141
	QQ(3)=0.	142
	AM55=0.50	143
	TS55=0.875*T55	144
13	DO 14 I=1,15	145
	CALL PROCOM (FAR55,TS55,CS55,AK55,CP55,REX55,PHI55,HS55)	146
	V55=AM55*CS55	147
	HSCAL=H55-V55**2/(2.*G*AJ)	148
	DELHS=HSCAL-HS55	149
	IF (ABS(DELHS).LE.0.0005*HSCAL) GO TO 15	150
14	TS55=TS55+DELHS/CP55	151
	ICOMIX=6	152
	GO TO 2	153
15	WQAT=C1*SQRT(AK55/REX55)*AM55/(1.+(AK55-1.)*AM55**2/2.)*(AK55+1.1)/(2.*(AK55-1.))	154
	AMX=AM55	155
	IGOGO=0	156
16	DIR=WQA/WQAT	157
	EW=(WQA-WQAT)/WQA	158
	CALL AFQUIR (QQ(1),AMX,EW,0.,30.,0.0005,DIR,AMXT,ICON)	159
	ICOMIX=7	160
	GO TO (17,22,2),ICON	161
17	IF (AMXT.LE.1.0) GO TO 20	162
	AMXT=0.7	163
	MCON=MCON+1	164
	IF (MCON.LE.1) GO TO 20	165
	IF (MODE.EQ.3) GO TO 19	166
	PCNF=DUMD1	167
	WRITE (8,50) PCNF,AMX,P55,PS55,P25,PS25	168
	PCNF=1.01*PCNF	169
	DUMD1=PCNF	170
18	NOMAP=7	171
	ICOMIX=0	172
	RETURN	173
19	WRITE (8,51) ZF,AMX,P55,PS55,P25,PS25	174
	ZF=0.99*ZF	175
	GO TO 18	176
20	IF (IGOGO.EQ.1) GO TO 21	177
	AM55=AMXT	178
	GO TO 13	179
21	AM25=AMXT	180
	GO TO 23	181
22	IF (IGOGO.EQ.1) GO TO 26	182
	PS55=P55/EXP((PHI55-PHIS55)/REX55)	183
	IF (IGASMX .EQ. 0) GO TO 41	184
	IF (IGASMX .EQ. -1) GO TO 35	185
	WQA=WG24/A25	186
	C1=P25*SQRT(G/(T25*AJ))*CAPSF	187
	MCON=0	188
	QQ(2)=0.	189
	QQ(3)=0.	190
	AM25=0.25	191
	TS25=0.875*T25	192
23	DO 24 I=1,15	193
	CALL PROCOM (FAR24,TS25,CS25,AK25,CP25,REX25,PHI25,HS25)	194
	V25=AM25*CS25	195
	HSCAL=H25-V25**2/(2.*G*AJ)	196
	DELHS=HSCAL-HS25	197
	IF (ABS(DELHS).LE.0.0005*HSCAL) GO TO 25	198
24	TS25=TS25+DELHS/CP25	199
		200



	ICOMIX=8	201
	GO TO 2	202
25	WQAT=C1*SQRT(AK25/REX25)*AM25/(1.+(AK25-1.)*AM25**2/2.)*((AK25+1.1)/(2.*(AK25-1.)))	203
	AMX=AM25	204
	IGOGO=1	205
	GO TO 16	206
26	PS25=P25/EXP((PHI25-PHIS25)/REX25)	207
27	WG6=WG24+WG55	208
	ERR(5)=(PS25-PS55)/PS25	209
	WF55 = FAR55*WG55/(FAR55+1.)	210
	WA55 = WG55/(FAR55+1.)	211
	WF24 = FAR24*WG24/(FAR24+1.)	212
	WA24 = WG24/(FAR24+1.)	213
	FAR6 = (WF55+WF24)/(WA55+WA24)	214
	H6=(WG24*H25+WG55*H55)/WG6	215
	CALL THERMO (1.,H6,T6,PHI6,AMX,1,FAR6,1)	216
	C1=PS55*A55*(1.+AK55*AM55**2)+PS25*A25*(1.+AK25*AM25**2)	217
	TS6=0.833*T6	218
	DO 32 I=1,15	219
	CALL PROCOM (FAR6,TS6,CS6,AK6,CP6,REX6,PHI S6,HS6)	220
	C2=WG6*SQRT(AJ*REX6*T6/(AK6*G))	221
	C3=C2/(CAPSF*C1)	222
	C4=(AK6-1.)/2.-(C3*AK6)**2	223
	C5=1.-2.*AK6*C3**2	224
	C6=C5**2+4.*C4*C3**2	225
	ICOMIX=9	226
	IF (C6) 28,29,30	227
28	CALL ERROR	228
	RETURN	229
29	AM62G=-C5/(2.*C4)	230
	GO TO 31	231
30	AM62G=(SQRT(C6)-C5)/(2.*C4)	232
31	IF (AM62G.LE.0.) GO TO 28	233
	AM6G=SQRT(AM62G)	234
	V6=AM6G*CS6	235
	HSCAL=H6-V6**2/(2.*G*AJ)	236
	DELHS=HSCAL-HS6	237
	IF (ABS(DELHS).LE.0.0005*HSCAL) GO TO 33	238
32	TS6=TS6+DELHS/CP6	239
	ICOMIX=10	240
	CALL ERROR	241
33	A6G=A25+A55	242
	C7=SQRT(1.+(AK6-1.)*AM62G/2.)	243
	PS6=C2/(CAPSF*A6G*AM6G*C7)	244
	P6=PS6*EXP((PHI6-PHIS6)/REX6)	245
	CALL THERMO (P6,H6,T6,S6,XX1,1,FAR6,0)	246
	S6AVE=(WG24*S25+WG55*S55)/WG6	247
	IF (S6.GE.S6AVE) GO TO 35	248
	S6=S6AVE	249
	P6=EXP(AMX*(PHI6-S6)/RDEM)	250
35	IF (IGASM.EQ.1) GO TO 43	251
	IF (IGASM.EQ.-1) GO TO 36	252
	IF (IGASM.EQ.2) GO TO 37	253
36	T6 = T55	254
	P6 = P55	255
	H6 = H55	256
	S6 = S55	257
	WG6 = WG55	258
	PS6 = PS55	259
	FAR6 = FAR55	260
	AK6 = AK55	261
37	IF (IDES.EQ.0) GO TO 38	262
C***	CALCULATES A6 AS A FUNCTION OF INPUT AM6	263
	TS6=T6/(1.0+(((AK6-1.0)/2.0)*AM6**2))	264
	DO 34 JJ=1,15	265
	AK6P=AK6	266
	CALL PROCOM (FAR6,TS6,CS6,AK6,CP6,REX6,PHI S6,HS6)	267
	V6=AM6*CS6	268
	DELA6=AK6P-AK6	269
	IF (ABS(DELA6).LE.0.0005*AK6) GO TO 54	270
34	TS6=T6/(1.0+(((AK6-1.0)/2.0)*AM6**2))	271
	ICOMIX=11	272
	CALL ERROR	273
		274

54	PS6=P6/((1.0+(((AK6-1.0)/2.0)*AM6**2))**(AK6/(AK6-1.0)))	275
	AM6ABD=AM6	276
	RHO=CAPSF*PS6/(AJ*REX6*TS6)	277
	A6=WG6/(RHO*V6)	278
	WRITE (6,52) A6	279
	GO TO 44	280
C	CALCULATES M6=F(A6DESIGN)	281
38	TS6P=T6/(1.0+(((AK6-1.0)/2.0)*AM6ABD**2))	282
	DO 39 I=1,15	283
	CALL PROCOM (FAR6,TS6P,CS6,AK6,CP6,REX6,PHIS6,HS6)	284
	PS6P=PS6*(TS6P/TS6)**(AK6/(AK6-1.0))	285
	RHO6=CAPSF*PS6P/(AJ*REX6*TS6P)	286
	V6=SQRT(2.*G*AJ*(H6-HS6))	287
	IF ((H6-HS6).LT.0.0) GO TO 42	288
	A6P=WG6/(RHO6*V6)	289
	DELA6=A6P-A6	290
	V6=WG6/(RHO6*A6)	291
	AM6=V6/CS6	292
	AM62=AM6**2	293
	IF (ABS(DELA6).LE.00.002*A6) GO TO 40	294
39	TS6P=T6/(1.0+(((AK6-1.0)/2.0)*AM62))	295
	ICOMIX=12	296
	CALL ERROR	297
40	TS6=TS6P	298
	PS6=PS6P	299
	GO TO 44	300
41	T6=T55	301
	P6=P55	302
	H6=H55	303
	S6=S55	304
	WG6=WG55	305
	PS6=PS55	306
	V6=V55	307
	AM6=AM55	308
	IF (IGASMX.EQ.0) A6=A55	309
	GO TO 44	310
42	WRITE (6,53) H6,HS6	311
	ICOMIX=13	312
	CALL ERROR	313
43	AM62=AM62G	314
	AM6=AM6G	315
	A6=A25+A55	316
	ICOMIX=0	317
44	CALL COAFBN	318
	RETURN	319
45	KKGO=1	320
	OPRDS=PRFDS*PRCDS	321
	PRFNEW=PRFDS*PS55/P25*1.02	322
	PRCNEW=OPRDS/PRFNEW	323
	ICOMIX=0	324
	CALL ENGBAL	325
	RETURN	326
C		327
C		328
46	FORMAT (22HOSQRT OF H55-HS55 NEG ,6E15.6,6H\$\$\$\$)	329
47	FORMAT (20HOTURBINE AREA DESIGN,6X6H A55=,E15.8,8H AM55=,E15.8)	330
48	FORMAT (22HOSQRT OF H25-HS25 NEG ,6E15.6,6H\$\$\$\$)	331
49	FORMAT (25HOTURBINE/DUCT AREA DESIGN,7H A55=,E15.8,8H AM55=,E15.8,8H A25=,E15.8,8H AM25=,E15.8)	332
50	FORMAT (12HOCOMIX PCNF=,F7.4,4H AM=,F8.6,5H P55=,F9.5,6H PS55=,F9.5,5H P25=,F9.5,6H PS25=,F9.5,6H\$\$\$\$)	333
51	FORMAT (10HOCOMIX ZF=,F8.5,4H AM=,F8.6,5H P55=,F9.5,6H PS55=,F9.5,15H P25=,F9.5,6H PS25=,F9.5,6H\$\$\$\$)	334
		335
52	FORMAT (3X,27HAFTERBURNER DESIGN AREA A6 F8.3)	336
53	FORMAT (3X,18HNEG.HS6 FACTOR H6 F9.4,3X,4HHS6 F9.4)	337
	END	338
		339
		340

\$IBFTC COMNOZ

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SUBROUTINE COMNOZ
COMMON /WORDS/ WORD
COMMON /DESIGN/
1IDES ,JDES ,KDES ,MODE ,INIT ,IDUMP ,IAMTP ,IGSMX,
2IDBURN,IAFTBN,IDCD ,IMCD ,IDSHOC,IMSHOC,NOZFLT,ITRYS ,
3BLOOPER,NOMAP ,NUMMAP,MAPEDG,TOLALL,ERR(9)
COMMON /ALL1/
1PCNFGU,PCNCGU,T4GU ,DUMD1 ,DUMD2 ,DELFG ,DELFN ,DELFEC,
2ZFDS ,PCNFDS,PRFDS ,ETAFDS,WAFFDS ,PRFCF ,ETAFCF,WAFCF ,
3ZCDS ,PCNCDS,PRCDS ,ETACDS,WACDS ,PRCCF ,ETACCF,WACCF ,
4T4DS ,WF8DS ,DTCODS,ETABDS,WA3CDS ,DPCODS,DTCCCF,ETABCF,
5TFHPDS,CNHPDS,ETHPDS,TFHPCF,CNHPCF,ETHPCF,DHHPCF,T2DS ,
6TFLPDS,CNLPDS,ETLPDS,TFLPDF,CNLPDF,ETLPDF,DHLPDF,T21DS ,
7T24DS ,WFDDSD,DTDUOS,ETADDS,WA23DS ,DPDUDS,DTDUCF,ETADCF,
8T7DS ,WFADS ,DTAFDS,ETAADS,WG6CDS ,DPAFDS,DTAFCF,ETAACF,
9A55 ,A25 ,A6 ,A7 ,A8 ,A9 ,A28 ,A29 ,
10$PS55 ,AM55 ,CVDNOZ,CVMNOZ,A8SAV ,A9SAV ,A28SAV,A29SAV
COMMON /ALL2/
1T1 ,P1 ,H1 ,S1 ,T2 ,P2 ,H2 ,S2 ,
2T21 ,P21 ,H21 ,S21 ,T3 ,P3 ,H3 ,S3 ,
3T4 ,P4 ,H4 ,S4 ,T5 ,P5 ,H5 ,S5 ,
4T55 ,P55 ,H55 ,S55 ,BLF ,BLC ,BLDU ,BLOB ,
5CNF ,PRF ,ETAF ,WAF ,WAF ,WA3 ,WG4 ,FAR4 ,
6CNC ,PRC ,ETAC ,WACC ,WAC ,ETAB ,DPCOM ,DUMP ,
7CNHP ,ETATHP,DHTCHP,DHTC ,BLHP ,WG5 ,FAR5 ,CS ,
8CNLP ,ETATLP,DHTCLP,DHTF ,BLLP ,WG55 ,FAR55 ,HPEXT ,
9AM ,ALTP ,ETAR ,ZF ,PCNF ,ZC ,PCNC ,WFB ,
10$TFFHP ,TFFLP ,PCBLF ,PCBLC ,PCBLDU,PCBLOB,PCBLHP,PCBLP
COMMON /ALL3/
1XP1 ,XWAF ,XWAC ,XBLF ,XBLDU ,XH3 ,DUMS1 ,DUMS2 ,
2XT21 ,XP21 ,XH21 ,XS21 ,T23 ,P23 ,H23 ,S23 ,
3T24 ,P24 ,H24 ,S24 ,T25 ,P25 ,H25 ,S25 ,
4T28 ,P28 ,H28 ,S28 ,T29 ,P29 ,H29 ,S29 ,
5WAD ,WFD ,WG24 ,FAR24 ,ETAD ,DPDUC ,BYPASS,DUMS3 ,
6TS28 ,PS28 ,V28 ,AM28 ,TS29 ,PS29 ,V29 ,AM29 ,
7XT55 ,XP55 ,XH55 ,XS55 ,XT25 ,XP25 ,XH25 ,XS25 ,
8XWFB ,XWG55 ,XFAR55 ,XWFD ,XWG24 ,XFAR24 ,XP1 ,DUMB ,
9T6 ,P6 ,H6 ,S6 ,T7 ,P7 ,H7 ,S7 ,
10$T8 ,P8 ,H8 ,S8 ,T9 ,P9 ,H9 ,S9
COMMON /ALL4/
1WG6 ,WFA ,WG7 ,FAR7 ,ETAA ,DPAFT ,V55 ,V25 ,
2PS6 ,V6 ,AM6 ,TS7 ,PS7 ,V7 ,AM7 ,AM25 ,
3TS8 ,PS8 ,V8 ,AM8 ,TS9 ,PS9 ,V9 ,AM9 ,
4VA ,FRD ,VJD ,FGMD ,VJM ,FGMM ,FGPD ,FGPM ,
5FGM ,FGP ,WFT ,WGT ,FART ,FG ,FN ,SFC ,
6WA32 ,DPWGDS,DPWING,WA32DS,A38 ,AM38 ,V38 ,T38 ,
7H38 ,P38 ,TS38 ,PS38 ,T39 ,H39 ,P39 ,TS39 ,
8V39 ,AM39 ,A39 ,BPRINT,WG37 ,CVDWNG,FGMNG,FGPNG,
9FNWING,FNMAIN,FNOVFN,PS39 ,FFOVFN,FCOVFN,FMNOFN,FNOVFD,
10$VJM ,T22 ,P22 ,H22 ,S22 ,T50 ,P50 ,H50
COMMON /ALL5/
1S50 ,WA22 ,ZI ,PCNI ,CNI ,PRI ,ETAI ,WACI ,
2TFFIP ,CNIP ,ETATIP,DHTCIP,DHTI ,BLIP ,PCBLIP,PCNIGU,
3ZIDS ,PCNIDS,PRI DS ,ETAIDS,WAIDS ,PRICF ,ETAI CF,WAICF ,
4TFIPDS,CNIPDS,ETIPDS,TFIPCF,CNIPCF,ETIPCF,DHIPCF,WAICDS,
5WAI ,PCBLI ,BLI ,T22DS,WA21 ,WG50 ,FAR50 ,A24 ,
6AM23 ,DUMSPL,FXFN2M,FXM2CP,AFTFAN,PUNT ,PCBLID,P6OSAV,
7AM6DSV,ETAASV,FAR7SV,T4PBL ,T41 ,FAN ,ISPOQL
COMMON /DYN/ ITRAN,TIME,DT,TF ,JTRAN,NSTEP,TPRINT,DTPRNT
DATA AWORD/6HMMNOZL/
WORD=AWORD
A8SAV=A8
A9SAV=A9
NOZM=0
IMNOZ=0
IF (ITRAN.EQ.1) CALL NOZCTR
IF (NOZFLT.EQ.1.OR.NOZFLT.EQ.3) NOZM=1
IF (IDES.EQ.1.OR.IAFTBN.GT.0.OR.NOZM.EQ.1) IMNOZ=1
IF (ITRAN.EQ.1) IMNOZ=0
IF (IMCD.EQ.1) GO TO 1
CALL CONVRG (T7,H7,P7,S7,FAR7,WG7,P1,IMNOZ,A8,P7R,T8,H8,P8,S8,TS8,
1PS8,V8,AM8,ICON)
GO TO (3,3,3,2),ICON

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1	CALL CONDIV (T7,H7,P7,S7,FAR7,WG7,P1,IMNOZ,A8,A9,P7R,T8,H8,P8,S8,T	74
	19,H9,P9,S9,TS8,TS9,PS8,PS9,V8,V9,AM8,AM9,ICON)	75
	IMSHOC=ICON	76
	GO TO (4,4,4,2),ICON	77
2	CALL ERROR	78
3	T9=T8	79
	H9=H8	80
	P9=P8	81
	S9=S8	82
	TS9=TS8	83
	PS9=PS8	84
	V9=V8	85
	AM9=AM8	86
	A9=A8	87
	IMSHOC=ICON+3	88
4	ERR(6)=(P7R-P7)/P7R	89
	IF (ISPOOL.EQ.1) ERR(3)=ERR(6)	90
	IF (IMNOZ.EQ.1) WRITE (6,5) A8,AM8,A9,AM9	91
	RETURN	92
C		93
C		94
5	FORMAT (14HNOZZLE DESIGN,10X8H           A8=,E15.8,8H       AM8=,E15.8,8H	95
	1   A9=,E15.8,8H       AM9=,E15.8)	96
	END	97

\$IRFTC CONDIV		
	SUBROUTINE CONDIV (TI,HI,PI,SI,FAR,WG,PA,IDES,AT,AO,PIR,TT,HT,PT,S	1
	IT,TO,HO,PO,SO,TST,TSO,PST,PSO,VT,VO,AMT,AMO,ICON)	2
C	ICON=1 SUBSONIC, COMPARE PIR WITH PI	3
C	ICON=2 SONIC, SHOCK INSIDE NOZZLE, COMPARE PIR WITH PI	4
C	ICON=3 SONIC, SHOCK OUTSIDE NOZZLE, COMPARE PIR WITH PI	5
C	ICON=4 ERROR	6
	COMMON/UNITS/ZI	7
	LOGICAL ZI	8
	DIMENSION Q(9)	9
	Q(2)=0.	10
	Q(3)=0.	11
	IF (ZI) GO TO 100	12
	AJ=778.26	13
	CAPSF=2116.7170	14
	G=32.174049	15
	GO TO 101	16
100	AJ=1.0	17
	CAPSF=101325.0	18
	G=1.0	19
101	CONTINUE	20
	CALL PROCOM (FAR, TI, XX1, XX2, XX3, XX4, PHII, XX6)	21
C ***	SONIC CALCULATIONS	22
	J=0	23
	TSS=0.833*TI	24
1	J=J+1	25
	CALL PROCOM (FAR, TSS, CSS, AK, CP, REXS, PHISS, HSS)	26
	HSCAL=HI-CSS**2/(2.*G*AJ)	27
	DELHS=HSCAL-HSS	28
	IF (ABS(DELHS)-0.0005*HSCAL) 4,4,2	29
2	TSS=TSS+DELHS/CP	30
	IF (J-15) 1,1,3	31
3	ICON=4	32
	RETURN	33
4	IF (IDES) 11,11,5	34
C ***	SONIC DESIGN, CALCULATE AT	35
5	VT=CSS	36
	TST=TSS	37
	PST=PI*(TST/TI)**(AK/(AK-1.))	38
	RHD=CAPSF*PST/(AJ*REXS*TST)	39
	AT=WG/(RHD*VT)	40
	AMT=1.0	41
C ***	IDEAL EXPANSION DESIGN, CALCULATE AO	42
	PSO=PA	43

	J=0	44
	TSO=TI*(PSO/PI)**.286	45
6	J=J+1	46
	CALL PROCOM (FAR,TSO,CSO,AK,CP,REX,PHISO,HSO)	47
	PHICAL=PHII-REX*ALOG(PI/PSO)	48
	DELPHI=PHICAL-PHISO	49
	IF (ABS(DELPHI)-0.0001*PHICAL) 8,8,7	50
7	TSO=TSO*EXP(4.*DELPHI)	51
	IF (J-15) 6,6,3	52
8	VO=SQRT(2.*G*AJ*(HI-HSO))	53
	AMO=VO/CSO	54
	AO=(AT/AMO)*(2.*(1.+(AK-1.)*AMO**2/2.)/(AK+1.))**((AK+1.)/(2.*(AK-	55
	11.)))	56
	PIR=PI	57
	ICON=3	58
9	TO=TI	59
	HO=HI	60
	PO=PI	61
	SO=SI	62
10	TT=TI	63
	HT=HI	64
	PT=PI	65
	ST=SI	66
	RETURN	67
C ***	ASSUME SONIC THROAT AND ISENTROPIC EXPANSION TO AO	68
11	VT=CSS	69
	AMT=1.0	70
	TST=TSS	71
	RHO=WG/(AT*VT)	72
	PST=RHO*AJ*REXS*TST/CAPSF	73
	PIR=PST*(TI/TST)**(AK/(AK-1.))	74
	IF (PST-PA) 12,27,27	75
12	TSO=0.95*TI	76
	MAM=0	77
13	CALL PROCOM (FAR,TSO,CSO,AK,CP,REX,PHISO,HSO)	78
	AMO=SQRT(2.*((TI/TSO)-1.)/(AK-1.))	79
	AOCAL=(AT/AMO)*(2.*(1.+(AK-1.)*AMO**2/2.)/(AK+1.))**((AK+1.)/(2.*	80
	1AK-1.)))	81
	EA=(AO-AOCAL)/AO	82
	DIR=SQRT(AO/AOCAL)	83
	CALL AFQUIR (Q(1),TSO,EA,0.,100.,0.0001,DIR,TSOT,JCON)	84
	GO TO (14,18,3),JCON	85
14	TSO=TSOT	86
	IF (TSO-TI) 15,13,16	87
15	TSC=2.*TI/(AK+1.)	88
	IF (TSO.GT.TSC) GO TO 17	89
16	TSO=0.98*TI	90
	GO TO 13	91
17	IF (Q(2).LT.30.0.OR.AMO.LT.0.95.OR.MAM.EQ.1) GO TO 13	92
	TSO=2.*TI/(2.+0.98*(AK-1.))	93
	MAM=1	94
	GO TO 13	95
18	PSO=PIR*(TSO/TI)**(AK/(AK-1.))	96
	IF (PSO-PA) 20,19,27	97
C ***	CRITICAL FLOW, ISENTROPIC EXPANSION TO PA	98
19	VO=AMO*CSO	99
	ICON=1	100
	GO TO 9	101
C ***	SUBSONIC FLOW	102
20	PSO=PA	103
	Q(2)=0.	104
	Q(3)=0.	105
	J=0	106
	TSO=0.833*TI	107
21	J=J+1	108
	CALL PROCOM (FAR,TSO,CSO,AK,CP,REX,PHISO,HSO)	109
	RHO=CAPSF*PSO/(AJ*REX*TSO)	110
	VO=WG/(RHO*AO)	111
	HSCAL=HI-VO**2/(2.*G*AJ)	112
	DELHS=HSCAL-HSO	113
	IF (ABS(DELHS)-0.0005*HSCAL) 23,23,22	114
22	TSO=TSO+DELHS/CP	115
	IF (J-15) 21,21,3	116

23	AMD=VO/CSO	117
	PIR=PSO*(TI/TSO)**(AK/(AK-1.))	118
	TST=TSO	119
24	CALL PROCOM (FAR,TST,CST,AK,CP,REX,PHIST,HST)	120
	PST=PIR*(TST/TI)**(AK/(AK-1.))	121
	RHO=PST*CAPSF/(AJ*REX*TST)	122
	VT=WG/(RHO*AT)	123
	HSCAL=HI-VT**2/(2.*G*AJ)	124
	EH=(HSCAL-HST)/HSCAL	125
	DIR=1.+(HSCAL-HST)/(CP*TST)	126
	CALL AFQUIR (Q(1),TST,EH,0.,20.,0.0005,DIR,TSTT,JCON)	127
	GO TO (25,26,3),JCON	128
25	TST=TSTT	129
	GO TO 24	130
26	AMT=VT/CST	131
	ICON=1	132
	GO TO 9	133
C ***	SUPERCRITICAL FLOW, ISENTROPIC EXPANSION TO PA	134
27	PSO=PA	135
	J=0	136
	TSO=TI*(PSO/PIR)**.286	137
28	J=J+1	138
	CALL PROCOM (FAR,TSO,CSO,AK,CP,REX,PHISO,HSO)	139
	PHICAL=PHII-REX*ALOG(PIR/PSO)	140
	DELPHI=PHICAL-PHISO	141
	IF (ABS(DELPHI)-0.0001*PHICAL) 30,30,20	142
29	TSO=TSO*EXP(4.0*DELPHI)	143
	IF (J-15) 28,28,3	144
30	VO=SQRT(2.*G*AJ*(HI-HSO))	145
	AMD=VO/CSO	146
	AOID=(AT/AMD)*(2.*(1.+(AK-1.)*AMD**2/2.)/(AK+1.))**((AK+1.)/(2.*(AK-1.)))	147
	ICON=3	148
	N=0	149
	IF (AO-AOID) 31,9,32	150
C ***	SUPERCRITICAL FLOW, ISENTROPIC EXPANSION TO AO	151
31	N=1	152
32	TSO=0.833*TI	153
	J=0	154
33	J=J+1	155
	CALL PROCOM (FAR,TSO,CSO,AK,CP,REX,PHISO,HSO)	156
	AMD=SQRT(2.*(TI/TSO)-1.)/(AK-1.))	157
	AOCAL=(AT/AMD)*(2.*(1.+(AK-1.)*AMD**2/2.)/(AK+1.))**((AK+1.)/(2.*(AK-1.)))	158
	DELA=AO-AOCAL	159
	IF (ABS(DELA)-0.0001*AO) 35,35,34	160
34	TSO=TSO*SQRT(AOCAL/AO)	161
	IF (J-50) 33,33,3	162
35	IF (N) 37,37,36	163
C ***	UNDEREXPANDED, SHOCK OUTSIDE NOZZLE	164
36	PSO=PIR*(TSO/TI)**(AK/(AK-1.))	165
	VO=AMD*CSO	166
	GO TO 9	167
C ***	OVEREXPANDED, FIND SHOCK POSITION	168
37	PSX=PIR*(TSO/TI)**(AK/(AK-1.))	169
	PSY=PSX*(2.*AK*AMD**2/(AK+1.)-(AK-1.)/(AK+1.))	170
	IF (PA-PSY) 38,39,39	171
C ***	OVEREXPANDED, SHOCK OUTSIDE NOZZLE	172
38	PSO=PSX	173
	VO=AMD*CSO	174
	GO TO 9	175
C ***	OVEREXPANDED, SHOCK INSIDE NOZZLE	176
39	PSO=PA	177
	J=0	178
	TSO=0.833*TI	179
40	J=J+1	180
	CALL PROCOM (FAR,TSO,CSO,AK,CP,REX,PHISO,HSO)	181
	RHO=CAPSF*PSO/(AJ*REX*TSO)	182
	VO=WG/(RHO*AO)	183
	HSCAL=HI-VO**2/(2.*G*AJ)	184
	DELHS=HSCAL-HSO	185
	IF (ABS(DELHS)-0.0005*HSCAL) 42,42,41	186
41	TSO=TSO+DELHS/CP	187
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42 IF (J-15) 40,40,3
   AMO=VO/CSO
   TO=TI
   HO=HI
   PO=PSO*(TO/TSO)**(AK/(AK-1.))
   SO=PHII-REX*ALOG(PO)
   ICON=2
   GO TO 10
   END

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\$IBFTC CONOUT

SUBROUTINE CONOUT (ICON)

COMMON /WORDS/ WORD

COMMON /DESIGN/

1IDES ,JDES ,KDES ,MODE ,INIT ,IDUMP ,IAMTP ,IGSMX,  
2IDBURN ,IAFTBN ,IDCD ,IMCD ,IDSHOC ,IMSHOC ,NOZFLT ,ITRYS ,  
3LOOPER ,NOMAP ,NUMMAP ,MAPEDG ,TOLALL ,ERR(9)

COMMON /ALL1/

1PCNFGU ,PCNCGU ,T4GU ,DUMD1 ,DUMD2 ,DELFG ,DELFN ,DELSFC ,  
2ZFDS ,PCNFDS ,PRFDS ,ETAFDS ,WAFDS ,PRFCF ,ETAFCF ,WAFCF ,  
3ZCDS ,PCNCDS ,PRCDS ,ETACDS ,WACDS ,PRCCF ,ETACCF ,WACCF ,  
4T4DS ,WFBDS ,DTCODS ,ETABDS ,WA3CDS ,DPCODS ,DTCOCF ,ETABCF ,  
5TFHPDS ,CNHPDS ,ETHPDS ,TFHPCF ,CNHPCF ,ETHPCF ,DHPHPCF ,T2DS ,  
6TFLPDS ,CNLPDS ,ETLPDS ,TFLPCF ,CNLPCF ,ETLPCF ,DHLPCF ,T21DS ,  
7T24DS ,WFDDS ,DTUDDS ,ETADDS ,WA23DS ,DPDUDS ,DTDUCF ,ETADCF ,  
8T7DS ,WFADS ,DTAFDS ,ETAADS ,WG6CDS ,DPAFDS ,DTAFCF ,ETAACF ,  
9A55 ,A25 ,A6 ,A7 ,A8 ,A9 ,A28 ,A29 ,  
10\$PS55 ,AM55 ,CVDNOZ ,CVMNOZ ,A8SAV ,A9SAV ,A28SAV ,A29SAV

COMMON /ALL2/

1T1 ,P1 ,H1 ,S1 ,T2 ,P2 ,H2 ,S2 ,  
2T21 ,P21 ,H21 ,S21 ,T3 ,P3 ,H3 ,S3 ,  
3T4 ,P4 ,H4 ,S4 ,T5 ,P5 ,H5 ,S5 ,  
4T55 ,P55 ,H55 ,S55 ,BLF ,BLC ,BLDU ,BLOB ,  
5CNF ,PRF ,ETAF ,WAF ,WAF ,WA3 ,WG4 ,FAR4 ,  
6CNC ,PRC ,ETAC ,WACC ,WAC ,ETAB ,DPCOM ,DUMP ,  
7CNHP ,ETATHP ,DHTCHP ,DHTC ,BLHP ,WG5 ,FAR5 ,CS ,  
8CNLP ,ETATLP ,DHTCLP ,DHTF ,BLLP ,WG55 ,FAR55 ,HPEXT ,  
9AM ,ALTP ,ETAR ,ZF ,PCNF ,ZC ,PCNC ,WFB ,  
10\$TFFHP ,TFFLP ,PCBLF ,PCBLC ,PCBLDU ,PCBLOB ,PCBLHP ,PCBLLP

COMMON /ALL3/

1XP1 ,XWAF ,XWAC ,XBLF ,XBLDU ,XH3 ,DUMS1 ,DUMS2 ,  
2XT21 ,XP21 ,XH21 ,XS21 ,T23 ,P23 ,H23 ,S23 ,  
3T24 ,P24 ,H24 ,S24 ,T25 ,P25 ,H25 ,S25 ,  
4T28 ,P28 ,H28 ,S28 ,T29 ,P29 ,H29 ,S29 ,  
5WAD ,WFD ,WG24 ,FAR24 ,ETAD ,DPDUC ,BYPASS ,DUMS3 ,  
6TS28 ,PS28 ,V28 ,AM28 ,TS29 ,PS29 ,V29 ,AM29 ,  
7XT55 ,XP55 ,XH55 ,XS55 ,XT25 ,XP25 ,XH25 ,XS25 ,  
8XWFB ,XWG55 ,XFAR55 ,XWFD ,XWG24 ,XFAR24 ,XXP1 ,DUMB ,  
9T6 ,P6 ,H6 ,S6 ,T7 ,P7 ,H7 ,S7 ,  
10T8 ,P8 ,H8 ,S8 ,T9 ,P9 ,H9 ,S9

COMMON /ALL4/

1WG6 ,WFA ,WG7 ,FAR7 ,ETAA ,DPAFT ,V55 ,V25 ,  
2PS6 ,V6 ,AM6 ,TS7 ,PS7 ,V7 ,AM7 ,AM25 ,  
3TS8 ,PS8 ,V8 ,AM8 ,TS9 ,PS9 ,V9 ,AM9 ,  
4VA ,FRD ,VJD ,FGMD ,VJM ,FGMM ,FGPD ,FGPM ,  
5FGM ,FGP ,WFT ,WGT ,FART ,FG ,FN ,SFC ,  
6WA32 ,DPWGDS ,DPWING ,WA32DS ,A38 ,AM38 ,V38 ,T38 ,  
7H38 ,P38 ,TS38 ,PS38 ,T39 ,H39 ,P39 ,TS39 ,  
8V39 ,AM39 ,A39 ,BPRINT ,WG37 ,CVDWNG ,FGMWNG ,FGPWNG ,  
9FNWING ,FNHAIN ,FNOVFN ,PS39 ,FFOVFN ,FCOVFN ,FNOVFN ,FNOVFD ,  
10\$VJW ,T22 ,P22 ,H22 ,S22 ,T50 ,P50 ,H50

COMMON /ALL5/

1S50 ,WA22 ,ZI ,PCNI ,CNI ,PRI ,ETAI ,WACI ,  
2TFFIP ,CNIP ,ETATIP ,DHTCIP ,DHTI ,BLIP ,PCBLIP ,PCNIGU ,  
3ZIDS ,PCNIDS ,PRIIDS ,ETAIDS ,WAIDS ,PRICF ,ETAICF ,WAICF ,  
4TFIPDS ,CNIPDS ,ETIPDS ,TFIPCF ,CNIPCF ,ETIPCF ,DHIPCF ,WAICDS ,  
5WAI ,PCBLI ,BLI ,T22DS ,WA21 ,WG50 ,FAR50 ,A24 ,  
6AM23 ,DUMSPL ,FXFN2M ,FXM2CP ,AFTFAN ,PUNT ,PCBLID ,P6DSAV ,  
7AM6DSV ,ETAASV ,FAR7SV ,T4PBL ,T41 ,FAN ,ISPODL

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DIMENSION PARAM(424),WORDY(424),IOUT(150),AOUT(6),MOUT(6)
EQUIVALENCE (PARAM,PCNFGR)
DATA (WORDY(I),I=1,98)/
16HPCNFGU,6HPCNCGU,6HT4GU ,6HDUMD1 ,6HDUMD2 ,6HDELF ,6HDELFN ,
26HDELSFC,6HZFDS ,6HPCNFDS,6HPRFDS ,6HETAFDS,6HWAFDS ,6HPRFCF ,
36HETAFCF,6HWAFCF ,6HZCDS ,6HPCNCDS,6HPRCDS ,6HETACDS,6HWACDS ,
46HPRCCF ,6HETACCF,6HWACCF ,6HT4DS ,6HWF8DS ,6HDTCCDS,6HETABDS,
56HWA3CDS,6HDPCDS,6HDTCCDF,6HETABCF,6HTFHPDS,6HCNHPOS,6HETHPDS,
66HTFNPCF,6HCNHPCF,6HETHPCF,6HDHPCF,6HT2DS ,6HTFLPDS,6HCNLPDS,
76HETLPDS,6HTFLPCF,6HCNLPDF,6HETLPCF,6HDHLPDF,6HT21DS ,6HT24DS ,
86HWF8DS ,6HDTDUDS,6HETADDS,6HWA23DS,6HDPDUDS,6HDTDUCF,6HETADCF,
96HT7DS ,6HWAFDS ,6HDTAFDS,6HETAADS,6HWG6CDS,6HDPAFDS,6HDTAFCF,
$6HETAACF,6HA55 ,6HA25 ,6HA6 ,6HA7 ,6HA8 ,6HA9 ,
$6HA28 ,6HA29 ,6HPS55 ,6HAM55 ,6HCVDNOZ,6HCVMNOZ,6HA8SAV ,
$6HA9SAV ,6HA28SAV,6HA29SAV,6HT1 ,6HP1 ,6H1 ,6HS1 ,
$6HT2 ,6HP2 ,6HH2 ,6HS2 ,6HT21 ,6HP21 ,6HH21 ,
$6HS21 ,6HT3 ,6HP3 ,6HH3 ,6HS3 ,6HT4 ,6HP4 /
DATA (WORDY(I),I=99,189)/
16HH4 ,6HS4 ,6HT5 ,6HP5 ,6HH5 ,6HS5 ,6HT55 ,
26HP55 ,6HH55 ,6HS55 ,6HBLF ,6HBLC ,6HBLDU ,6HBL0B ,
36HCNF ,6HPRF ,6HETAF ,6HWAF ,6HWAF ,6HWA3 ,6HWG4 ,
46HFAR4 ,6HCNC ,6HPRC ,6HETAC ,6HWACC ,6HWAC ,6HETAB ,
56HDPCOM ,6HDUMP ,6HCNMP ,6HETATHP,6HDHTCMP,6HDHTC ,6HBLHP ,
66HWG5 ,6HFAR5 ,6HCS ,6HCNLP ,6HETATLP,6HDHTCLP,6HDHTF ,
76HBLLP ,6HWG55 ,6HFAR55 ,6HHPEXT ,6HAM ,6HALTP ,6HETAR ,
86HZF ,6HPCNF ,6HZC ,6HPCNC ,6HWF8 ,6HTFFHP ,6HTFFLP ,
96HPCBLF ,6HPCBLC ,6HPCBLDU,6HPCBLOB,6HPCBLHP,6HPCBLLP,6HXP1 ,
$6HXWAF ,6HXWAC ,6HXBLF ,6HXBLDU ,6HXH3 ,6HDUMS1 ,6HDUMS2 ,
$6HXT21 ,6HXP21 ,6HXH21 ,6HXS21 ,6HT23 ,6HP23 ,6HH23 ,
$6HS23 ,6HT24 ,6HP24 ,6HH24 ,6HS24 ,6HT25 ,6HP25 ,
$6HH25 ,6HS25 ,6HT28 ,6HP28 ,6HH28 ,6HS28 ,6HT29 /
DATA (WORDY(I),I=190,280)/
16HP29 ,6HH29 ,6HS29 ,6HWAD ,6HWFD ,6HWG24 ,6HFAR24 ,
26HETAD ,6HDPDUC ,6HBPASS,6HDUMS3 ,6HTS28 ,6HPS28 ,6HV28 ,
36HAM28 ,6HTS29 ,6HPS29 ,6HV29 ,6HAM29 ,6HXT55 ,6HXP55 ,
46HXH55 ,6HXS55 ,6HXT25 ,6HXP25 ,6HXH25 ,6HXS25 ,6HXWFB ,
56HXWG55 ,6HXFAR55,6HXWFD ,6HXWG24 ,6HXFAR24,6HXP1 ,6HDUMB ,
66HT6 ,6HP6 ,6HH6 ,6HS6 ,6HT7 ,6HP7 ,6HH7 ,
76HS7 ,6HT8 ,6HP8 ,6HH8 ,6HS8 ,6HT9 ,6HP9 ,
86HH9 ,6HS9 ,6HWG6 ,6HWFA ,6HWG7 ,6HFAR7 ,6HETAA ,
96HDPAPT ,6HV55 ,6HV25 ,6HPS6 ,6HV6 ,6HAM6 ,6HTS7 ,
$6HPS7 ,6HV7 ,6HAM7 ,6HAM25 ,6HTS8 ,6HPS8 ,6HV8 ,
$6HAM8 ,6HTS9 ,6HPS9 ,6HV9 ,6HAM9 ,6HVA ,6HFRD ,
$6HVJD ,6HFGMD ,6HVJM ,6HFGMM ,6HFGPD ,6HFGPM ,6HFGM ,
$6HFGP ,6HWFT ,6HWGT ,6HFART ,6HFG ,6HFN ,6HSFC /
DATA (WORDY(I),I=281,373)/
16HWA32 ,6HDPWGD,6HDPWING,6HWA32DS,6HA38 ,6HAM38 ,
26HV38 ,6HT38 ,6HH38 ,6HP38 ,6HTS38 ,6HPS38 ,6HT39 ,
36HH39 ,6HP39 ,6HTS39 ,6HV39 ,6HAM39 ,6HA39 ,6HBPRINT,
46HWG37 ,6HCVDWNG,6HFGWNG,6HFGPWNG,6HFNWING,6HFNMAIN,6HFVOVFN,
56HPS39 ,6HFFOVFN,6HFCOVFN,6HFMNOFN,6HFNQVFD,6HVJM ,
96HT22 ,6HP22 ,6HH22 ,6HS22 ,6HT50 ,6HP50 ,6HH50 ,
$6HS50 ,6HWA22 ,6HZI ,6HPCNI ,6HCNI ,6HPRI ,6HETAI ,
$6HWACI ,6HTFFIP,6HCNIP ,6HETATIP,6HDHTCIP,6HDHTI ,6HBLIP ,
$6HPCBLIP,6HPCNIGU,6HZIDS ,6HPCNIDS,6HPRIDS ,6HETAIDS,6HWAIDS ,
$6HPRICF ,6HETAI CF,6HWAICF ,6HTFIPDS,6HCNIPDS,6HETIPDS,6HTFIPCF,
$6HCNIPCF,6HETIPCF,6HDHPCF,6HWAICDS,6HWA1 ,6HPCBLI ,6HBLI ,
$6HT22DS ,6HWA21 ,6HWG50 ,6HFAR50 ,6HA24 ,6HAM23 ,6HDUMSPL,
$6HFXFN2M,6HFXM2CP,6HAFTFAN,6HPUNT ,6HPCBLID,6HP6DSAV,6HAM6DSV,
$6HETAASV,6HFAR7SV,6HT4PBL ,6HT41 /
DATA THEEND,BLANK,LIMIT/6HTHEEND,6H ,373/
COMMON/UNITS/SI
LOGICAL SI
IF (ICON.EQ.1) GO TO 24
IF (SI) GO TO 22
WRITE (6,21)
21 FORMAT (1X,30HTHE OUTPUT IS IN ENGLISH UNITS)
GO TO 24
22 WRITE (6,23)
23 FORMAT (1X,25HTHE OUTPUT IS IN SI UNITS)
24 CONTINUE
GO TO (1,6),ICON
C *** INPUT SECTION

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1	DO 4 N=1,150	132
	NUM=N	133
	PEAD (5,11) AIN,CHANGE	134
	IF (AIN.EQ.THEEND) GO TO 5	135
	DO 2 J=1,LIMIT	136
	JJ=J	137
	IF (AIN.EQ.WORDY(J)) GO TO 3	138
2	CONTINUE	139
	WRITE (6,12) AIN	140
	GO TO 4	141
3	IOUT(NUM)=JJ	142
	IF (CHANGE.NE.BLANK) WORDY(JJ)=CHANGE	143
4	CONTINUE	144
	WRITE (6,13)	145
5	NUM=NUM-1	146
	RETURN	147
C ***	OUTPUT SECTION	148
6	IF (NUM.EQ.1) GO TO 10	149
	N=NUM	150
	J=6	151
	DO 9 I=1,NUM,6	152
	IF (N.GT.6) GO TO 7	153
	J=N	154
7	N=N-6	155
	DO 8 K=1,J	156
	L=I+K-1	157
	M=IOUT(L)	158
	WOUT(K)=WORDY(M)	159
8	AOUT(K)=PARAM(M)	160
	WRITE (6,14) (WOUT(K),K=1,J)	161
	WRITE (6,15) (AOUT(K),K=1,J)	162
	IF (N.LE.6) GO TO 10	163
9	CONTINUE	164
10	RETURN	165
C		166
C		167
C		168
C		169
11	FORMAT (A6,6X,A6)	170
12	FORMAT (10H0THE WORD ,A6,26H NOT FOUND IN COMMON ARRAY)	171
13	FORMAT (22H0ERROR IN CONOUT INPUT)	172
14	FORMAT (26X,A6,5(9XA6))	173
15	FORMAT (1H ,20X6E15.6)	174
	END	

\$IBFTC	CONVRG	1
	SUBROUTINE CONVRG (TI,HI,PI,SI,FAR,WG,PA,IDES,AD,PR,TO,HO,PO,SO,TS	2
	IO,PSO,VO,AMO,ICON)	3
C	ICON=1 SUBSONIC, COMPARE PI WITH PR	4
C	ICON=2 SONIC, COMPARE PI WITH PR	5
C	ICON=4 ERROR	6
	COMMON/UNITS/ZI	7
	LOGICAL ZI	8
	IF (ZI) GO TO 100	9
	AJ=778.26	10
	CAPSF=2116.217	11
	G=32.174049	12
	CPG=.250	13
	GO TO 101	14
100	AJ=1.0	15
	CAPSF=1.0	16
	G=1.0	17
	CPG=1048.	18
101	CONTINUE	19
	CALL PROCOM (FAR,TI,XX1,XX2,XX3,XX4,PHI1,XX6)	20
C ***	SONIC CALCULATIONS	21
	J=0	22
	TSS=0.833*TI	23
1	J=J+1	24
	CALL PROCOM (FAR,TSS,CSS,AKS,CP,REXS,PHISS,HSS)	

	HSCAL=HI-CSS**2/(2.*G*AJ)	25
	DELHS=HSCAL-HSS	26
2	IF (ABS(DELHS)-0.0005*HSCAL) 4,4,2	27
	TSS=TSS+DELHS/CP	28
	IF (J-15) 1,1,3	29
3	ICON=4	30
	RETURN	31
4	IF (IDES) 12,12,5	32
C ***	ISENTROPIC EXPANSION CALCULATIONS	33
5	J=0	34
	TSI=TI*(PA/PI)**0.286	35
6	J=J+1	36
	CALL THERMO (PA,HSI,TSI,SSI,XX1,1,FAR,0)	37
	IF (ABS(SSI-SI)-0.0001*SI) 8,8,7	38
7	TSI=TSI/EXP((SSI-SI)/CPG)	39
	IF (J-30) 6,6,3	40
8	VIS=SQRT(2.*G*AJ*(HI-HSI))	41
	IF (VIS-CSS) 9,11,11	42
C ***	SUBSONIC DESIGN, CALCULATE AO	43
9	VO=VIS	44
	TSD=TSI	45
	PSO=PA	46
	CALL PROCOM (FAR,TSD,CSO,XX2,XX3,REX,PHISO,HSO)	47
	RHO=CAPSF*PSO/(AJ*REX*TSD)	48
	AO=WG/(RHO*VO)	49
	AMO=VO/CSO	50
	PR=PI	51
	ICON=1	52
10	TO=TI	53
	HO=HI	54
	PO=PI	55
	SO=SI	56
	RETURN	57
C ***	SONIC DESIGN, CALCULATE AO	58
11	VO=CSS	59
	TSD=TSS	60
	PSO=PI*(TSD/TO)**(AKS/(AKS-1.))	61
	RHO=CAPSF*PSO/(AJ*REX*TSD)	62
	AO=WG/(RHO*VO)	63
	AMO=1.0	64
	PR=PI	65
	ICON=2	66
	GO TO 10	67
C ***	NON-DESIGN, CALCULATE CRITICAL CONDITIONS.	68
12	VO=CSS	69
	TSD=TSS	70
	PSO=PA	71
	RHO=CAPSF*PSO/(AJ*REX*TSD)	72
	AOCRIT=WG/(RHO*VO)	73
	AMO=1.0	74
	PR=PSO*(TI/TSD)**(AKS/(AKS-1.))	75
	IF (AO-AOCRIT) 13,13,14	76
C ***	NON-DESIGN, CRITICAL AND SUPERCRITICAL CONDITIONS	77
13	PSO=PSO*AOCRIT/AO	78
	PR=PR*AOCRIT/AO	79
	ICON=2	80
	GO TO 10	81
C ***	NON-DESIGN, SUBSONIC CALCULATIONS	82
14	PSO=PA	83
	J=0	84
	TSD=0.833*TSD	85
15	J=J+1	86
	CALL PROCOM (FAR,TSD,CSO,AKO,CP,REX,PHISO,HSO)	87
	RHO=CAPSF*PSO/(AJ*REX*TSD)	88
	VO=WG/(RHO*AO)	89
	HSCAL=HI-VO**2/(2.*G*AJ)	90
	DELHS=HSCAL-HSD	91
	IF (ABS(DELHS)-0.0005*HSCAL) 17,17,16	92
16	TSD=TSD+DELHS/CP	93
	IF (J-15) 15,15,3	94
17	AMO=VO/CSO	95
	PR=PSO*(TI/TSD)**(AKO/(AKO-1.))	96
	ICON=1	97

GO TO 10  
END

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\$IBFTC DERIV

```
FUNCTION DERIV(I,X)
COMMON /DYN/ ITRAN,TIME,DT,TF,JTRAN,NSTEP,TPRINT,DTPRNT
COMMON /FOC/ FO(50,4)
IF(JTRAN.EQ.1) GO TO 1
DERIV=0.0
FO(I,1)= X
FO(I,2)=X
FO(I,3)=DERIV
FO(I,4)=DERIV
RETURN
1 XO=FO(I,2)
DERIV=(X-XO)/DT
FO(I,1)= X
FO(I,3)=DERIV
RETURN
END
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\$IBFTC ENGBAL

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SUBROUTINE ENGBAL
COMMON /WORDS/ WORD
COMMON /DESIGN/
1IDES ,JDES ,KDES ,MODE ,INIT ,IDUMP ,IAMTP ,IGASMX,
2IDBURN,IAFTBN,IDCD ,IMCD ,IDSHOC,IMSHOC,NOZFLT,ITRYS ,
3LOOPER,NOMAP ,NUMMAP,MAPELG,TOLALL,ERR(9)
COMMON /ALL1/
1PCNFGU,PCNCGU,T4GU ,DUMD1 ,DUMD2 ,DELFG ,DELFN ,DELSFC,
2ZFDS ,PCNFDS,PRFDS ,ETAFDS,WAFDS ,PRFCF ,ETAFCF,WAFCF ,
3ZCDS ,PCNCDS,PRCDS ,ETACDS,WACDS ,PRCCF ,ETACCF,WACCF ,
4T4DS ,WFBDS ,DTCODS,ETABDS,WA3CDS,DPCODS,DTCOCF,ETABCF,
5TFHPDS,CNHPDS,ETHPDS,TFHPCF,CNHPCF,ETHPCF,DHHPCF,T2DS ,
6TFLPDS,CNLPDS,ETLPDS,TFLPCF,CNLPFC,ETLPFC,DHLPFC,T21DS ,
7T24DS ,WFDDSD,DTDDSD,ETAADD,WA23DS,DPDUDS,DTDUFC,ETAADF,
8T7DS ,WFADS ,DTAFDS,ETAADS,WG6CDS,DPAFDS,DTAFCF,ETAACF,
9A55 ,A25 ,A6 ,A7 ,A8 ,A9 ,A28 ,A29 ,
$PS55 ,AM55 ,CVDNOZ,CVMNOZ,A8SAV ,A9SAV ,A28SAV,A29SAV
COMMON /ALL2/
1T1 ,P1 ,H1 ,S1 ,T2 ,P2 ,H2 ,S2 ,
2T21 ,P21 ,H21 ,S21 ,T3 ,P3 ,H3 ,S3 ,
3T4 ,P4 ,H4 ,S4 ,T5 ,P5 ,H5 ,S5 ,
4T55 ,P55 ,H55 ,S55 ,BLF ,BLC ,BLDU ,BLOB ,
5CNF ,PRF ,ETAF ,WAF ,WAF ,WA3 ,WG4 ,FAR4 ,
6CNC ,PRC ,ETAC ,WACC ,WAC ,ETAB ,DPCOM ,DUMP ,
7CNHP ,ETATHP,DHTCHP,DHTC ,BLHP ,WG5 ,FAR5 ,CS ,
8CNLP ,ETATLP,DHTCLP,DHTF ,BLLP ,WG55 ,FAR55 ,HPEXT ,
9AM ,ALTP ,ETAR ,ZF ,PCNF ,ZC ,PCNC ,WFB ,
$TFFHP ,TFFLP ,PCBLF ,PCBLC ,PCBLDU,PCBLOB,PCBLHP,PCBLP
COMMON /ALL3/
1XP1 ,XWAF ,XWAC ,XBLF ,XBLDU ,XH3 ,DUMS1 ,DUMS2 ,
2XT21 ,XP21 ,XH21 ,XS21 ,T23 ,P23 ,H23 ,S23 ,
3T24 ,P24 ,H24 ,S24 ,T25 ,P25 ,H25 ,S25 ,
4T28 ,P28 ,H28 ,S28 ,T29 ,P29 ,H29 ,S29 ,
5WAD ,WFD ,WG24 ,FAR24 ,ETAD ,DPDUC ,BYPASS,DUMS3 ,
6TS28 ,PS28 ,V28 ,AM28 ,TS29 ,PS29 ,V29 ,AM29 ,
7XT55 ,XP55 ,XH55 ,XS55 ,XT25 ,XP25 ,XH25 ,XS25 ,
8XWFB ,XWG55 ,XFAR55,XWFD ,XWG24 ,XFAR24,XXP1 ,DUMB ,
9T6 ,P6 ,H6 ,S6 ,T7 ,P7 ,H7 ,S7 ,
$T8 ,P8 ,H8 ,S8 ,T9 ,P9 ,H9 ,S9 ,
COMMON /ALL4/
1WG6 ,WFA ,WG7 ,FAR7 ,ETAA ,DPAFT ,V55 ,V25 ,
2PS6 ,V6 ,AM6 ,TS7 ,PS7 ,V7 ,AM7 ,AM25 ,
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3TS8 ,PS8 ,V8 ,AM8 ,TS9 ,PS9 ,V9 ,AM9 , 43
4VA ,FRD ,VJD ,FGMD ,VJM ,FGMM ,FGPD ,FGPM , 44
5FGM ,FGP ,WFT ,WGT ,FART ,FG ,FN ,SFC , 45
6WA32 ,DPWGDS ,DPWING ,WA32DS ,A38 ,AM38 ,V38 ,T38 , 46
7H38 ,P38 ,TS38 ,PS38 ,T39 ,H39 ,P39 ,TS39 , 47
8V39 ,AM39 ,A39 ,BPRINT ,WG37 ,CVDWNG ,FGMWNG ,FGPWNG , 48
9FNWING ,FNMAIN ,FMOVFN ,PS39 ,FFOVFN ,FCOVFN ,FMNOFN ,FNOVFD , 49
$VJM ,T22 ,P22 ,H22 ,S22 ,T50 ,P50 ,H50 50
COMMON /ALL5/
1S50 ,WA22 ,ZI ,PCNI ,CNI ,PRI ,ETAI ,WACI , 51
2TFFIP ,CNIP ,ETATIP ,DHTCIP ,DHTI ,BLIP ,PCBLIP ,PCNIGU , 52
3ZIDS ,PCNIDS ,PRIDS ,ETAIDS ,WAIDS ,PRICF ,ETAICF ,WAICF , 53
4TFIPDS ,CNIPDS ,ETIPDS ,TFIPCF ,CNIPCF ,ETIPCF ,DHIPCF ,WAICDS , 54
5WAI ,PCBLI ,BLI ,T22DS ,WA21 ,WG50 ,FAR50 ,A24 , 55
6AM23 ,DUMSPL ,FXFN2M ,FXM2CP ,AFTFAN ,PUNT ,PCBLID ,P6DSAV , 56
7AM6DSV ,ETAASV ,FAR7SV ,T4PBL ,T41 ,FAN ,ISPOOL 57
COMMON /DYN/ ITRAN ,TIME ,DT ,TF ,JTRAN ,NSTEP ,TPRINT ,DTPRNT 58
LOGICAL ERRER ,FXFN2M ,FXM2CP ,DUMSPL ,FAN 59
DIMENSION DELSAV(9) 60
COMMON/ERER/ERRER 61
DIMENSIONVAR(9) ,DEL(9) ,ERRR(9) ,DELVAR(9) ,EMAT(9,9) ,VMAT(9) ,AMAT(9) 62
DATA AWORD/6HENGBAL/ 63
DATA VDELTA ,VLIM ,VCHNGE ,NOMISX/ 64
1 1.E-4 ,0.100 ,0.850 ,4/ 65
DATA DEL/9*0./ 66
DATA DELSAV/9*1.E-4/ 67
IF(ITRAN.NE.1) GO TO 100 68
CALL SYG(1) 69
JTRAN=1 70
INIT=1 71
NSTEP=NSTEP+1 72
TIME=DT*FLOAT(NSTEP) 73
IF(TIME.GT.TF) GO TO 100 74
CALL DISTRB 75
CALL COINLT 76
GO TO 101 77
100 CALL PUTIN 78
101 CONTINUE 79
IF (INIT.EQ.1) GO TO 1 80
TFFHP=TFHPDS 81
TFFIP=TFIPDS 82
IF (FXM2CP) TFFIP=TFHPDS 83
TFFLP=TFLPDS 84
1 LOOPER=0 85
NUMMAP=0 86
NOMISS=0 87
2 LOOP=0 88
MISMAT=0 89
NOMAP=0 90
IGO=2 91
DO 3 I=1,9 92
VMAT(I)=0. 93
AMAT(I)=0. 94
DELVAR(I)=0. 95
DO 3 L=1,9 96
3 EMAT(I,L)=0. 97
4 LOOPER=LOOPER+1 98
CALL COFAN 99
WORD=AWORD 100
IF(.NOT.FAN) DUMSPL=.TRUE. 101
IF (LOOPER.GT.ITRYS) ERRER=.TRUE. 102
IF (LOOPER.GT.ITRYS) GO TO 26 103
IF (NOMAP.GT.0) GO TO 2 104
NUMMAP=0 105
5 VAR(1)=ZF*100. 106
IF (MODE.NE.3) VAR(2)=PCNF 107
IF (MODE.EQ.3) VAR(2)=T4/10. 108
VAR(3)=ZC*100. 109
IF (MODE.NE.1) VAR(4)=PCNC 110
IF (MODE.EQ.1) VAR(4)=T4/10. 111
VAR(5)=TFFHP 112
VAR(6)=TFFLP 113
VAR(7)=ZI*100. 114
VAR(8)=PCNI 115

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	VAR(9)=TFFIP	117
	NMAX=9	118
	IF(FAN) GO TO 39	119
	NMAX=6	120
	IF(ISPOOL.EQ.2) GO TO 7	121
	NMAX=3	122
	VAR(3)=TFFLP	123
	GO TO 7	124
39	IF(.NOT.FXFN2M.AND.(.NOT.DUMSPL)) GO TO 6	125
	NMAX=7	126
	IF (DUMSPL) NMAX=6	127
6	IF (.NOT.FXM2CP) GO TO 7	128
	NMAX=7	129
	VAR(4)=PCNI	130
	VAR(5)=TFFIP	131
7	CONTINUE	132
	DO 8 I=1,NMAX	133
	IF (ABS(ERR(I)).GT.TOLALL) GO TO 9	134
8	CONTINUE	135
	IF(ITRAN.EQ.1) CALL ROLL	136
	CALL PERF	137
	CALL ERROR	138
9	IF (LOOP.GT.0) GO TO 11	139
	MAPEDG=0	140
	MAPSET=0	141
	DO 10 I=1,NMAX	142
	ERRB(I)=ERR(I)	143
10	DEL(I)=VDELTA*VAR(I)	144
	GO TO 14	145
11	IF (MISMAT.GT.0) GO TO 29	146
	IF (MAPEDG.EQ.0) GO TO 12	147
	MAPEDG=0	148
	MAPSET=1	149
	VAR(LOOP)=VAR(LOOP)+2.*DEL(LOOP)	150
	GO TO 15	151
12	IF (MAPSET.EQ.0) VAR(LOOP)=VAR(LOOP)+DEL(LOOP)	152
	IF (MAPSET.EQ.1) VAR(LOOP)=VAR(LOOP)-DEL(LOOP)	153
	MAPSET=0	154
	DO 13 I=1,NMAX	155
	IF (DEL(LOOP).NE.0.) DEL SAV(LOOP)=DEL(LOOP)	156
	IF (DEL(LOOP).EQ.0.) DEL(LOOP)=DEL SAV(LOOP)	157
	EMAT(I,LOOP)=(ERRB(I)-ERR(I))/DEL(LOOP)	158
13	CONTINUE	159
14	LOOP=LOOP+1	160
	IF (LOOP.GT.NMAX) GO TO 17	161
	VAR(LOOP)=VAR(LOOP)-DEL(LOOP)	162
15	ZF=VAR(1)/100.	163
	IF (MODE.NE.3) PCNF=VAR(2)	164
	IF (MODE.EQ.3) T4=VAR(2)*10.	165
	ZC=VAR(3)/100.	166
	IF (MODE.NE.1) PCNC=VAR(4)	167
	IF (MODE.EQ.1) T4=VAR(4)*10.	168
	TFFHP=VAR(5)	169
	TFFLP=VAR(6)	170
	ZI=VAR(7)/100.	171
	PCNI=VAR(8)	172
	TFFIP=VAR(9)	173
	IF (.NOT.FXM2CP) GO TO 16	174
	PCNI=VAR(4)	175
	TFFIP=VAR(5)	176
16	IF (ISPOOL.EQ.1) TFFLP=VAR(3)	177
	IF (ZI.LT.0.) ZI=0.05	178
	IF (ZF.LT.0.) ZF=0.05	179
	IF (ZC.LT.0.) ZC=0.05	180
	GO TO (2,4),IGO	181
17	DO 18 I=1,NMAX	182
18	AMAT(I)=-ERRB(I)	183
	DO 20 I=1,NMAX	184
	IZERO=0	185
	DO 19 LOOP=1,NMAX	186
19	IF (EMAT(I,LOOP).EQ.0.) IZERO=IZERO+1	187
	IF (IZERO.LT.NMAX) GO TO 20	188
	WRITE (6,32) I	189

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	LOOPER=ITRYS+100	190
	GO TO 26	191
20	CONTINUE	192
	DO 22 LOOP=1,NMAX	193
	IZERO=0	194
	DO 21 I=1,NMAX	195
21	IF (EMAT(I,LOOP).EQ.0.) IZERO=IZERO+1	196
	IF (IZERO.LT.NMAX) GO TO 22	197
	WRITE (6,33) LOOP	198
	LOOPER=ITRYS+100	199
	GO TO 26	200
22	CONTINUE	201
23	CALL MATRIX (EMAT,VMAT,AMAT,NMAX)	202
	LBIG=0	203
	VARBIG=0.	204
	DO 24 L=1,NMAX	205
	ABSVAR=ABS(VMAT(L))	206
	IF (ABSVAR.LE.VLIM*VAR(L)) GO TO 24	207
	IF (ABSVAR.LE.VARBIG) GO TO 24	208
	LBIG=L	209
	VARBIG=ABSVAR	210
24	CONTINUE	211
	VRATIO=1.0	212
	IF (LBIG.GT.0) VRATIO=VLIM*VAR(LBIG)/VARBIG	213
	ERRAVE=0.0	214
	VMTAVE=0.0	215
	DELAVE=0.0	216
	DO 25 L=1,NMAX	217
	DELVAR(L)=VRATIO*VMAT(L)	218
	ERRAVE=ERRAVE+ABS(AMAT(L))/FLOAT(NMAX)	219
	VAR(L)=VAR(L)+DELVAR(L)	220
	VMTAVE=VMTAVE+ABS(VMAT(L))/FLOAT(NMAX)	221
25	DELAVE=DELAVE+ABS(DELVAR(L))/FLOAT(NMAX)	222
	IF (MISMAT.GT.0) GO TO 31	223
	IF (NOMISS.EQ.0) MISMAT=)	224
	IF (MISMAT.EQ.0) IGO=1	225
26	WRITE (8,34) LOOPER	226
	DO 27 I=1,NMAX	227
27	WRITE (8,35) AMAT(I),(EMAT(I,L),L=1,9),VMAT(I),DELVAR(I),VAR(I)	228
	WRITE (8,36) ERRAVE,VMTAVE,DELAVE	229
28	IF (LOOPER.LT.ITRYS) GO TO 15	230
	CALL ERROR	231
	RETURN	232
29	VMTAVX=VMTAVE	233
	DO 30 I=1,NMAX	234
30	AMAT(I)=-ERR(I)	235
	GO TO 23	236
31	WRITE (8,37) AMAT,ERRAVE,DELVAR,DELAVE,VMAT,VMTAVE,VAR	237
	MISMAT=MISMAT+1	238
	IF (VMTAVE.LT.VCHNGE*VMTAVX) GO TO 28	239
	WRITE (8,38)	240
	IF (MISMAT.LT.NOMISS) NOMISS=1	241
	MISMAT=0	242
	LOOP=0	243
	IGO=2	244
	GO TO 5	245
C		246
C		247
32	FORMAT (4HOROW,I2,16H IS ZERO IN EMAT)	248
33	FORMAT (7HOCOLUMN,I2,16H IS ZERO IN EMAT)	249
34	FORMAT (8HB  ERRB,28X23HERROR MATRIX AFTER LOOP,I4,29X4HVMAT,6X6H	250
	IDELVAR,7X14HVARIABLE\$\$\$\$\$)	251
35	FORMAT (1H0,F8.4,10F9.3,2F11.4,6H\$\$\$\$\$)	252
36	FORMAT (1H0,F8.4,32X14HAVERAGE VALUES,31X,2F11.4,6H\$\$\$\$\$)	253
37	FORMAT (12H0-----  AMAT,10F11.6,6H\$\$\$\$\$,/,12H -----DELVAR,10F11.6	254
	1,6H\$\$\$\$\$,/,12H -----  VMAT,10F11.6,6H\$\$\$\$\$,/,12H -----  VAR,9F1	255
	21.6,6H\$\$\$\$\$)	256
38	FORMAT (1H0,50X22HCHANGE TOO SMALL\$\$\$\$\$)	257
	END	258

\$IBFTC ERROR

```

SUBROUTINE ERROR
COMMON /WORDS/ WORD
COMMON /DESIGN/
1IDES ,JDES ,KDES ,MODE ,INIT ,IDUMP ,IAMTP ,IGASHX,
2IDBURN ,IAFTBN ,IOCD ,IMCD ,IDSHOC ,IMSHOC ,NOZFLT ,ITRYS ,
3
4
5
6
7
COMMON /ALL1/
8
9
10
11
12
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15
16
17
18
COMMON /ALL2/
19
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COMMON /ALL3/
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COMMON /ALL4/
41
42
43
44
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51
COMMON /ALL5/
52
53
54
55
56
57
58
59
COMMON /WHRRERR/ICOFB ,ICODUC ,ICCMIX
60
61
62
63
64
65
66
67
68
69
70
COMMON /ERER/ERRER
71
DIMENSION TRASH1(80) ,TRASH2(80) ,TRASH3(80) ,TRASH4(80) ,TRASH5(80)
72
EQUIVALENCE (TRASH1 ,PCNFGU) , (TRASH2 ,T1) , (TRASH3 ,XP1) , (TRASH4 ,WG6)
73
EQUIVALENCE (TRASH5 ,S50)

```

	DATA AWORD/6HCOMMON/	74
	ERRER=.TRUE.	75
	WRITE (6,2) WORD	76
	WORD=AWORD	77
	WRITE (6,3) WORD,ZF,PCNF,ZI,PCNI,ZC,PCNC,T4,MODE	78
	WRITE (6,4)	79
	WRITE (6,5) (TRASH1(I),I=1,80)	80
	WRITE (6,6)	81
	WRITE (6,5) (TRASH2(I),I=1,80)	82
	WRITE (6,4)	83
	WRITE (6,5) (TRASH3(I),I=1,80)	84
	WRITE (6,4)	85
	WRITE (6,5) (TRASH4(I),I=1,80)	86
	WRITE (6,4)	87
	WRITE (6,8) (TRASH5(I),I=1,55)	88
	WRITE (6,4)	89
	WRITE (6,7) LOOPER	90
	IF (IDUMP.EQ.0) GO TO 1	91
	WRITE (6,6)	92
	CALL SYG (2)	93
1	CALL ENGBAL	94
	RETURN	95
C		96
C		97
2	FORMAT (28HOAN ERROR HAS BEEN FOUND IN ,A6)	98
3	FORMAT (1H0,A6,9X,7E15.6,I4)	99
4	FORMAT (2H0 )	100
5	FORMAT (1H ,8E15.6)	101
6	FORMAT (1H1)	102
7	FORMAT (25H0FAILED TO CONVERGE AFTER,I4,6H LOOPS)	103
8	FORMAT (1H+,30X,6E15.6/(1H ,8E15.6))	104
	END	105

	\$IBFTC ETAAB	
	SUBROUTINE ETAAB (FAR,EM6,P6,ETA,ETAADS,ETAASV,P6DS,P6DSAV,AM6DS,A	1
	IM6DSV,IDES,FAR7DS,FAR7SV)	2
	DIMENSION FART(25),ETABRT(25),EM6T(7),DELM6(7),P6T(14),DELP6(14)	3
	DIMENSION X(3),Y(3)	4
	DATA FART/.0390,.0585,.0732,.0878,.0976,.1171,.1268,.1463,.1619,	5
	1.1834,.1951,.2195,.2439,.2927,.3415,.4146,.4634,.5366,.6341,.7317,	6
	2.8293,.9268,1.000,1.0634,1.7/	7
	DATA ETABRT/.9400,.9887,1.0193,1.0306,1.0227,.9672,.9377,.9207,	8
	1.9354,.9626,.9773,1.0193,1.0532,1.077,1.0781,1.077,1.0747,1.0668,	9
	21.0578,1.0510,1.0374,1.0192,1.00,.9626,.9151/	10
	DATA EM6T/1.00,1.071,1.190,1.309,1.428,1.547,1.666/	11
	DATA DELM6/0.,.013,.041,.073,.110,.147,.187/	12
	DATA P6T/.220,.2267,.250,.300,.3333,.3767,.4167,.500,.5833,.6667,	13
	1.75,.8333,.9167,1.0/	14
	DATA DELP6/-.142,-.125,-.10,-.075,-.062,-.05,-.041,-.027,-.019,	15
	1-.013,-.008,-.004,-.0021,0./	16
	IF (IDES.NE.1) GO TO 5	17
	DO 1 K=1,25	18
1	ETABRT(K)=ETABRT(K)*ETAADS/ETAASV	19
	DO 2 K=1,25	20
2	FART(K)=FART(K)*FAR7DS/FAR7SV	21
	DO 3 K=1,7	22
3	EM6T(K)=EM6T(K)*AM6DS/AM6DSV	23
	DO 4 M=1,14	24
4	P6T(M)=P6T(M)*P6DS/P6DSAV	25
	ETAASV=ETAADS	26
	P6DSAV=P6DS	27
	FAR7SV=FAR7DS	28
	AM6DSV=AM6DS	29
	RETURN	30
5	CONTINUE	31
	N=0	32
	IF (FAR.GT.0.067) GO TO 8	33
	DO 6 J=1,25	34
6	IF (FAR.GE.FART(J)) N=J-1	35



	IF (N.EQ.0) N=1	36
	IF (N.GE.24) N=23	37
	DO 7 I=1,3	38
	NN=N-1+I	39
	X(I)=FART(NN)	40
7	Y(I)=ETABRT(NN)	41
	CALL PARABO (X,Y,FAR,ETA1)	42
	GO TO 9	43
8	ETA1=-2.*FAR+.1948	44
9	M=0	45
	DO 10 J=1,7	46
10	IF (EM6.GE.EM6T(J)) M=J-1	47
	IF (M.EQ.0) M=1	48
	IF (M.GE.6) M=5	49
	DO 11 I=1,3	50
	MM=M-1+I	51
	X(I)=EM6T(MM)	52
11	Y(I)=DELM6(MM)	53
	CALL PARABO (X,Y,EM6,COR1)	54
	L=0	55
	DO 12 J=1,14	56
12	IF (P6.GE.P6T(J)) L=J-1	57
	IF (L.EQ.0) L=1	58
	IF (L.GE.13) L=12	59
	DO 13 I=1,3	60
	LL=L-1+I	61
	X(I)=P6T(LL)	62
13	Y(I)=DELP6(LL)	63
	CALL PARABO (X,Y,P6,COR2)	64
	ETA=ETA1*(1.-COR1)*(1.+COR2)	65
	RETURN	66
	END	67

\$IBFTC FASTBK

	SUBROUTINE FASTBK	1
	COMMON /WORDS/ WORD	2
	COMMON /DESIGN/	3
	1IDES ,JDES ,KDES ,MODE ,INIT ,IDUMP ,IAMTP ,IGASMX,	4
	2IDBURN ,IAFTBN ,IDCD ,IMCD ,IDSHOC ,IMSHOC ,NOZFLT ,ITRYS ,	5
	3LOOPER ,NOMAP ,NUMMAP ,MAPEDG ,TOLALL ,ERR(9)	6
	COMMON /ALL1/	7
	1PCNFGU ,PCNCGU ,T4GU ,DUMD1 ,DUMD2 ,DELFG ,DELFN ,DELSFC,	8
	2ZFDSD ,PCNFSD ,PRFSD ,ETAFSD ,WAFSD ,PRFCF ,ETAFCF ,WAFCF ,	9
	3ZCDS ,PCNCDS ,PRCDS ,ETACDS ,WACDS ,PRCCF ,ETACCF ,WACCF ,	10
	4T4DS ,WFBDS ,DTCODS ,ETABDS ,WA3CDS ,DPCODS ,DTCOCF ,ETABCF ,	11
	5TFHPDS ,CNHPDS ,ETHPDS ,TFHPCF ,CNHPCF ,ETHPCF ,DHHPCF ,T2DS ,	12
	6TFLPDS ,CNLPDS ,ETLPDS ,TFLPCF ,CNLPCF ,ETLPCF ,DHLPCF ,T21DS ,	13
	7T24DS ,WFDDSD ,DTDUOS ,ETAODS ,WA23DS ,DPDUDS ,DTDUUCF ,ETAODCF ,	14
	8T7DS ,WFADSD ,DTAFSD ,ETAADS ,WG6CDS ,DPAFSD ,DTAFCF ,ETAACF ,	15
	9A55 ,A25 ,A6 ,A7 ,A8 ,A9 ,A28 ,A29 ,	16
	\$PS55 ,AM55 ,CVDNOZ ,CVMNOZ ,A8SAV ,A9SAV ,A28SAV ,A29SAV	17
	COMMON /ALL2/	18
	1T1 ,P1 ,H1 ,S1 ,T2 ,P2 ,H2 ,S2 ,	19
	2T21 ,P21 ,H21 ,S21 ,T3 ,P3 ,H3 ,S3 ,	20
	3T4 ,P4 ,H4 ,S4 ,T5 ,P5 ,H5 ,S5 ,	21
	4T55 ,P55 ,H55 ,S55 ,BLF ,BLC ,BLDU ,BLOB ,	22
	5CNF ,PRF ,ETAF ,WAF ,WAF ,WA3 ,WG4 ,FAR4 ,	23
	6CNC ,PRC ,ETAC ,WACC ,WAC ,ETAB ,DPCOM ,DUMP ,	24
	7CNHP ,ETATHP ,DHTCHP ,DHTC ,BLHP ,WG5 ,FAR5 ,CS ,	25
	8CNLP ,ETATLP ,DHTCLP ,DHTF ,BLLP ,WG55 ,FAR55 ,HPEXT ,	26
	9AM ,ALTP ,ETAR ,ZF ,PCNF ,ZC ,PCNC ,WFB ,	27
	\$TFFHP ,TFFLP ,PCBLF ,PCBLC ,PCBLDU ,PCBLOB ,PCBLHP ,PCBLP	28
	COMMON /ALL3/	29
	1XP1 ,XWAF ,XWAC ,XBLF ,XBLOU ,XH3 ,DUMS1 ,DUMS2 ,	30
	2XT21 ,XP21 ,XH21 ,XS21 ,T23 ,P23 ,H23 ,S23 ,	31
	3T24 ,P24 ,H24 ,S24 ,T25 ,P25 ,H25 ,S25 ,	32
	4T28 ,P28 ,H28 ,S28 ,T29 ,P29 ,H29 ,S29 ,	33
	5WAD ,WFD ,WG24 ,FAR24 ,ETAD ,DPDUC ,BYPASS ,DUMS3 ,	34

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6TS28	,PS28	,V28	,AM28	,TS29	,PS29	,V29	,AM29		35
7XT55	,XP55	,XH55	,XS55	,XT25	,XP25	,XH25	,XS25		36
8XWFB	,XWG55	,XFAR55	,XWFD	,XWG24	,XFAR24	,XXP1	,DUMB		37
9T6	,P6	,H6	,S6	,T7	,P7	,H7	,S7		38
\$T8	,P8	,H8	,S8	,T9	,P9	,H9	,S9		39
COMMON /ALL4/									40
1WG6	,WFA	,WG7	,FAR7	,ETAA	,DPAFT	,V55	,V25		41
2PS6	,V6	,AM6	,TS7	,PS7	,V7	,AM7	,AM25		42
3TS8	,PS8	,V8	,AM8	,TS9	,PS9	,V9	,AM9		43
4VA	,FRD	,VJD	,FGMD	,VJM	,FGMM	,FGPD	,FGPM		44
5FGM	,FGP	,WFT	,WGT	,FART	,FG	,FN	,SFC		45
6WA32	,DPWGDS	,DPWING	,WA32DS	,A38	,AM38	,V38	,T38		46
7H38	,P38	,TS38	,PS38	,T39	,H39	,P39	,TS39		47
8V39	,AM39	,A39	,BPRINT	,WG37	,CVDWNG	,FGMWNG	,FGPWNG		48
9FNWING	,FNMAIN	,FWOVFN	,PS39	,FFOVFN	,FCOVFN	,FMNOFN	,FNOVFD		49
\$VJW	,T22	,P22	,H22	,S22	,T50	,P50	,H50		50
COMMON /ALL5/									51
1S50	,WA22	,ZI	,PCNI	,CNI	,PRI	,ETAI	,WACI		52
2TFFIP	,CNIP	,ETATIP	,DHTCIP	,DHTI	,BLIP	,PCBLIP	,PCNIGU		53
3ZIDS	,PCNIDS	,PRIDS	,ETAIDS	,WAIDS	,PRICF	,ETAICF	,WAICF		54
4TFIPDS	,CNIPDS	,ETIPDS	,TFIPCF	,CNIPCF	,ETIPCF	,DHIPCF	,WAICDS		55
5WAI	,PCBLI	,BLI	,T22DS	,WA21	,WG50	,FAR50	,A24		56
6AM23	,DUMSPL	,FXFN2M	,FXM2CP	,AFTFAN	,PUNT	,PCBLID	,P6DSAV		57
7AM6DSV	,ETAASV	,FAR7SV	,T4PBL	,T41	,FAN	,ISPOOL			58
LOGICAL FAN									59
XT55=T55									60
XP55=P55									61
XH55=H55									62
XS55=S55									63
IF(FAN) GO TO 1									64
T25=T21									65
P25=P21									66
H25=H21									67
S25=S21									68
WG24=WAF-BLF									69
1	XT25=T25								70
XP25=P25									71
XH25=H25									72
XS25=S25									73
XWFB=WFB									74
XWG55=WG55									75
XFAR55=FAR55									76
XWFD=WFD									77
XWG24=WG24									78
XFAR24=FAR24									79
XXP1=P1									80
CALL COMIX									81
RETURN									82
END									83

\$IBFTC FRTOSD									
SUBROUTINE FRTOSD									1
COMMON /WORDS/ WORD									2
COMMON /DESIGN/									3
1IDES ,JDES ,KDES ,MODE ,INIT ,IDUMP ,IAMTP ,IGASMX,									4
2IDBURN ,IAFTBN ,IOCD ,IMCD ,IDSHOC ,IMSHOC ,NOZFLT ,ITRYS ,									5
3LOOPER ,NOMAP ,NUMMAP ,MAPEDG ,TCLALL ,ERR(9)									6
COMMON /ALL1/									7
1PCNFGU ,PCNCGU ,T4GU ,DUMD1 ,DUMD2 ,DELFG ,DELFN ,DELSFC,									8
2ZFDS ,PCNFDS ,PRFDS ,ETAFDS ,WAFDS ,PRFCF ,ETAFCF ,WAFCF ,									9
3ZCDS ,PCNCDS ,PRCDS ,ETACDS ,WACDS ,PRCCF ,ETACCF ,WACCF ,									10
4T4DS ,WFBDS ,DTCODS ,ETABDS ,WA3CDS ,DPCODS ,DTCOCF ,ETABCF ,									11
5TFHPDS ,CNHPDS ,ETHPDS ,TFHPCF ,CNHPCF ,ETHPCF ,DHHPCF ,T2DS ,									12
6TFLPDS ,CNLPDS ,ETLPDS ,TFLPCF ,CNLPCF ,ETLPCF ,DHLPCF ,T21DS ,									13
7T24DS ,WFDD ,DTDUDS ,ETAADS ,WA23DS ,DPOUDS ,DTDUCF ,ETAACF ,									14
8T7DS ,WFADS ,DTAFDS ,ETAADS ,WG6CDS ,DPAFDS ,DTAFCF ,ETAACF ,									15
9A55 ,A25 ,A6 ,A7 ,A8 ,A9 ,A28 ,A29 ,									16
\$PS55 ,AM55 ,CVDNOZ ,CVMNOZ ,A8SAV ,A9SAV ,A2BSAV ,A29SAV									17
COMMON /ALL2/									18

1T1	,P1	,H1	,S1	,T1	,P2	,H2	,S2	19
2T2	,P2	,H2	,S21	,T3	,P3	,H3	,S3	20
3T3	,P3	,H3	,S4	,T5	,P5	,H5	,S5	21
4T4	,P55	,H55	,S55	,BLF	,BLC	,BLDU	,BLOB	22
5CNF	,PRF	,ETAF	,WAF	,WAF	,WA3	,WG4	,FAR4	23
6CNC	,PRC	,ETAC	,WACC	,WAC	,ETAB	,DPCOM	,DUMP	24
7CNHP	,ETATHP	,DHTCHP	,DHTC	,BLHP	,WG5	,FAR5	,CS	25
8CNLP	,ETATLP	,DHTCLP	,DHTF	,BLLP	,WG55	,FAR55	,HPEXT	26
9AM	,ALTP	,ETAR	,ZF	,PCNF	,ZC	,PCNC	,WFB	27
\$TFFHP	,TFFLP	,PCBLF	,PCBLC	,PCBLDU	,PCBLOB	,PCBLHP	,PCBLLP	28
COMMON /ALL3/								29
1XP1	,XWAF	,XWAC	,XBLF	,XBLOU	,XH3	,DUMS1	,DUMS2	30
2XT21	,XP21	,XH21	,XS21	,T23	,P23	,H23	,S23	31
3T24	,P24	,H24	,S24	,T25	,P25	,H25	,S25	32
4T28	,P28	,H28	,S28	,T29	,P29	,H29	,S29	33
5WAD	,WFD	,WG24	,FAR24	,ETAD	,DPDUC	,BYPASS	,DUMS3	34
6TS28	,PS28	,V28	,AM28	,TS29	,PS29	,V29	,AM29	35
7XT55	,XP55	,XH55	,XS55	,XT25	,XP25	,XH25	,XS25	36
8XWFB	,XWG55	,XFAR55	,XWFD	,XWG24	,XFAR24	,XXP1	,DUMB	37
9T6	,P6	,H6	,S6	,T7	,P7	,H7	,S7	38
\$T8	,P8	,H8	,S8	,T9	,P9	,H9	,S9	39
COMMON /ALL4/								40
1WG6	,WFA	,WG7	,FAR7	,ETAA	,DPAFT	,V55	,V25	41
2PS6	,V6	,AM6	,TS7	,PS7	,V7	,AM7	,AM25	42
3TS8	,PS8	,V8	,AM8	,TS9	,PS9	,V9	,AM9	43
4VA	,FRD	,VJD	,FGMD	,VJM	,FGMM	,FGPD	,FGPM	44
5FGM	,FGP	,WFT	,WGT	,FART	,FG	,FN	,SFC	45
6WA32	,DPWGDS	,DPWING	,WA32DS	,A38	,AM38	,V38	,T38	46
7H38	,P38	,TS38	,PS38	,T39	,H39	,P39	,TS39	47
8V39	,AM39	,A39	,BPRINT	,WG37	,CVDWNS	,FGMWNG	,FGPWNG	48
9FNWING	,FNMAIN	,FNDOFN	,PS39	,FFOVFN	,FCOVFN	,FMNOFN	,FNOVFN	49
\$VJW	,T22	,P22	,H22	,S22	,T50	,P50	,H50	50
COMMON /ALL5/								51
1S50	,WA22	,ZI	,PCNI	,CNI	,PRI	,ETAI	,WACI	52
2TFFIP	,CNIP	,ETATIP	,DHTCIP	,DHTI	,BLIP	,PCBLIP	,PCNIGU	53
3ZIDS	,PCNIDS	,PRIDS	,ETAIDS	,WAIDS	,PRICF	,ETAICF	,WAICF	54
4TFIPDS	,CNIPDS	,ETIPDS	,TFIPCF	,CNIPCF	,ETIPCF	,DHIPCF	,WAICDS	55
5WAI	,PCBLI	,BLI	,T22DS	,WA21	,WG50	,FAR50	,A24	56
6AM23	,DUMSPL	,FXFN2M	,FXM2CP	,AFTFAN	,PUNT	,PCBLID	,P6DSAV	57
7AM6DSV	,ETAASV	,FAR7SV	,T4PBL	,T41	,FAN	,ISPOOL		58
LOGICAL FAN								59
XP1=P1								60
XWAF=WAF								61
XWAC=WAC								62
XBLF=BLF								63
XBLOU=BLDU								64
XH3=H3								65
XT21=T21								66
XP21=P21								67
XH21=H21								68
XS21=S21								69
IF(FAN) CALL CODUCT								70
IF(FAN) RETURN								71
CALL FASTBK								72
RETURN								73
END								74

*E-8111*  
*SBM (54)*  
*p. 75*  
*78%*

\$IBFTC GEN2								1
COMMON /WORDS/ WORD								2
COMMON /DESIGN/								3
1IDES	,JDES	,KDES	,MODE	,INIT	,IDUMP	,IAMTP	,IGASMX	4
2IOBURN	,IAFTBN	,IOCD	,IMCD	,IDSHOC	,IMSHOC	,NOZFLT	,ITRYS	5
3LOOPER	,NOMAP	,NUMMAP	,MAPELG	,TOLALL	,ERR(9)			6
COMMON /ALL1/								7
1PCNFGU	,PCNCGU	,T4GU	,DUMD1	,DUMD2	,DELFG	,DELFN	,DELSFC	8
2ZFDS	,PCNFDS	,PRFDS	,ETAFDS	,WAFDS	,PRFCF	,ETAFCF	,WAFCF	9
3ZCDS	,PCNCDS	,PRCDS	,ETACDS	,WACDS	,PRCCF	,ETACCF	,WACCF	10
4T4DS	,WFBDS	,DTCODS	,ETABDS	,WA3CDS	,DPCODS	,DTCOCF	,ETABCF	11
5TFHPDS	,CNHPDS	,ETHPDS	,TFHPCF	,CNHPCF	,ETHPCF	,DHHPCF	,T2DS	11

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6TFLPDS, CNLPDS, ETL PDS, TFLPCF, CNLPCF, ETLPCF, DHLPCF, T2LDS , 12
7T24DS , WFDD , DTDUDS, ETADDS, WA23DS, DPDUDS, DTDFCF, ETADCF, 13
8T7DS , WFADS , DTAFDS, ETAADS, WG6CDS, DPAFDS, DTAFCF, ETAACF, 14
9A55 , A25 , A6 , A7 , A8 , A9 , A28 , A29 , 15
$P55 , AM55 , CVDNOZ, CVMNOZ, A8SAV , A9SAV , A28SAV, A29SAV 16
COMMON /ALL2/
IT1 , P1 , H1 , S1 , T2 , P2 , H2 , S2 , 17
2T21 , P21 , H21 , S21 , T3 , P3 , H3 , S3 , 18
3T4 , P4 , H4 , S4 , T5 , P5 , H5 , S5 , 19
4T55 , P55 , H55 , S55 , BLF , BLC , BLDU , BLOB , 20
5CNF , PRF , ETAF , WAF , WAF , WA3 , WG4 , FAR4 , 21
6CNC , PRC , ETAC , WACC , WAC , ETAB , DPCOM , DUMP , 22
7CNHP , ETATHP, DHTCHP, DHTC , BLHP , WG5 , FAR5 , CS , 23
8CNLP , ETATLP, DHTCLP, DHTF , BLLP , WG55 , FAR55 , HPEXT , 24
9AM , ALTP , ETAR , ZF , PCNF , ZC , PCNC , WFB , 25
$TFFHP , TFFLP , PCBLF , PCBLC , PCBLDU, PCBLOB, PCBLHP, PCBLLP 26
COMMON /ALL3/ 27
IXP1 , XWAF , XWAC , XBLF , XBLDU , XH3 , DUMS1 , DUMS2 , 28
2XT21 , XP21 , XH21 , XS21 , T23 , P23 , H23 , S23 , 29
3T24 , P24 , H24 , S24 , T25 , P25 , H25 , S25 , 30
4T28 , P28 , H28 , S28 , T29 , P29 , H29 , S29 , 31
5WAD , WFD , WG24 , FAR24 , ETAC , DPDU , BYPASS, DUMS3 , 32
6TS28 , PS28 , V28 , AM28 , TS29 , PS29 , V29 , AM29 , 33
7XT55 , XP55 , XH55 , XS55 , XT25 , XP25 , XH25 , XS25 , 34
8XWFB , XWG55 , XFAR55, XWFD , XWG24 , XFAR24, XXP1 , DUMB , 35
9T6 , P6 , H6 , S6 , T7 , P7 , H7 , S7 , 36
$T8 , P8 , H8 , S8 , T9 , P9 , H9 , S9 , 37
COMMON /ALL4/ 38
1WG6 , WFA , WG7 , FAR7 , ETAA , DPAFT , V55 , V25 , 39
2PS6 , V6 , AM6 , TS7 , PS7 , V7 , AM7 , AM25 , 40
3TS8 , PS8 , V8 , AM8 , TS9 , PS9 , V9 , AM9 , 41
4VA , FRD , VJD , FGMD , VJM , FGMM , FGP , FGPM , 42
5FGM , FGP , WFT , WGT , FART , FG , FN , SFC , 43
6WA32 , DPWGDS, DPWING, WA32DS, A38 , AM38 , V38 , T38 , 44
7H38 , P38 , TS38 , PS38 , T39 , H39 , P39 , TS39 , 45
8V39 , AM39 , A39 , BPRINT, WG37 , CVDWNG, FGMWNG, FGPWNG, 46
9FNWING, FNMAIN, FWOVFN, PS39 , FFOVFN, FCOVFN, FMNOFN, FNOVFO, 47
$VJW , T22 , P22 , H22 , S22 , T50 , P50 , H50 , 48
COMMON /ALL5/ 49
1S50 , WA22 , ZI , PCNI , CNI , PRI , ETAI , WACI , 50
2TFFIP , CNIP , ETATIP, DHTCIP, DHTI , BLIP , PCBLLP, PCNIGU , 51
3ZIDS , PCNIDS, PRIDS , ETAIDS, WAIDS , PRICF , ETAICF, WAICF , 52
4TFIPDS, CNIPDS, ETIPDS, TFIPCF, CNIPCF, ETIPCF, DHIPCF, WAICDS, 53
5WAI , PCBLI , BLI , T22DS, WA21 , WG50 , FAR50 , A24 , 54
6AM23 , DUMSPL, FXFN2M, FXM2CP, AFTFAN, PUNT , PCBLID, P6DSAV, 55
7AM6DSV, ETAASV, FAR7SV, T4PBL , T41 , FAN , ISPOOL 56
COMMON /VOLS/ VFAN, VINTC, VCOMP, VCOMB, VHPTRB, VIPTRB, VLPTRB, VAFTBN, 57
1 VFDUCT, VWDUCT 58
COMMON /DYN/ ITRAN, TIME, DT, TF, JTRAN, NSTEP, TPRINT, DTPRNT 59
COMMON/LOOPPR/KKGO, PRFNEW, PRCNEW 60
DATAIII/O/ 61
DIMENSION X(1) 62
EQUIVALENCE (X, IDES) 63
LOGICAL ERRER, CLEAR 64
DATA CLEAR/.TRUE./ 65
COMMON/ERER/ERRER 66
LOGICAL RSTART 67
RSTART=.TRUE. 68
ERRER=.FALSE. 69
ITRAN=0 70
JTRAN=0 71
NSTEP = 0 72
TIME = 0.0 73
TPRINT = 0.0 74
DTPRNT = 0.0 75
IF (.NOT.CLEAR) CALL ENGBAL 76
CLEAR=.FALSE. 77
DO 1 J=1, 415 78
X(J)=0. 79
1 C SET ARBITRARY VALUES FOR INTERMEDIATE SPOOL DESIGN PARAMETERS TO 80
C AVOID ERROR WHEN RUNNING A DUMMYSPOOL ENGINE 81
PRIDS=1.5 82
ETAIDS=1.0 83
PCNIDS=100. 84
85

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ZIDS=.75
PCNCDS=100.
IF (III.EQ.0) KKGO=0
IF (IRSTART) CALL CONOUT(1)
P6DSAV=1.
AM6DSV=1.
ETAASV=1.
FAR7SV=1.
CALL ENGBAL
STOP
END

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$IBFTC GUESS
FUNCTION GUESS(M,T,TD,P,PD,W,WD,D,DD,VD)
IF (M.EQ.0) GUESS=VD*((T/TD)**1.60)*((DD/D)**0.50)
IF (M.EQ.1) GUESS=VD*((P/PD)**1.80)*((DD/D)**0.33)
IF (M.EQ.2) GUESS=VD*((W/WD)**0.33)*((DD/D)**1.00)
IF (M.EQ.3) GUESS=VD*((W/WD)**0.00)*((P/PD)**0.50)
IF (M.EQ.4) GUESS=VD*((W/WD)**0.00)*((P/PD)**0.50)
IF (M.EQ.5) GUESS=VD*((T/TD)**1.1)*((DD/D)**.7)
IF (M.EQ.6) GUESS=VD*((P/PD)**1.00)*((D/DD)**0.25)
IF (M.EQ.7) GUESS=VD*((P/PD)**0.62)*((D/DD)**0.31)
IF (M.EQ.8) GUESS=VD*((T/TD)**1.2)*DD/D
IF (M.EQ.9) GUESS=VD*P/PD*((D/DD)**1.5)
RETURN
END

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$IBFTC INDUMY
SUBROUTINE INDUMY (CNI,ZI,WACI,IDES)
COMMON/DUMINT/CNXX(15),PRXX(15,15),WACXX(15,15),ETAXX(15,15),
INCNX,NPTX(15)
DIMENSION WACAR(15),XCNXX(15)
DATA XCNXX/.001,.1,.2,.3,.5,.8,1.,1.5,2.0,3.0,4.0,5.0,6.,7.,9./
DATA WACAR/5.,4.5,4.,3.5,3.,2.5,2.,1.5,1.,.8,.6,.4,.25,.1,.05/
IF (IDES.NE.1) GO TO 1
WAIDS=WACI
CNIDS=CNI
ZI=2./3.5
1 NCNX=15
DO 2 I=1,15
NPTX(I)=15
CNXX(I)=XCNXX(I)*CNIDS
DO 2 J=1,15
PRXX(I,J)=FLOAT(J+3)/4.
ETAXX(I,J)=1.
2 WACXX(J,I)=WACAR(I)*(.993+.001*FLOAT(J))*WAIDS
RETURN
END

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$IBFTC MATRIX
SUBROUTINE MATRIX (E,V,A,N)
DIMENSION E(9,9),V(9),A(9),PIV(10),T(9,10)
NN=N+1
NM=N-1
DO 1 I=1,N
T(I,NN)=A(I)
DO 1 J=1,N
T(I,J)=E(I,J)
DO 7 I=1,N
TEMP=0.

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DO 2 J=I,N
IF (TEMP.GT.ABS(T(J,I))) GO TO 2
TEMP=ABS(T(J,I))
IPIV=J
2 CONTINUE
IPI=I+1
DO 3 J=IPI,NN
3 PIV(J)=T(IPIV,J)/T(IPIV,I)
IFROM=N
ITO=N
4 IF (IFROM.EQ.IPIV) GO TO 6
RM=-T(IFROM,I)
DO 5 J=IPI,NN
5 T(ITO,J)=T(IFROM,J)+RM*PIV(J)
ITO=ITO-1
6 IFROM=IFROM-1
IF (IFROM.GE.I) GO TO 4
DO 7 J=IPI,NN
7 T(I,J)=PIV(J)
DO 8 I=1,NN
J=NN-I
K=N-I
DO 8 L=J,N
8 T(K,NN)=T(K,NN)-T(K,L)*T(L,NN)
DO 9 I=1,N
9 V(I)=T(I,NN)
RETURN
END

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\$IBFTC OUTPUT

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SUBROUTINE OUTPUT
COMMON /WORDS/ WORD
COMMON /DESIGN/
1 IDES ,JDES ,KDES ,MODE ,INIT ,IDUMP ,IAMTP ,IGASMX,
2 2IDBURN,IAFTBN,IDCD ,IMCD ,IDSHOC,IMSHOC,NOZFLT,[TRY5 ,
3 3LOOPER,NOMAP ,NUMMAP,MAPEDG,TOLALL,ERR(9)
4 COMMON /ALL1/
5 IPCNFGU,PCNCGU,T4GU ,DUMD1 ,DUMD2 ,DELFG ,DELFN ,DELSFC,
6 2ZFDS ,PCNFDS,PRFDS ,ETAFDS,WAFDS ,PRFCF ,ETAFCF,WAFCF ,
7 3ZCDS ,PCNCDS,PRCDS ,ETACDS,WACDS ,PRCCF ,ETACCF,WACCF ,
8 4T4DS ,WFBDS ,DTCODS,ETABDS,WA3CDS,DPCODS,DTCOCF,ETABCF,
9 5TFHPDS,CNHPS,ETHPDS,TFHPCF,CNHPCF,ETHPCF,DHHPCF,T2DS ,
10 6TFLPDS,CNLPDS,ETL PDS,TFLPCF,CNLPFC,ETLPCF,DHLPFC,T21DS ,
11 7T24DS ,WFDD ,DTDUDS,ETADDS,WA23DS,DPDUDS,DTDUCF,ETADCF,
12 8T7DS ,WFADS ,DTAFDS,ETAADS,WG6CDS,DPAFDS,DTAFCF,ETAACF,
13 9A55 ,A25 ,A6 ,A7 ,A8 ,A9 ,A28 ,A29 ,
14 $PS55 ,AM55 ,CVDNOZ,CVMNOZ,A8SAV ,A9SAV ,A28SAV,A29SAV
15 COMMON /ALL2/
16 IT1 ,P1 ,H1 ,S1 ,T2 ,P2 ,H2 ,S2 ,
17 2T21 ,P21 ,H21 ,S21 ,T3 ,P3 ,H3 ,S3 ,
18 3T4 ,P4 ,H4 ,S4 ,T5 ,P5 ,H5 ,S5 ,
19 4T55 ,P55 ,H55 ,S55 ,BLF ,BLC ,BLDU ,BLOB ,
20 5CNF ,PRF ,ETAF ,WAF ,WAF ,WA3 ,WG4 ,FAR4 ,
21 6CNC ,PRC ,ETAC ,WACC ,WAC ,ETAB ,DPCOM ,DUMP ,
22 7CNHP ,ETATHP,DHTCHP,DHTC ,BLHP ,WG5 ,FAR5 ,CS ,
23 8CNLP ,ETATLP,DHTCLP,DHTF ,BLLP ,WG55 ,FAR55 ,HPEXT ,
24 9AM ,ALTP ,ETAR ,ZF ,PCNF ,ZC ,PCNC ,WFB ,
25 $TFFHP ,TFFLP ,PCBLF ,PCBLC ,PCBLDU,PCBLOB,PCBLHP,PCBLLP
26 COMMON /ALL3/
27 1XP1 ,XWAF ,XWAC ,XBLF ,XBLDU ,XH3 ,DUMS1 ,DUMS2 ,
28 2XT21 ,XP21 ,XH21 ,XS21 ,T23 ,P23 ,H23 ,S23 ,
29 3T24 ,P24 ,H24 ,S24 ,T25 ,P25 ,H25 ,S25 ,
30 4T28 ,P28 ,H28 ,S28 ,T29 ,P29 ,H29 ,S29 ,
31 5WAD ,WFD ,WG24 ,FAR24 ,ETAD ,DPDUC ,BYPASS,DUMS3 ,
32 6TS28 ,PS28 ,V28 ,AM28 ,TS29 ,PS29 ,V29 ,AM29 ,
33 7XT55 ,XP55 ,XH55 ,XS55 ,XT25 ,XP25 ,XH25 ,XS25 ,
34 8XWFB ,XWG55 ,XFAR55 ,XWFD ,XWG24 ,XFAR24 ,XP1 ,DUMB ,
35 9T6 ,P6 ,H6 ,S6 ,T7 ,P7 ,H7 ,S7 ,
36 $T8 ,P8 ,H8 ,S8 ,T9 ,P9 ,H9 ,S9
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COMMON /ALL4/
1WG6 ,WFA ,WG7 ,FAR7 ,ETAA ,DPAFT ,V55 ,V25 ,
2PS6 ,V6 ,AM6 ,TS7 ,PS7 ,V7 ,AM7 ,AM25 ,
3TS8 ,PS8 ,V8 ,AM8 ,TS9 ,PS9 ,V9 ,AM9 ,
4VA ,FRD ,VJD ,FGMD ,VJM ,FGMM ,FGPD ,FGPM ,
5FGM ,FGP ,WFT ,WGT ,FART ,FG ,FN ,SFC ,
6WA32 ,DPWGDS,DPWING,WA32DS,A38 ,AM38 ,V38 ,T38 ,
7H38 ,P38 ,TS38 ,PS38 ,T39 ,H39 ,P39 ,TS39 ,
8V39 ,AM39 ,A39 ,BPRINT,WG37 ,CVDWNG,FGMWNG,FGPWNG,
9FNWING,FNMAIN,FWOVFN,PS39 ,FFOVFN,FCOVFN,FMNOFN,FNOVFD,
$VJW ,T22 ,P22 ,H22 ,S22 ,T50 ,P50 ,H50
COMMON /ALL5/
1S50 ,WA22 ,ZI ,PCNI ,CNI ,PRI ,ETAI ,WACI ,
2TFFIP ,CNIP ,ETATIP,DHTCIP,DHTI ,BLIP ,PCBLIP,PCNIGU,
3ZIDS ,PCNIDS,PRI DS ,ETAIDS,WAIDS ,PRICF ,ETAICF,WAICF ,
4TFIPDS,CNIPDS,ETIPDS,TFIPCF,CNIPCF,ETIPCF,DHIPCFC,WAICOS,
5WAI ,PCBLI ,BLI ,T22DS ,WA21 ,WG50 ,FAR50 ,A24 ,
6AM23 ,DUMSPL,FXFN2M,FXM2CP,AFTFAN,PUNT ,PCBLID,P6DSAV,
7AM6DSV,ETAASV,FAR7SV,T4PBL ,T41 ,FAN ,ISPOOL
COMMON /DYN/ ITRAN,TIME,DT,TF,JTRAN,NSTEP,TPRINT,DTPRNT
DIMENSION W(5,4),ANS1(80),ANS2(80),ANS3(80),ANS4(80),ANS5(80)
EQUIVALENCE (ANS1,PCNFGU),(ANS2,T1),(ANS3,XP1),(ANS4,WG6)
EQUIVALENCE (ANS5,S50)
LOGICAL FXFN2M,FXM2CP,AFTFAN,DUMSPL,FAN
DATA AWORD1,AWORD2/6HOUTPUT,6HCOMMON/
DATA (W(1,I),I=1,4)/6H SUBSON,6HIC C-D,6H NOZZL,6HE /
DATA (W(2,I),I=1,4)/6HSHOCK ,6HINSIDE,6H C-D N,6HNOZZLE /
DATA (W(3,I),I=1,4)/6HSHOCK ,6HOUTSID,6HE C-D ,6HNOZZLE/
DATA (W(4,I),I=1,4)/6H SUBSON,6HIC CON,6HVERG ,6HNOZZLE/
DATA (W(5,I),I=1,4)/6HSONIC ,6HCONVER,6HGENT N,6HNOZZLE /
TPRINT=TPRINT+DTPRNT
IF (ITRAN.EQ.1) WRITE (6,29) TIME
29 FORMAT(1HB,20X7H TIME=,F7.4)
WORD=AWORD1
IF (IDBURN.GT.0) GO TO 2
IF (IAFTBN.GT.0) GO TO 1
WRITE (6,7) WORD,AM,ALTP,T4,ETAR
GO TO 3
1 WRITE (6,8) WORD,AM,ALTP,T4,T7,ETAR
GO TO 3
2 WRITE (6,9) WORD,AM,ALTP,T4,T24,ETAR
3 IF (FXFN2M) WRITE (6,17)
IF (FXM2CP) WRITE (6,18)
IF (FAN) GO TO 25
WRITE(6,26) ISPOOL
26 FORMAT(1HO,14,15H SPOOL TURBOJET)
GO TO 27
25 IF (.NOT.FXFN2M.AND.(.NOT.FXM2CP).AND.(.NOT.DUMSPL)) WRITE(6,19)
IF (DUMSPL) WRITE (6,23)
IF (PCBLID.EQ.0.) WRITE (6,20)
IF (PCBLID.EQ.0..AND.AFTFAN) WRITE (6,21)
IF (PCBLID.NE.0..AND.AFTFAN) WRITE (6,22)
27 CALL CONOUT(2)
WRITE (6,10) (W(1,SHOC,I),I=1,4),FG,FN,SFC
IF (IGASMX.GT.0.OR..NOT.FAN) GO TO 4
WRITE (6,11) (W(1,SHOC,I),I=1,4)
4 WRITE (6,12) LOOPER
IF (IDES.NE.1) GO TO 5
WORD=AWORD2
WRITE (6,13) WORD,ZF,PCNF,ZI,PCNI,ZC,PCNC,T4,MODE
WRITE (6,14)
WRITE (6,15) (ANS1(I),I=1,80)
WRITE (6,14)
WRITE (6,15) (ANS2(I),I=1,80)
WRITE (6,14)
WRITE (6,15) (ANS3(I),I=1,80)
WRITE (6,14)
WRITE (6,15) (ANS4(I),I=1,80)
WRITE (6,14)
WRITE (6,15) (ANS5(I),I=1,55)
WRITE (6,14)
IF (IDES.EQ.1) GO TO 6
5 CONTINUE

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A8=A8SAV
A9=A9SAV
A28=A28SAV
A29=A29SAV
IF (IDUMP.NE.2) GO TO 6
WRITE (6,16)
CALL SYG (2)
CALL ENGBAL
RETURN
C
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7   FORMAT (1HB,A6,14X7H   AM=,F7.3,6X7H   ALTP=,F7.0,6X7H   T4=,F8.2
1,25X7H   ETAR=,F7.4)
8   FORMAT (1HB,A6,14X7H   AM=,F7.3,6X7H   ALTP=,F7.0,6X7H   T4=,F8.2
1,5X7H   T7=,F8.2,5X7H   ETAR=,F7.4)
9   FORMAT (1HB,A6,14X7H   AM=,F7.3,6X7H   ALTP=,F7.0,6X7H   T4=,F8.2
1,5X7H   T24=,F8.2,5X7H   ETAR=,F7.4)
10  FORMAT (6HOMAIN ,4A6,9X3HFG=,F9.2,18X4HSFC=,F8.5)
11  FORMAT (6H DUCT ,4A6)
12  FORMAT (16HOCONVERGED AFTER,I4,6H LOOPS,/,1H1)
13  FORMAT (1H ,A6,9X,7E15.6,I4)
14  FORMAT (1H )
15  FORMAT (1H ,8E15.6)
16  FORMAT (1H1)
17  FORMAT (65HOFAN AND MIDDLE SPOOL ARE ATTACHED , USE INNER AND OUTE
IR TURBINES)
18  FORMAT (74HOMIDDLE AND COMPRESSOR SPOOLS ARE ATTACHED , USE MIDDLE
1 AND OUTER TURBINES)
19  FORMAT (19HOTHREE SPOOL ENGINE)
20  FORMAT (21HONO AIRFLOW INTO WING)
21  FORMAT (1H+22X,14H, AFT-TURBOFAN)
22  FORMAT (14HO AFT-TURBOFAN)
23  FORMAT (22HOMIDDLE SPOOL IS DUMMY)
END

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$IBFTC PARABO
SUBROUTINE PARABO (X,Y,XD,YANS)
DIMENSION X(3),Y(3)
A=((X(1)-X(2))*(Y(1)-Y(3))-(X(1)-X(3))*(Y(1)-Y(2)))/((X(1)-X(2))*
IX(1)-X(3))*(X(3)-X(2)))
B=((X(1)**2-X(2)**2)*(Y(1)-Y(3))-(X(1)**2-X(3)**2)*(Y(1)-Y(2)))/((
IX(1)-X(2))*(X(1)-X(3))*(X(2)-X(3)))
D=(Y(1)*X(2)**2-Y(2)*X(1)**2-B*X(2)*X(1)*(X(2)-X(1)))/(X(2)**2-X(1
1)**2)
YANS=(A*XD+B)*XD+D
RETURN
END

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$IBFTC PERF
SUBROUTINE PERF
COMMON /WORDS/ WORD
COMMON /DESIGN/
1IDES ,JDES ,KDES ,MODE ,INIT ,IDUMP ,IAMTP ,IGASMX,
2IDURN ,IAFTBN ,IDCD ,IMCD ,IDSHOC ,IMSHOC ,NOZFLT ,ITRYS ,
3LOOPER ,NOMAP ,NUMMAP ,MAPEDG ,TOLALL ,ERR(9)
COMMON /ALL1/
1PCNFGU ,PCNCGU ,T4GU ,DUMD1 ,DUMD2 ,DELFG ,DELFN ,DELSFC,
2ZFDS ,PCNFDS ,PRFDS ,ETAFDS ,WAFDS ,PRFCF ,ETACCF ,WACCF ,
3ZCDS ,PCNCDS ,PRCDS ,ETACDS ,WACDS ,PRCCF ,ETACCF ,WACCF ,
4T4DS ,WFBDS ,DTCODS ,ETABDS ,WA3CDS ,DPCODS ,DTCOCF ,ETABCF ,
5TFHPDS ,CNHPDS ,ETHPDS ,TFHPCF ,CNHPCF ,ETHPCF ,DHPCF ,T2DS ,
6TFLPDS ,CNLPDS ,ETLPDS ,TFLPCF ,CNLPCF ,ETLPCF ,DHLPCF ,T21DS ,
7T24DS ,WFDDS ,DTODS ,ETADDS ,WA23DS ,DPDUDS ,DTDUCF ,ETADCF ,

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8T7DS ,WFADS ,DTAFDS,ETAADS,WG6CDS,DPAFDS,DTAFCF,ETAACF,
9A55 ,A25 ,A6 ,A7 ,A8 ,A9 ,A28 ,A29 ,
$P555 ,AM55 ,CVDNOZ,CVMNOZ,A8SAV ,A9SAV ,A28SAV,A29SAV
COMMON /ALL2/
1T1 ,P1 ,H1 ,S1 ,T2 ,P2 ,H2 ,S2 ,
2T21 ,P21 ,H21 ,S21 ,T3 ,P3 ,H3 ,S3 ,
3T4 ,P4 ,H4 ,S4 ,T5 ,P5 ,H5 ,S5 ,
4T55 ,P55 ,H55 ,S55 ,BLF ,BLC ,BLDU ,BLOB ,
5CNF ,PRF ,ETAF ,WAF ,WAF ,WA3 ,WG4 ,FAR4 ,
6CNC ,PRC ,ETAC ,WACC ,WAC ,ETAB ,DPCOM ,DUMP ,
7CNHP ,ETATHP,DHTCHP,DHTC ,BLHP ,WG5 ,FAR5 ,CS ,
8CNLP ,ETATLP,DHTCLP,DHTF ,BLLP ,WG55 ,FAR55 ,HPEXT ,
9AM ,ALTP ,ETAR ,ZF ,PCNF ,ZC ,PCNC ,WFB ,
$TFFHP ,TFFLP ,PCBLF ,PCBLC ,PCBLDU,PCBLOB,PCBLHP,PCBLLP
COMMON /ALL3/
1XP1 ,XWAF ,XWAC ,XBLF ,XBLDU ,XH3 ,DUMS1 ,DUMS2 ,
2XT21 ,XP21 ,XH21 ,XS21 ,T23 ,P23 ,H23 ,S23 ,
3T24 ,P24 ,H24 ,S24 ,T25 ,P25 ,H25 ,S25 ,
4T28 ,P28 ,H28 ,S28 ,T29 ,P29 ,H29 ,S29 ,
5WAD ,WFD ,WG24 ,FAR24 ,ETAD ,DPDUC ,BYPASS ,DUMS3 ,
6TS28 ,PS28 ,V28 ,AM28 ,T2S29 ,PS29 ,V29 ,AM29 ,
7XT55 ,XP55 ,XH55 ,XS55 ,XT25 ,XP25 ,XH25 ,XS25 ,
8XWFB ,XWG55 ,XFAR55 ,XWFD ,XWG24 ,XFAR24 ,XFP1 ,DUMB ,
9T6 ,P6 ,H6 ,S6 ,T7 ,P7 ,H7 ,S7 ,
$T8 ,P8 ,H8 ,S8 ,T9 ,P9 ,H9 ,S9
COMMON /ALL4/
1WG6 ,WFA ,WG7 ,FAR7 ,ETAA ,DPAFT ,V55 ,V25 ,
2PS6 ,V6 ,AM6 ,TS7 ,PS7 ,V7 ,AM7 ,AM25 ,
3TS8 ,PS8 ,V8 ,AM8 ,TS9 ,PS9 ,V9 ,AM9 ,
4VA ,FRD ,VJD ,FGMD ,VJM ,FGMM ,FGPD ,FGPM ,
5FGM ,FGP ,WFT ,WGT ,FART ,FG ,FN ,SFC ,
6WA32 ,DPWGDS,DPWING,WA32DS,A38 ,AM38 ,V38 ,T38 ,
7H38 ,P38 ,TS38 ,PS38 ,T39 ,H39 ,P39 ,TS39 ,
8V39 ,AM39 ,A39 ,BPRINT,WG37 ,CVDWNG,FGMWNG,FGPWNG,
9FNWING,FNMAIN,FWOVFN,PS39 ,FFOVFN,FCOVFN,FMNOFN,FNOVFD,
$VJW ,T22 ,P22 ,H22 ,S22 ,T50 ,P50 ,H50
COMMON /ALL5/
1S50 ,WA22 ,ZI ,PCNI ,CNI ,PRI ,ETAI ,WACI ,
2TFFIP ,CNIP ,ETATIP,DHTCIP,DHTI ,BLIP ,PCBLIP,PCNIGU,
3ZIDS ,PCNIDS,PRIDS ,ETAIDS,WAIDS ,PRICF ,ETAICF,WAICF ,
4TFIPDS,CNIPDS,ETIPDS,TFIPCF,CNIPCF,ETIPCF,DHIPCF,WAICDS,
5WAI ,PCBLI ,BLI ,T22DS ,WA21 ,WG50 ,FAR50 ,A24 ,
6AM23 ,DUMSPL,FXFN2M,FXM2CP,AFTFAN,PUNT ,PCBLID,P6DSAV,
7AM6DSV,ETAASV,FAR7SV,T4PBL ,T41 ,FAN ,ISPOOL
COMMON /DYN/ ITRAN,TIME,DT,TF,JTRAN,NSTEP,TPRINT,DTPRNT
COMMON/UNITS/SI
LOGICAL SI
LOGICAL AFTFAN,DUMSPL,FAN
DATA AWORD/6H PERF/
WORD=AWORD
IF (SI) GO TO 100
G=32.174049
CAPSF=2116.2170
GO TO 101
100 G=1.0
CAPSF=1.0
101 CONTINUE
WFT=WFB+WFD+WFA
WAT=WAF-BLOB
IF (AFTFAN) WAT=WAT+WAI
WGT=WAT+WFT
FART=WFT/WAT
VA=AM*CS
FRD=VA*WAF/G
IF (AFTFAN) FRD=VA*(WAF+WAI)/G
VJM=CVMNOZ*V9
FGMM=VJM*WG7/G
FGPM=CAPSF*(PS9-P1)*A9
IF (IGASMX.GT.0.OR..NOT.FAN) GO TO 1
VJD=CVDNOZ*V29
FGMD=VJD*WG24/G
FGPD=CAPSF*(PS29-P1)*A29
VJW=0.

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FGMNG=0.
FGPWNG=0.
FGWING=0.
FNWING=0.
IF (PCBLID.EQ.0.) GO TO 2
VJW=CVDWNG*V39
FGMNG=VJW*WG37/G
FGPWNG=CAPSF*(PS39-P1)*A39
FGWING=FGMNG+FGPWNG
FNWING=FGWING-VA*WA32/G
2 FGM=FGMM+FGMD+FGMNG
FGP=FGPM+FGPD+FGPWNG
FNMAIN=(FGMM+FGMD+FGPM+FGPD)-VA*(WAF-WA32)/G
IF (AFTFAN) FNMAIN=(FGMM+FGMD+FGPM+FGPD)-VA*(WAF+WAI-WA32)/G
FG=FGM+FGP
FN=FG-FRD
SFC=3600.*WFT/FN
FG=DELFG*FG
FN=DELFN*FN
SFC=DELSFC*SFC
FFAN=FGMD+FGPD-VA*WAD/G
FCORE=FNMAIN-FFAN
FFOVN=FFAN/FN
FCOVN=FCORE/FN
FWOVN=FNWING/FN
FMNOFN=FNMAIN/FN
IF (IDES.EQ.1) FDES=FN
FNOVFD=FN/FDES
IF (.NOT.DUMSPL) GO TO 3
PCNI=1.C
CNI=0.
3 IF (ITRAN.EQ.1.AND.TIME.LT.TPRINT) CALL ENGBAL
CALL OUTPUT
CALL ERROR
RETURN
END

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$IBFTC PROCOM
SUBROUTINE PROCOM (FARX,TEX,CSEX,AKEX,CPEX,REX,PHI,HEX)
COMMON/UNITS/SI
LOGICAL SI
C IF SI UNITS ARE USED, CONVERT TEX TO DEGREES RANKINE
IF (SI) TEX=TEX*9.0/5.0
IF (FARX.LE.0.067623) GO TO 1
FARX=0.067623
1 IF (TEX.GE.300.) GO TO 2
TEX=300.
2 IF (TEX.LE.4000.) GO TO 3
TEX=4000.
3 IF (FARX.GE.0.0) GO TO 4
FARX=0.0
C AIR PATH
4 CPA(((((((1.0115540E-25*TEX-1.4526770E-21)*TEX+7.6215767E-18)*TEX-
11.5128259E-14)*TEX-6.7178376E-12)*TEX+6.5519486E-08)*TEX-5.1536879
2E-05)*TEX+2.5020051E-01
HEA(((((((1.2644425E-26*TEX-2.0752522E-22)*TEX+1.2702630E-18)*TEX
1-3.0256518E-15)*TEX-1.6794594E-12)*TEX+2.1839826E-08)*TEX-2.576844
20E-05)*TEX+2.5020051E-01)*TEX-1.7558886E+00
SEA+2.5020051E-01*ALOG(TEX)+(((((((1.4450767E-26*TEX-2.4211288E-22
1)*TEX+1.5243153E-18)*TEX-3.7820648E-15)*TEX-2.2392790E-12)*TEX+3.2
2759743E-08)*TEX-5.1576879E-05)*TEX+4.5432300E-02
IF (FARX.LE.0.0) GO TO 5
C FUEL/AIR PATH
5 CPF(((((((7.2678710E-25*TEX-1.3335668E-20)*TEX+1.0212913E-16)*TEX-
14.2051104E-13)*TEX+9.9686793E-10)*TEX-1.3771901E-06)*TEX+1.2258630
2E-03)*TEX+7.3816638E-02
HEF(((((((9.0848388E-26*TEX-1.9050949E-21)*TEX+1.7021525E-17)*TEX
1-8.4102208E-14)*TEX+2.4921698E-10)*TEX-4.5906332E-07)*TEX+6.129315
20E-04)*TEX+7.3816638E-02)*TEX+3.0581530E+01

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SEF=+7.3816638E-02*ALOG(TEX)+((((11.0382670E-25*TEX-2.2226118E-21
1)*TEX+2.0425826E-17)*TEX-1.0512776E-13)*TEX+3.3228928E-10)*TEX-6.8
2859505E-07)*TEX+1.2258630E-03)*TEX+6.483398E-01
5 CPEX=(CPA+FARX*CPF)/(1.+FARX)
HEX=(HEA+FARX*HEF)/(1.+FARX)
PHI=(SEA+FARX*SEF)/(1.+FARX)
AMW=28.97-.946186*FARX
REX=1.986375/AMW
AKEX=CPEX/(CPEX-REX)
CSEX=SQRT(AKEX*REX*TEX*25031.37)
IF (SI) GO TO 100
GO TO 101
100 CPEX=CPEX*4185.7666
HEX=HEX*2325.4259
PHI=PHI*4185.7666
REX=REX*4185.7666
CSEX=CSEX*.3048
TEX=TEX*5.0/9.0
101 CONTINUE
RETURN
END

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\$IBFTC PUTIN

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SUBROUTINE PUTIN
COMMON /WORDS/ WORD
COMMON /DESIGN/
11DES ,JDES ,KDES ,MODE ,INIT ,IDUMP ,IAMTP ,IGSMX,
2IDBURN,IAFTBN,IDCD ,IMCD ,IDSHOC,IMSHOC,NOZFLT,ITRYS ,
3LOOPER,NOMAP ,NUMMAP,MAPEDG,TOLALL,ERR(9)
COMMON /ALL1/
1PCNFGU,PCNCGU,T4GU ,DUMD1 ,DUMD2 ,DELFG ,DELFN ,DELSFC,
2ZFDS ,PCNFDS,PRFDS ,ETAFDS,WAFFDS ,PRFCF ,ETAFCF,WAFCF ,
3ZCDS ,PCNCDS,PRCDS ,ETACDS,WACDS ,PRCCF ,ETACCF,WACCF ,
4T4DS ,WF8DS ,DTCODS,ETABOS,WA3CDS,DPCODS,DTCOCF,ETABCF,
5TFHPDS,CNHPDS,ETHPDS,TFLPCF,CNHPCF,ETHPCF,DHHPCF,T2DS ,
6TFLPDS,CNL PDS,ETL PDS,TFLPCF,CNLPCF,ETLPCF,DHLPDF,T21DS ,
7T24DS ,WFDDSD,DTDUDS,ETADDS,WA23DS,DPDUDS,DTDUCF,ETADCF,
8T77DS ,WFADS ,DTAFDS,ETAADS,WG6CDS,DPAFDS,DTAFCF,ETAACF,
9A55 ,A25 ,A6 ,A7 ,A8 ,A9 ,A28 ,A29 ,
$PS55 ,AM55 ,CVDNOZ,CVMNOZ,A8SAV ,A9SAV ,A28SAV,A29SAV
COMMON /ALL2/
1T1 ,P1 ,H1 ,S1 ,T2 ,P2 ,H2 ,S2 ,
2T21 ,P21 ,H21 ,S21 ,T3 ,P3 ,H3 ,S3 ,
3T4 ,P4 ,H4 ,S4 ,T5 ,P5 ,H5 ,S5 ,
4T55 ,P55 ,H55 ,S55 ,BLF ,BLC ,BLDU ,BLOB ,
5CNF ,PRF ,ETAF ,WAF ,WAF ,WAF ,WA3 ,WG4 ,FAR4 ,
6CNC ,PRC ,ETAC ,WACC ,WAC ,ETAB ,DPCOM ,DUMP ,
7CNHP ,ETATHP,DHTCHP,DHTC ,BLHP ,WG5 ,FAR5 ,CS ,
8CNLP ,ETATLP,DHTCLP,DHTF ,BLLP ,WG55 ,FAR55 ,HPEXT ,
9AM ,ALTP ,ETAR ,ZF ,PCNF ,ZC ,PCNC ,WFB ,
$TFFHP ,TFFLP ,PCBLF ,PCBLC ,PCBLDU,PCBLOB,PCBLHP,PCBLLP
COMMON /ALL3/
1XP1 ,XWAF ,XWAC ,XBLF ,XBLDU ,XH3 ,DUMS1 ,DUMS2 ,
2XT21 ,XP21 ,XH21 ,XS21 ,T23 ,P23 ,H23 ,S23 ,
3T24 ,P24 ,H24 ,S24 ,T25 ,P25 ,H25 ,S25 ,
4T28 ,P28 ,H28 ,S28 ,T29 ,P29 ,H29 ,S29 ,
5WAD ,WFD ,WG24 ,FAR24 ,ETAD ,DPDUC ,BYPASS,DUMS3 ,
6TS28 ,PS28 ,V28 ,AM28 ,TS29 ,PS29 ,V29 ,AM29 ,
7XT55 ,XP55 ,XH55 ,XS55 ,XT25 ,XP25 ,XH25 ,XS25 ,
8XWFB ,XWG55 ,XFAR55,XWFD ,XWG24 ,XFAR24,XXP1 ,DUMB ,
9T6 ,P6 ,H6 ,S6 ,T7 ,P7 ,H7 ,S7 ,
$T8 ,P8 ,H8 ,S8 ,T9 ,P9 ,H9 ,S9 ,
COMMON /ALL4/
1WG6 ,WFA ,WG7 ,FAR7 ,ETAA ,DPAFT ,V55 ,V25 ,
2PS6 ,V6 ,AM6 ,TS7 ,PS7 ,V7 ,AM7 ,AM25 ,
3TS8 ,PS8 ,V8 ,AM8 ,TS9 ,PS9 ,V9 ,AM9 ,
4VA ,FRD ,VJD ,FGMD ,VJM ,FGMM ,FGPD ,FGPH ,
5FGM ,FGP ,WFT ,WGT ,FART ,FG ,FN ,SFC ,
6WA32 ,DPMGDS,DPMING,WA32DS,A38 ,AM38 ,V38 ,T38 ,

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7H38 ,P38 ,TS38 ,PS38 ,T39 ,H39 ,P39 ,TS39 , 47
8V39 ,AM39 ,A39 ,BPRINT,WG37 ,CVDWNG,FGMWNG,FGPWNG, 48
9FNWNG,FNMAIN,FWOVFN,PS39 ,FFOVFN,FCOVFN,FMNOFN,FNOVFD, 49
$VJW ,T22 ,P22 ,H22 ,S22 ,T50 ,P50 ,H50 50
COMMON /ALL5/ 51
1S50 ,WA22 ,ZI ,PCNI ,CNI ,PRI ,ETAI ,WACI , 52
2TFFIP ,CNIP ,ETATIP,DHTCIP,DHTI ,BLIP ,PCBLIP,PCNIGU, 53
3ZIDS ,PCNIDS,PRIDS ,ETAIDS,WAIDS ,PRICF ,ETAICF,WAICF , 54
4TFIPDS,CNIPDS,ETIPDS,TFIPCF,CNIPCF,ETIPCF,DHIPCF,WAICDS, 55
5WAI ,PCBLI ,BLI ,T22DS ,WA21 ,WG50 ,FAR50 ,A24 , 56
6AM23 ,DUMSPL,FXFN2M,FXM2CP,AFTFAN,PUNT ,PCBLID,P6DSAV, 57
7AM6DSV,ETAASV,FAR7SV,T4PBL ,T41 ,FAN ,ISPOOL 58
COMMON /DELCH/ DELT1 59
COMMON /DYN/ ITRAN,TIME,DT,TF,JTRAN,NSTEP,TPRINT,DTPRNT 60
COMMON /RPM/ XNHPDS,XNIPDS,XNLPS,PMIHP,PMIIP,PMILP 61
COMMON /VOLS/ VFAN,VINTC,VCOMP,VCOMB,VHPTRB,VIPTRB,VLPTRB,VAFTBN, 62
1 VFDUCT,VWDUCT 63
COMMON /UNITS/ SI 64
LOGICAL ERRER,FXFN2M,FXM2CP,DUMSPL,AFTFAN,FAN,SI 65
DATA AWORD/6HPUTIN / 66
COMMON/LOOPPR/KKGO,PRFNEW,PRCNEW 67
DIMENSION XSAVE(405),XFILL(1) 68
EQUIVALENCE (XFILL,IDES) 69
COMMON/ERRER/ERRER 70
C *** IDES =1 FOR CALCULATING DESIGN POINT 71
C *** ITRAN =1 THIS POINT IS THE IC FOR A TRANSIENT 72
C *** MODE =0 FOR CONSTANT T4 73
C *** MODE =1 FOR CONSTANT PCNC 74
C *** MODE =2 FOR CONSTANT WFB 75
C *** MODE =3 FOR CONSTANT PCNF 76
C *** INIT =1 WILL NOT INITIALIZE POINT 77
C *** IDUMP =1 WILL DUMP LOOPING WRITE-OUTS IF ERROR OCCURS 78
C *** IDUMP =2 WILL DUMP LOOPING WRITE-OUTS AFTER EVERY POINT 79
C *** IAMTP =0 WILL USE INPUT AM AND MIL SPEC ETAR 80
C *** IAMTP =1 WILL USE INPUT AM AND INPUT ETAR 81
C *** IAMTP =2 WILL USE T1=T1+DELT1 AND STANDARD P1 82
C *** IAMTP =3 WILL USE P2 AND STANDARD T1 83
C *** IAMTP =4 WILL USE T2 AND P2 84
C *** IAMTP =5 WILL USE RAM2 FOR SPECIAL RECOVERY 85
C *** IGASMX=-1 SEPARATE FLOW, INPUT AM6 86
C *** IGASMX=0 SEPARATE FLOW, A6=A55 87
C *** IGASMX=1 WILL MIX DUCT AND MAIN STREAMS, A6=A25+A55 88
C *** IGASMX=2 WILL MIX DUCT AND MAIN STREAMS, INPUT AM6 89
C *** IDBURN=1 FOR DUCT BURNING, INPUT T24 90
C *** IDBURN=2 FOR DUCT BURNING, INPUT WFD 91
C *** IAFTBN=1 FOR AFTERBURNING, INPUT T7 92
C *** IAFTBN=2 FOR AFTERBURNING, INPUT WFA 93
C *** IDCD =1 DUCT NOZZLE WILL BE C-D 94
C *** IMCD =1 MAIN NOZZLE WILL BE C-D 95
C *** NOZFLT=1 FOR FLOATING MAIN NOZZLE 96
C *** NOZFLT=2 FOR FLOATING DUCT NOZZLE 97
C *** NOZFLT=3 FOR FLOATING MAIN AND DUCT NOZZLES 98
C *** ITRYS =N NUMBER OF PASSES THRU ENGINE BEFORE QUITTING 99
NAMELIST /DATAIN/ ISPOOL,FAN,SI,DELT1, 100
1IDES,MODE,IDUMP,IAMTP,IGASMX,IDBURN,IAFTBN,IDCD,IMCD,NOZFLT,ITRYS, 101
2FXFN2M,FXM2CP,AFTFAN,DUMSPL,TOLALL,DELFG,DELFN,DELSFC,PCNFDS,PRFDS 102
3,ETAFDS,PCNCDS,PRCDS,ETACDS,T4DS,WFBDS,ETABDS,DPCODS,ETHPDS,ETLPDS 103
4,DPDUDS,T7DS,ETAADS,DPAFDS,A6,A8,A28,PS55,AM55,CVDNOZ,CVMNOZ,T2,P2 104
5,T4,WAFCD,S,WACCD,S,HPEXT,AM,ALTP,ETAR,PCNF,PCNC,WFB,PCBLF,PCBLC, 105
6PCBLDU,PCBLOB,PCBLHP,PCBLLP,T24,ETAD,T7,WFA,ETAA,AM6,AM23,DPWGD,S, 106
7A38,PCNIDS,PCBLIP,ZFDS,ZCDS,ZIDS,PCBLID,TFHPDS,CNHPDS,TFIPDS, 107
8CNIPDS,TFLPDS,CNLPDS,PRIDS,ETAIDS,ETIPDS,WAICDS,PCBLI,CVDWNG, 108
9ITRAN,DTPRNT,TF,INIT,DT,XNHPDS,XNIPDS,XNLPS,PMIHP,PMIIP,PMILP, 109
1VFAN,VINTC,VCOMP,VCOMB,VHPTRB,VIPTRB,VLPTRB,VAFTBN,VFDUCT,VWDUCT 110
WORD=AWORD 111
ITRAN=0 112
JTRAN=0 113
TIME = 0.0 114
NSTEP = 0 115
TPRINT = 0.0 116
DTPRNT = 0.0 117
CALL ZERO 118
IF (KKGO.EQ.1) GO TO 5 119
IDES=0 120

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	READ (5,DATAIN)	121
	IF (ERRER.AND.IAFTBN.GT.0) GO TO 1	122
	IF (ERRER.AND.IDBURN.GT.0) GO TO 1	123
	IF (ERRER.AND.NOZFLT.GT.0) GO TO 1	124
	ERRER=.FALSE.	125
C	TABLE IS REFERENCED TO COMMON/ALL/FIRST ENTRY	126
	IF (IDES.EQ.0) GO TO 7	127
	IF (KKG0.NE.2) GO TO 3	128
	DO 2 I=1,397	129
2	XFILL(I)=XSAVE(I)	130
	READ (5,DATAIN)	131
3	CONTINUE	132
C	SAVE INPUT IN CASE OF LOOP ON PRESSURE RATIOS	133
	DO 4 I=1,397	134
4	XSAVE(I)=XFILL(I)	135
	GO TO 7	136
5	DO 6 I=1,397	137
6	XFILL(I)=XSAVE(I)	138
	WRITE (6,8) PRFDS,PRFNEW,PRCDS,PRCNEW	139
	PRCDS=PRCNEW	140
	PRFDS=PRFNEW	141
7	CONTINUE	142
	KKG0=2	143
	IF (IAFTBN.GT.0.OR.IDBURN.GT.0.CR.NOZFLT.GT.0) INIT=1	144
	IF (MODE.EQ.0) WRITE (8,9) IDES,AM,ALTP,T4,T24,T7	145
	IF (MODE.EQ.1) WRITE (8,10) IDES,AM,ALTP,PCNC,T24,T7	146
	IF (MODE.EQ.2) WRITE (8,11) IDES,AM,ALTP,WFB,T24,T7	147
	IF (IDES.EQ.1) WAFCD=WAFCDS	148
	IF (DUMSPL) WAICDS=WACCD	149
	IF (IDES.EQ.1) WACI=WAICDS	150
	IF (IDES.EQ.1) WACC=WACCD	151
	CALL COINLT	152
	RETURN	153
C		154
C		155
8	FORMAT (18HOCHANGE PRFDS FROM,F9.3,4H TO,F9.3,16H AND PRCDS FROM	156
	1,F10.3,4H TO,F10.3)	157
9	FORMAT (1H0,7H IDES=,I3,10X7H AM=,F7.3,6X7H ALTP=,F7.0,6X7H	158
1	T4=,F8.2,5X7H T24=,F8.2,5X7H T7=,F8.2,6H\$\$\$\$\$)	159
10	FORMAT (1H0,7H IDES=,I3,10X7H AM=,F7.3,6X7H ALTP=,F7.0,6X7H	160
1	PCNC=,F8.3,5X7H T24=,F8.2,5X7H T7=,F8.2,6H\$\$\$\$\$)	161
11	FORMAT (1H0,7H IDES=,I3,10X7H AM=,F7.3,6X7H ALTP=,F7.0,6X7H	162
1	WFB=,F8.4,5X7H T24=,F8.2,5X7H T7=,F8.2,6H\$\$\$\$\$)	163
	END	164

\$IBFTC RAM		1
	SUBROUTINE RAM (AM,ETAR)	2
	IF (AM.GT.1.) GO TO 2	3
	ETAR=1.	4
1	RETURN	5
2	IF (AM.GT.5.) GO TO 3	6
	ETAR=1.-0.075*((AM-1.)**1.35)	7
	GO TO 1	8
3	ETAR=800./((AM**4)+935.)	9
	GO TO 1	10
	END	

\$IBFTC RAM2		1
	SUBROUTINE RAM2 (AM,ETAR)	2
	DIMENSION PRINLT(15),FMN(15)	3
	DIMENSION Y(3),X(3)	4
	DATA FMN/0.,.1,.2,.3,.4,.5,.8,1.1,1.2,1.4,1.6,1.8,2.2,2.4,2.7/	5
	DATA PRINLT/.9,.932,.95,.961,.968,.97,.9701,.97,.9681,.958,.94.	6
	1.9181,.858,.8201,.75/	

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M=0
DO 1 J=1,15
1 IF (AM.GE.FMN(J)) M=J-1
IF (M.EQ.0) M=1
IF (M.GE.14) M=13
DO 2 I=1,3
MM=M-1+I
X(I)=FMN(MM)
2 Y(I)=PRINLT(MM)
CALL PARABO (X,Y,AM,ETAR)
RETURN
END

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$IBFTC ROLL
SUBROUTINE ROLL
COMMON/FOC/FO(50,4)
COMMON/SOC/SO(10,6)
COMMON/CDELAY/PDATA(5,50),TIMEPT(50)
DO 1 I=1,50
FO(I,2)=FO(I,1)
1 FO(I,4)=FO(I,3)
DO 2 I=1,10
SO(I,6)=SO(I,5)
SO(I,5)=SO(I,4)
SO(I,3)=SO(I,2)
2 SO(I,2)=SO(I,1)
DO 3 I=1,49
N1=51-I
NO=50-I
TIMEPT(N1)=TIMEPT(NO)
DO 3 J=1,5
3 PDATA(J,N1)=PDATA(J,NO)
RETURN
END

```

```

$IBFTC SEARCH
SUBROUTINE SEARCH (P,A,B,C,D,AX,NA,BX,CX,DX,NO,NAM,NOM,NCODE)
DIMENSION AX(NAM),BX(NAM,NOM),CX(NAM,NOM),DX(NAM,NOM),NO(NAM),Q(9)
C *** NEEDS SUBROUTINE AFQUIR
C *** AX AND BX MUST BE STORED LO TO HI
C *** P=INPUT PROPORTION BETWEEN 0.0 AND 1.0
C IF NOT INPUT, P MUST EQUAL -1.
C *** NCODE=00 OK
C NCODE=01 A LO
C NCODE=02 A HI
C NCODE=07 ERROR
C NCODE=10 B LO
C NCODE=20 B HI
NCODE=0
C=0.
D=0.
C *** FIND A
DO 1 I=1,NA
IH=I
1 IF (A.LT.AX(I)) GO TO 2
CONTINUE
IF (A.GT.AX(IH)) NCODE=2
A=AX(IH)
GO TO 3
2 IF (IH.GT.1) GO TO 3
NCODE=1
IH=2
A=AX(1)
3 IL=IH-1

```

	LIMH=NO(IH)	29
	LIML=NO(IL)	30
C ***	FIND B	31
	PRM=(A-AX(IL))/(AX(IH)-AX(IL))	32
	PP=P	33
	IF (P.GE.0.) GO TO 6	34
	BL=BX(IL,1)+PRM*(BX(IH,1)-BX(IL,1))	35
	BH=BX(IL,LIML)+PRM*(BX(IH,LIMH)-BX(IL,LIML))	36
	IF (B.GE.BL) GO TO 4	37
	NCODE=NCODE+10	38
	B=BL	39
	GO TO 5	40
4	IF (B.LE.BH) GO TO 5	41
	NCODE=NCODE+20	42
	BHM=BX(IL,LIML-1)+PRM*(BX(IH,LIMH-1)-BX(IL,LIML-1))	43
	CHM=CX(IL,LIML-1)+PRM*(CX(IH,LIMH-1)-CX(IL,LIML-1))	44
	DHM=DX(IL,LIML-1)+PRM*(DX(IH,LIMH-1)-DX(IL,LIML-1))	45
	CH=CX(IL,LIML)+PRM*(CX(IH,LIMH)-CX(IL,LIML))	46
	DH=DX(IL,LIML)+PRM*(DX(IH,LIMH)-DX(IL,LIML))	47
	CSLOPE=(CH-CHM)/(BH-BHM)	48
	DSLOPE=(DH-DHM)/(BH-BHM)	49
	C=CH+CSLOPE*(B-BH)	50
	D=DH+DSLOPE*(B-BH)	51
	RETURN	52
5	PP=0.5	53
	Q(2)=0.	54
	Q(3)=0.	55
6	BH=PP*(BX(IH,LIMH)-BX(IH,1))+BX(IH,1)	56
	BL=PP*(BX(IL,LIML)-BX(IL,1))+BX(IL,1)	57
	DO 7 J=2,LIMH	58
	JH=J	59
	IF (BH.LT.BX(IH,J)) GO TO 8	60
7	CONTINUE	61
8	JL=JH-1	62
	DO 9 K=2,LIML	63
	KH=K	64
	IF (BL.LT.BX(IL,K)) GO TO 10	65
9	CONTINUE	66
10	KL=KH-1	67
	PR=(BX(IH,JL)-BH)/(BX(IH,JH)-BX(IH,JL))	68
	CH=CX(IH,JL)-PR*(CX(IH,JH)-CX(IH,JL))	69
	DH=DX(IH,JL)-PR*(DX(IH,JH)-DX(IH,JL))	70
	PR=(BX(IL,KL)-BL)/(BX(IL,KH)-BX(IL,KL))	71
	CL=CX(IL,KL)-PR*(CX(IL,KH)-CX(IL,KL))	72
	DL=DX(IL,KL)-PR*(DX(IL,KH)-DX(IL,KL))	73
	BT=BL+PRM*(BH-BL)	74
	CT=CL+PRM*(CH-CL)	75
	DT=DL+PRM*(DH-DL)	76
	IF (P.GE.0.) GO TO 13	77
	DIR=SQRT(B/BT)	78
	ERR=(B-BT)/B	79
	CALL AFQUIR(Q(1),PP,ERR,0.,25.,0.001,DIR,PT,ICON)	80
	GO TO (11,13,12),ICON	81
11	PP=PT	82
	IF (PP.LT.0.) PP=0.	83
	IF (PP.GT.1.) PP=1.	84
	GO TO 6	85
12	NCODE=7	86
13	B=BT	87
	C=CT	88
	D=DT	89
	RETURN	90
	END	91

\$IBFTC	SYG	
	SUBROUTINE SYG (ICON)	1
	DIMENSION WORD(132)	2
	DATA ONEDOL/6H\$ /	3
	GO TO (1,2),ICON	4

1	END FILE 8	5
	REWIND 8	6
	RETURN	7
C	TERMINATE THE FILE	8
2	WRITE (8,10)	9
	END FILE 8	10
	REWIND 8	11
C	READ RECORD	12
3	READ (8,11) (WORD(I),I=1,132)	13
C	CHECK FOR 12 LEADING DOLLAR SIGNS	14
	DO 4 I=1,12	15
	IF (WORD(I)-ONEDOL) 5,4,5	16
4	CONTINUE	17
	RETURN	18
C	CHECK FOR 6 TRAILING DOLLAR SIGNS	19
5	DO 8 I=1,132	20
	I=I	21
	IF (WORD(I)-ONEDOL) 8,6,8	22
6	K=I+5	23
	DO 7 J=I,K	24
	IF (WORD(J)-ONEDOL) 8,7,8	25
7	CONTINUE	26
	GO TO 9	27
8	CONTINUE	28
	WRITE (6,12)	29
	RETURN	30
C	PRINT LINE	31
9	I=I-1	32
	WRITE (6,11) (WORD(M),M=1,I)	33
	GO TO 3	34
C		35
C		36
10	FORMAT (12H\$\$\$\$\$\$\$\$\$)	37
11	FORMAT (132A1)	38
12	FORMAT (1H0,12HERROR IN SYG)	39
	END	40

\$IBFTC	THCOMP	
	SUBROUTINE THCOMP (PR,ETA,T,H,S,P,TO,HQ,SO,PO)	1
	COMMON /UNITS/ SI	2
	LOGICAL SI	3
	CPG=.250	4
	IF (SI) CPG=1048.	5
	PO=P*PR	6
	TP=T*PR**0.28572	7
	DO 1 I=1,25	8
	CALL THERMO (PO,HP,TP,SP,X1,0,X2,0)	9
	DELS=SP-S	10
	IF (ABS(DELS).LE.0.00005*S) GO TO 2	11
1	TP=TP/EXP(DELS/CPG)	12
	CALL ERROR	13
2	HO=H+((HP-H)/ETA)	14
	CALL THERMO (PO,HQ,TO,SO,X1,0,X2,1)	15
	RETURN	16
	END	17

\$IBFTC	THERMO	
	SUBROUTINE THERMO (PX,HX,TX,SX,AMX,L,FAR,K)	1
	COMMON/UNITS/SI	2
	LOGICAL SI	3
	IF (SI) GO TO 100	4
	DEM=1.986375	5
	CPG=.250	6
	PSTD=1.0	7



GO TO 101	8
100 DEM=8316.41	9
CPG=1048.	10
PSTD=101325.	11
101 CONTINUE	12
FX=0.	13
IF (L.EQ.1) FX=FAR	14
IF (K.EQ.1) GO TO 1	15
CALL PROCOM (FX,TX,CS,AK,CP,R,PHI,HX)	16
GO TO 3	17
1 TX=HX/CPG	18
DO 2 I=1,15	19
CALL PROCOM (FX,TX,CS,AK,CP,R,PHI,H)	20
DELH=HX-H	21
IF (ABS(DELH).LE.0.00001*HX) GO TO 3	22
2 TX=TX+DELH/CPG	23
WRITE (8,4)	24
3 SX=PHI-R*ALOG(PX/PSTD)	25
AMX=DEM/R	26
RETURN	27
C	28
C	29
4 FORMAT (31HOND CONVERGENCE IN THERMO\$\$\$\$\$)	30
END	31

\$IBFTC THTURB	
SUBROUTINE THTURB (DH,ETA,FAR,H,S,P,TO,HO,SO,PO)	1
COMMON/UNITS/ZI	2
LOGICAL ZI	3
IF (ZI) GO TO 100	4
DEM=1.986375	5
GO TO 101	6
100 DEM=8316.41	7
101 CONTINUE	8
HO=H-DH	9
HOP=H-DH/ETA	10
PT=P/2.	11
DO 1 I=1,25	12
CALL THERMO (PT,HOP,TT,ST,AMWT,1,FAR,1)	13
DELS=ST-S	14
IF (ABS(DELS).LE.0.00005*S) GO TO 2	15
1 PT=P*EXP(DELS*AMWT/DEM+ALOG(PT/P))	16
CALL ERROR	17
2 PO=PT	18
CALL THERMO (PO,HO,TO,SO,X1,1,FAR,1)	19
RETURN	20
END	21

\$IBFTC WDUCTI	
SUBROUTINE WDUCTI	1
COMMON /WORDS/ WORD	2
COMMON /DESIGN/	3
1IDES ,JDES ,KDES ,MODE ,INIT ,IDUMP ,IAMTP ,IGASM,	4
2IDBURN,IAFTBN,IDCD ,IMCD ,IDSHOC,INSHOC,NOZFLT,ITRYS ,	5
3LOOPER,NOMAP ,NUMMAP,MAPEDG,TOLALL,ERR(9)	6
COMMON /ALL1/	7
1PCNFGU,PCNCGU,T4GU ,DUMD1 ,DUMD2 ,DELFG ,DELFN ,DELSFC,	8
2ZFDS ,PCNFDS,PRFDS ,ETAFDS,MAFDS ,PRFCF ,ETAFCF,MAFCF ,	9
3ZCDS ,PCNCDS,PRCDS ,ETACDS,WACDS ,PRCCF ,ETACCF,WACCF ,	10
4T4DS ,WF8DS ,DTCODS,ETABDS,WA3CDS ,DPCODS ,DTCOCF,ETABCF,	11
5TFHPDS,CNHPDS,ETHPDS,TFHPCF,CNHPCF,ETHPCF,DHHPCF,T2DS ,	12
6TFLPDS,CNLPDS,ETLPDS,TFLPCF,CNLPDF,ETLPCF,DHLPDF,T21DS ,	13
7T24DS ,WFDDSD ,DTDUOS,ETADDS,WA23DS ,DPDUOS ,DTDUCF,ETADCF,	14
8T7DS ,WFADS ,DTAFDS,ETAADS,WG6CDS ,DTAFCF,ETAACF,	15

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	9A55	,A25	,A6	,A7	,A8	,A9	,A28	,A29		16	
	\$PS55	,AM55	,CVDNOZ	,CVMNOZ	,ABSAV	,A9SAV	,A28SAV	,A29SAV		17	
	COMMON	/ALL2/								18	
	1T1	,P1	,H1	,S1	,T2	,P2	,H2	,S2		19	
	2T21	,P21	,H21	,S21	,T3	,P3	,H3	,S3		20	
	3T4	,P4	,H4	,S4	,T5	,P5	,H5	,S5		21	
	4T55	,P55	,H55	,S55	,BLF	,BLC	,BLDU	,BLOB		22	
	5CNF	,PRF	,ETAF	,WAF	,WAF	,WA3	,WG4	,FAR4		23	
	6CNC	,PRC	,ETAC	,WACC	,WAC	,ETAB	,OPCOM	,DUMP		24	
	7CNHP	,ETATHP	,DHTCHP	,DHTC	,BLHP	,WG5	,FAR5	,CS		25	
	8CNLP	,ETATLP	,DHTCLP	,DHTF	,BLLP	,WG55	,FAR55	,HPEXT		26	
	9AM	,ALTP	,ETAR	,ZF	,PCNF	,ZC	,PCNC	,WFB		27	
	\$TFFHP	,TFFLP	,PCBLF	,PCBLC	,PCBLDU	,PCBLOB	,PCBLHP	,PCBLLP		28	
	COMMON	/ALL3/								29	
	1XP1	,XWAF	,XWAC	,XBLF	,XBLDU	,XH3	,DUMS1	,DUMS2		30	
	2XT21	,XP21	,XH21	,XS21	,T23	,P23	,H23	,S23		31	
	3T24	,P24	,H24	,S24	,T25	,P25	,H25	,S25		32	
	4T28	,P28	,H28	,S28	,T29	,P29	,H29	,S29		33	
	5WAD	,WFD	,WG24	,FAR24	,ETAD	,DPDUC	,BYPASS	,DUMS3		34	
	6TS28	,PS28	,V28	,AM28	,TS29	,PS29	,V29	,AM29		35	
	7XT55	,XP55	,XH55	,XS55	,XT25	,XP25	,XH25	,XS25		36	
	8XWFB	,XWG55	,XFAR55	,XWFD	,XWG24	,XFAR24	,XXP1	,DUMB		37	
	9T6	,P6	,H6	,S6	,T7	,P7	,H7	,S7		38	
	\$T8	,P8	,H8	,S8	,T9	,P9	,H9	,S9		39	
	COMMON	/ALL4/								40	
	1WG6	,WFA	,WG7	,FAR7	,ETAA	,DPAFT	,V55	,V25		41	
	2PS6	,V6	,AM6	,TS7	,PS7	,V7	,AM7	,AM25		42	
	3TS8	,PS8	,V8	,AM8	,TS9	,PS9	,V9	,AM9		43	
	4VA	,FRD	,VJD	,FGMD	,VJM	,FGMM	,FGPD	,FGPM		44	
	5FGM	,FGP	,WFT	,WGT	,FART	,FG	,FN	,SFC		45	
	6WA32	,DPWGDS	,DPWING	,WA32DS	,A38	,AM38	,V38	,T38		46	
	7H38	,P38	,TS38	,PS38	,T39	,H39	,P39	,TS39		47	
	8V39	,AM39	,A39	,BPRINT	,WG37	,CVDWNG	,FGMWNG	,FGPWNG		48	
	9FNWING	,FNMAIN	,FNOVFN	,PS39	,FFOVFN	,FCOVFN	,FMNOFN	,FNOVFD		49	
	\$VJW	,T22	,P22	,H22	,S22	,T50	,P50	,H50		50	
	COMMON	/ALL5/								51	
	1S50	,WA22	,ZI	,PCNI	,CNI	,PRI	,ETAI	,WACI		52	
	2TFFIP	,CNIP	,ETATIP	,DHTCIP	,DHTI	,BLIP	,PCBLIP	,PCNIGU		53	
	3ZIDS	,PCNIDS	,PRIDS	,ETAIDS	,WAIDS	,PRICF	,ETAI CF	,WAICF		54	
	4TFIPDS	,CNIPDS	,ETIPDS	,TFIPCF	,CNIPCF	,ETIPCF	,DHIPCF	,WAICDS		55	
	5WAI	,PCBLI	,BLI	,T22DS	,WA21	,WG50	,FAR50	,A24		56	
	6AM23	,DUMSPL	,FXFN2M	,FXM2CP	,AFTFAN	,PUNT	,PCBLID	,P6DSAV		57	
	7AM6DSV	,ETAASV	,FAR7SV	,T4PBL	,T41	,FAN	,ISPOOL			58	
	COMMON	/VOLS/	VFAN	VINTC	VCOMP	VCOMB	VHPTRB	VI PTRB	VL PTRB	VAF TBN	59
	1	VFDUCT	VWDUCT								60
	COMMON	/UNITS/	SI								61
	LOGICAL	SI									62
	DATA	AWORD/6HWDUCTI/									63
	DIMENSION	Q(9)									64
	DIMENSION	XZERO(26)									65
	EQUIVALENCE	(XZERO,DPWING)									66
	WORD	=AWORD									67
	IF(SI)	GO TO 100									68
	RA	=.0252									69
	AJ	=2.719									70
	GO TO	101									71
100	RA	=286.9									72
	AJ	=1.0									73
101	CONTINUE										74
	IF(PCBLID.GT.0.)	GO TO 3									75
	XZERS	=CVDWNG									76
	DO 1 I=1,26										77
1	XZERO(I)	=0.0									78
	CVDWNG	=XZERS									79
	RETURN										80
3	CONTINUE										81
	P32	=P21									82
	H32	=H21									83
	T32	=T21									84
	BPRINT	=WA32/WAC									85
	WA32C	=WA32*SQRT(T32)/P32									86
	IF(IDES.EQ.1)	WA32DS=WA32C									87
	DPWING	=DPWGDS*WA32C/WA32DS									88

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DPWING=AMIN1(1.0,DPWING)
P36=P32*(1.-DPWING)
T36=T32
H36=H32
CALL THERMO (P36,H36,T36,S36,XX2,1,0.0,0)
WG37=WA32
T37=T36
P37=P36
H37=H36
S37=S36
IF (VWDUCT.EQ.0.0) GO TO 21
Q(2)=0.0
Q(3)=0.0
WG37P=WG37
H37P=H37
P37DOT=DERIV(22,P37)
18 CONTINUE
CALL THERMO(P37,H37,T37,S37,XX2,1,0.0,0)
WG37=WG37P-P37DOT*VWDUCT/T37/1.4/RA
U37=H37-RA*AJ*T37
U37DOT=DERIV(23,U37)
H37X=(WG37P*H37P-(WG37P-WG37)*U37-U37DOT*P37*VWDUCT/T37/RA)/WG37
ERRW=(H37-H37X)/H37
DIR=SQRT(ABS(H37/H37X))
CALL AFQUIR(Q(1),T37,ERRW,0.,20.,0.0001,DIR,T37T,IGO)
GO TO (19,21,20), IGO
19 T37=T37T
GO TO 18
20 CALL ERROR
21 CONTINUE
NOZD=0
CALL CONVRG (T37,H37,P37,S37,0.0,WG37,P1,IDES,A38,P38R,T38,H38,P38
1,S38,TS38,PS38,V38,AM38,ICON)
GO TO (5,5,5,4),ICON
4 CALL ERROR
5 T39=T38
H39=H38
P39=P38
S39=S38
TS39=TS38
V39=V38
AM39=AM38
A39=A38
PS39=PS38
IDSHOC=ICON+3
ERR(7)=(P38R-P38)/P38R
IF (IDES.EQ.1) WRITE (6,6) A38,AM38,A39,AM39
RETURN
C
C
6 FORMAT (18HINTER DUCT DESIGN,5X,8H A38=,E15.8,8H AM38=,E15.8
1,8H A39=,E15.8,8H AM39=,E15.8)
END

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$IBFTC ZERO
SUBROUTINE ZERO
COMMON /WORDS/ WORD
COMMON /DESIGN/
1IDES ,JDES ,KDES ,MODE ,INIT ,DUMP ,IAMTP ,IGASMX,
2IDBURN,IAFTBN,IDCD ,IMCD ,IDSHOC,IMSHOC,NOZFLT,ITRYS ,
3LOOPER,NOMAP ,NUMMAP,MAPEDG,TOLALL,ERR(9)
COMMON /ALL1/
1PCNFGU,PCNCGU,T4GU ,DUMD1 ,DUMD2 ,DELFG ,DELFN ,DELSFC,
2ZFDS ,PCNFDS,PRFDS ,ETAFDS,WAFFDS ,PRFCF ,ETAFCF,WAFCF ,
3ZCDS ,PCNCDS,PRCDS ,ETACDS,WACDS ,PRCCF ,ETACCF,WACCF ,
4T4DS ,WF8DS ,DTCODS,ETABDS,WA3CDS,DPCODS,DTCCOF,ETABCF,
5TFHPDS,CNHPDS,ETHPDS,TFHPCF,CNHPCF,ETHPCF,DHHPCF,T2DS ,
6TFLPDS,CNLPDS,ETL PDS,TFLPCF,CNLP CF,ETLPCF,DHLP CF,T21DS ,
7T24DS ,WFDD ,DTDUDS,ETADD,WA23DS,DPOUDS,DTDUCF,ETADCF,
8
9
10
11
12
13
14

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8T7DS ,WFAADS ,DTAFDS,ETAADS,WG6CDS,DPAFDS,DTAFCF,ETAACF,      15
9A55 ,A25 ,A6 ,A7 ,A8 ,A9 ,A28 ,A29 ,      16
$PS55 ,AM55 ,CVDNOZ,CVMNOZ,A8SAV ,A9SAV ,A28SAV,A29SAV      17
COMMON /ALL2/
1T1 ,P1 ,H1 ,S1 ,T2 ,P2 ,H2 ,S2 ,      18
2T21 ,P21 ,H21 ,S21 ,T3 ,P3 ,H3 ,S3 ,      19
3T4 ,P4 ,H4 ,S4 ,T5 ,P5 ,H5 ,S5 ,      20
4T55 ,P55 ,H55 ,S55 ,BLF ,BLC ,BLDU ,BLOB ,      21
5CNF ,PRF ,ETAF ,WAF ,WAF ,WA3 ,WG4 ,FAR4 ,      22
6CNC ,PRC ,ETAC ,WACC ,WAC ,ETAB ,DPCOM ,DUMP ,      23
7CNHP ,ETATHP,DHTCHP,DHTC ,BLHP ,WG5 ,FAR5 ,CS ,      24
8CNLP ,ETATLP,DHTCLP,DHTF ,BLLP ,WG55 ,FAR55 ,HPEXT ,      25
9AM ,ALTP ,ETAR ,ZF ,PCNF ,ZC ,PCNC ,WFB ,      26
$TFFHP ,TFFLP ,PCBLF ,PCBLC ,PCBLDU,PCBLOB,PCBLHP,PCBLLP      27
COMMON /ALL3/
1XP1 ,XWAF ,XWAC ,XBLF ,XBLDU ,XH3 ,DUMS1 ,DUMS2 ,      28
2XT21 ,XP21 ,XH21 ,XS21 ,T23 ,P23 ,H23 ,S23 ,      29
3T24 ,P24 ,H24 ,S24 ,T25 ,P25 ,H25 ,S25 ,      30
4T28 ,P28 ,H28 ,S28 ,T29 ,P29 ,H29 ,S29 ,      31
5WAD ,WFD ,WG24 ,FAR24 ,ETAD ,DPDUC ,BYPASS ,DUMS3 ,      32
6TS28 ,PS28 ,V28 ,AM28 ,TS29 ,V29 ,AM29 ,      33
7XT55 ,XP55 ,XH55 ,XS55 ,XT25 ,XP25 ,XH25 ,XS25 ,      34
8XWFB ,XWG55 ,XFAR55,XWFD ,XWG24 ,XFAR24,XXP1 ,DUMB ,      35
9T6 ,P6 ,H6 ,S6 ,T7 ,P7 ,H7 ,S7 ,      36
$T8 ,P8 ,H8 ,S8 ,T9 ,P9 ,H9 ,S9 ,      37
COMMON /ALL4/
1WG6 ,WFA ,WG7 ,FAR7 ,ETAA ,DPAFT ,V55 ,V25 ,      38
2PS6 ,V6 ,AM6 ,TS7 ,PS7 ,V7 ,AM7 ,AM25 ,      39
3TS8 ,PS8 ,V8 ,AM8 ,TS9 ,PS9 ,V9 ,AM9 ,      40
4VA ,FRD ,VJD ,FGMD ,VJM ,FGMM ,FGPD ,FGPM ,      41
5FGM ,FGP ,WFT ,WGT ,FART ,FG ,FN ,SFC ,      42
6WA32 ,DPWGD ,DPWING,WA32DS,A38 ,AM38 ,V38 ,T38 ,      43
7H38 ,P38 ,TS38 ,PS38 ,T39 ,H39 ,P39 ,TS39 ,      44
8V39 ,AM39 ,A39 ,BPRINT,WG37 ,CVDWNG,FGMWNG,FGPWNG,      45
9FNWING,FNMAIN,FNOVFN,PS39 ,FFOVFN,FCOVFN,FMNOFN,FNOVFD,      46
$VJW ,T22 ,P22 ,H22 ,S22 ,T50 ,P50 ,H50      47
COMMON /ALL5/
1S50 ,WA22 ,ZI ,PCNI ,CNI ,PRI ,ETAI ,WACI ,      48
2TFFIP ,CNIP ,ETATIP,DHTCIP,DHTI ,BLIP ,PCBLIP,PCNIGU,      49
3ZIDS ,PCNIDS,PRIDS ,ETAIDS,WAIDS ,PRICF ,ETAICF,WAICF ,      50
4TFIPDS,CNIPDS,ETIPDS,TFIPCF,CNIPCF,ETIPCF,OHIPCF,WAICDS,      51
5WAI ,PCBLI ,BLI ,T22DS ,WA21 ,WG50 ,FAR50 ,A24 ,      52
6AM23 ,DUMSPL,FXFN2M,FXM2CP,AFTFAN,PUNT ,PCBLID,P6DSAV,      53
7AM6DSV,ETAASV,FAR7SV,T4PBL ,T41 ,FAN ,ISPOOL      54
DIMENSION Z1(63),Z2(48),Z3(10),Z4(62)
EQUIVALENCE (Z1,T1),(Z2,XP1),(Z3,XT55),(Z4,XFAR55)
IDES=0      55
JDES=0      56
INIT=0      57
IOBURN=0      58
IAFTBN=0      59
IDSHOC=3      60
IMSHOC=3      61
NOZFLT=0      62
T2Q=T2      63
P2Q=P2      64
T4Q=T4      65
DO 1 I=1,63      66
1 Z1(I)=0.      67
DO 2 I=1,48      68
2 Z2(I)=0.      69
DO 3 I=1,10      70
3 Z3(I)=0.      71
DO 4 I=1,62      72
4 Z4(I)=0.      73
T2=T2Q      74
P2=P2Q      75
T4=T4Q      76
CALL SYG (1)      77
RETURN      78
END      79

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$IBFTC BLKCMF
C THIS IS GENERALIZED COMP. MAP FOR UNREALISTIC SUPERSONIC ENGINE
BLOCK DATA
COMMON / COMP/CN(15),PR(15,15),WAC(15,15),ETA(15,15),N,NP(15)
DATA N,NP/10,2*6,2*8,4*10,2*8,5*0/
DATA CN/.562,.674,.787,.899,1.,1.034,1.067,1.124,1.236,1.292,5*0./
DATA (PR( 1,J),WAC( 1,J),ETA( 1,J),J=1, 6)/
1 1.00000, 51.000, 0.59082, 1.84000, 50.200, 0.62178,
2 2.42800, 49.500, 0.64242, 2.86900, 48.800, 0.65274,
3 3.83500, 46.700, 0.67338, 4.54900, 44.500, 0.64242/
DATA (PR( 2,J),WAC( 2,J),ETA( 2,J),J=1, 6)/
1 1.00000, 59.300, 0.59082, 1.96600, 59.300, 0.64242,
2 3.09300, 58.800, 0.69402, 3.93300, 57.900, 0.72498,
3 4.68900, 56.700, 0.74562, 5.52900, 55.000, 0.72498/
DATA (PR( 3,J),WAC( 3,J),ETA( 3,J),J=1, 8)/
1 1.00000, 70.000, 0.58566, 1.84000, 70.000, 0.64242,
2 2.68000, 70.000, 0.68370, 3.40800, 69.500, 0.72498,
3 4.52100, 68.800, 0.77744, 5.44500, 67.900, 0.79292,
4 6.31300, 66.400, 0.77744, 6.52300, 65.700, 0.76970/
DATA (PR( 4,J),WAC( 4,J),ETA( 4,J),J=1, 8)/
1 1.00000, 84.800, 0.58050, 2.00800, 84.800, 0.64242,
2 3.42900, 84.800, 0.72498, 4.60500, 84.800, 0.77744,
3 5.69700, 84.000, 0.80840, 6.61400, 83.300, 0.82904,
4 7.53800, 81.700, 0.80840, 7.95800, 80.500, 0.79292/
DATA (PR( 5,J),WAC( 5,J),ETA( 5,J),J=1,10)/
1 1.00000, 101.700, 0.57190, 2.51900, 101.700, 0.64242,
2 3.98200, 101.700, 0.72498, 5.27700, 101.700, 0.77744,
3 6.48800, 101.200, 0.80840, 7.20200, 101.000, 0.83936,
4 8.00000, 100.000, 0.86000, 8.56700, 99.500, 0.83936,
5 9.38600, 98.100, 0.80840, 9.59600, 97.400, 0.80582/
DATA (PR( 6,J),WAC( 6,J),ETA( 6,J),J=1,10)/
1 1.00000, 108.100, 0.57018, 2.85500, 108.100, 0.64242,
2 4.29700, 108.100, 0.72498, 5.61300, 108.100, 0.77744,
3 6.93600, 107.600, 0.80840, 7.62200, 107.100, 0.83936,
4 8.54600, 106.700, 0.86000, 9.13400, 106.000, 0.83936,
5 9.92500, 104.500, 0.80840, 10.21900, 104.000, 0.80410/
DATA (PR( 7,J),WAC( 7,J),ETA( 7,J),J=1,10)/
1 1.00000, 114.500, 0.55986, 3.26100, 114.500, 0.64242,
2 4.75900, 114.500, 0.72498, 6.11700, 114.500, 0.77744,
3 7.45400, 114.500, 0.80840, 8.30800, 114.300, 0.83936,
4 9.21800, 113.600, 0.84968, 9.63800, 113.300, 0.83936,
5 10.51300, 112.600, 0.80840, 10.99600, 112.400, 0.79808/
DATA (PR( 8,J),WAC( 8,J),ETA( 8,J),J=1,10)/
1 1.00000, 122.900, 0.53922, 1.68600, 122.900, 0.57018,
2 3.84900, 122.900, 0.64242, 5.46600, 122.900, 0.72498,
3 6.86600, 122.900, 0.77744, 8.37100, 122.900, 0.80840,
4 8.96600, 122.600, 0.82388, 9.88300, 122.100, 0.83936,
5 10.91200, 121.700, 0.80840, 11.81500, 120.700, 0.77744/
DATA (PR( 9,J),WAC( 9,J),ETA( 9,J),J=1, 8)/
1 1.00000, 139.800, 0.47644, 4.35300, 139.800, 0.60114,
2 7.62200, 139.800, 0.72498, 10.21900, 139.800, 0.77744,
3 11.05900, 139.800, 0.78260, 11.89900, 139.500, 0.77744,
4 13.15900, 139.300, 0.72498, 13.65600, 139.000, 0.69918/
DATA (PR(10,J),WAC(10,J),ETA(10,J),J=1, 8)/
1 1.00000, 146.200, 0.46612, 3.76500, 146.200, 0.57018,
2 6.48100, 146.200, 0.64242, 9.17600, 146.200, 0.72498,
3 10.21900, 146.200, 0.75078, 11.47900, 146.200, 0.75078,
4 12.71100, 146.200, 0.72498, 14.41200, 146.200, 0.64242/
END

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$IBFTC BLKFAN
C THIS IS A GENERALIZED FAN MAP FOR UNREALISTIC SUPERSONIC ENGINE
BLOCK DATA
COMMON / FAN/CN(15),PR(15,15),WAC(15,15),ETA(15,15),N,NP(15)
DATA N,NP/10,6,3*7,5*10,8,5*0/
DATA CN/0.3,0.4,0.5,0.6,0.7,0.8,0.9,1.0,1.1,1.2,5*0./
DATA (PR( 1,J),WAC( 1,J),ETA( 1,J),J=1, 6)/
1 1.00000, 243.600, 0.75592, 1.01200, 229.800, 0.76120,

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2	1.02800,	199.800,	0.76648,	1.03840,	166.800,	0.75592,	8	
3	1.04480,	133.200,	0.72512,	1.04800,	86.400,	0.64152/	9	
	DATA (PR( 2,J),WAC( 2,J),ETA( 2,J),J=1, 7)/							10
1	1.00000,	286.800,	0.75592,	1.02000,	270.000,	0.77616,	11	
2	1.04000,	253.200,	0.79200,	1.05840,	233.400,	0.79728,	12	
3	1.07520,	209.400,	0.80256,	1.09200,	183.600,	0.77616,	13	
4	1.10000,	156.600,	0.74008/				14	
	DATA (PR( 3,J),WAC( 3,J),ETA( 3,J),J=1, 7)/							15
1	1.00000,	333.600,	0.75064,	1.02560,	322.800,	0.77616,	16	
2	1.05120,	310.200,	0.80256,	1.08000,	291.600,	0.82808,	17	
3	1.11600,	259.800,	0.84392,	1.13200,	240.000,	0.82808,	18	
4	1.14800,	213.600,	0.77616/				19	
	DATA (PR( 4,J),WAC( 4,J),ETA( 4,J),J=1, 7)/							20
1	1.00000,	383.400,	0.74536,	1.03680,	376.200,	0.77616,	21	
2	1.08800,	358.200,	0.82808,	1.12400,	340.200,	0.85448,	22	
3	1.16000,	313.200,	0.88000,	1.18960,	276.600,	0.82808,	23	
4	1.19520,	266.400,	0.80784/				24	
	DATA (PR( 5,J),WAC( 5,J),ETA( 5,J),J=1,10)/							25
1	1.00000,	439.800,	0.72512,	1.06400,	436.800,	0.77616,	26	
2	1.11840,	428.400,	0.82808,	1.14800,	420.600,	0.85448,	27	
3	1.18400,	406.800,	0.88000,	1.20960,	393.600,	0.90112,	28	
4	1.21760,	388.200,	0.90376,	1.22400,	383.400,	0.90112,	29	
5	1.24400,	368.400,	0.88000,	1.26720,	342.600,	0.82808/	30	
	DATA (PR( 6,J),WAC( 6,J),ETA( 6,J),J=1,10)/							31
1	1.00000,	499.800,	0.68816,	1.10000,	499.800,	0.77616,	32	
2	1.16000,	493.200,	0.82808,	1.20000,	485.400,	0.85448,	33	
3	1.22800,	476.400,	0.88000,	1.25520,	466.800,	0.90112,	34	
4	1.27200,	456.600,	0.91080,	1.28640,	448.200,	0.90112,	35	
5	1.30240,	433.200,	0.88000,	1.33200,	406.800,	0.82720/	36	
	DATA (PR( 7,J),WAC( 7,J),ETA( 7,J),J=1,10)/							37
1	1.00000,	566.400,	0.64152,	1.07600,	566.400,	0.72512,	38	
2	1.15200,	566.400,	0.77616,	1.21920,	559.800,	0.82808,	39	
3	1.26000,	553.200,	0.85888,	1.28960,	544.800,	0.88000,	40	
4	1.33120,	528.600,	0.90112,	1.36160,	509.400,	0.88000,	41	
5	1.39120,	483.600,	0.82808,	1.40000,	474.000,	0.81752/	42	
	DATA (PR( 8,J),WAC( 8,J),ETA( 8,J),J=1,10)/							43
1	1.00000,	633.600,	0.60016,	1.04400,	633.600,	0.64152,	44	
2	1.13520,	633.600,	0.72512,	1.22080,	633.000,	0.77616,	45	
3	1.29440,	625.800,	0.82808,	1.34000,	616.800,	0.85888,	46	
4	1.40000,	600.000,	0.88000,	1.42800,	586.800,	0.85888,	47	
5	1.44800,	576.600,	0.82808,	1.48000,	553.200,	0.78672/	48	
	DATA (PR( 9,J),WAC( 9,J),ETA( 9,J),J=1,10)/							49
1	1.00000,	700.200,	0.56936,	1.10400,	700.200,	0.64152,	50	
2	1.22000,	700.200,	0.72512,	1.32400,	700.200,	0.77616,	51	
3	1.40000,	700.200,	0.80256,	1.44800,	698.400,	0.80784,	52	
4	1.50000,	693.600,	0.80256,	1.53360,	683.400,	0.77616,	53	
5	1.56800,	666.600,	0.74536,	1.58400,	656.400,	0.72512/	54	
	DATA (PR(10,J),WAC(10,J),ETA(10,J),J=1, 8)/							55
1	1.00000,	750.000,	0.51744,	1.16320,	750.000,	0.64152,	56	
2	1.31200,	750.000,	0.72512,	1.40000,	750.000,	0.75592,	57	
3	1.48000,	750.000,	0.76120,	1.54000,	750.000,	0.75064,	58	
4	1.58000,	749.400,	0.72512,	1.66000,	736.800,	0.64152/	59	
	END							60

\$IBFTC BLKINT

C	THIS IS A GENERALIZED FAN MAP FOR UNREALISTIC SUPERSONIC ENGINE	1						
	BLOCK DATA	2						
	COMMON / INT / CN(15),PR(15,15),WAC(15,15),ETA(15,15),N,NP(15)	3						
	DATA N,NP/10,6,3*7,5*10,8,5*0/	4						
	DATA CN/0.3,0.4,0.5,0.6,0.7,0.8,0.9,1.0,1.1,1.2,5*0./	5						
	DATA (PR( 1,J),WAC( 1,J),ETA( 1,J),J=1, 6)/	6						
1	1.00000,	121.800,	0.75592,	1.01800,	114.900,	0.76120,	7	
2	1.04200,	99.900,	0.76648,	1.05760,	83.400,	0.75592,	8	
3	1.06720,	66.600,	0.72512,	1.07200,	43.200,	0.64152/	9	
	DATA (PR( 2,J),WAC( 2,J),ETA( 2,J),J=1, 7)/							10
1	1.00000,	143.400,	0.75592,	1.03000,	135.000,	0.77616,	11	
2	1.06000,	126.600,	0.79200,	1.08760,	116.700,	0.79728,	12	
3	1.11280,	104.700,	0.80256,	1.13800,	91.800,	0.77616,	13	
4	1.15000,	78.300,	0.74008/				14	

DATA (PR( 3,J),WAC( 3,J),ETA( 3,J),J=1, 7)/		15
1 1.00000, 166.800, 0.75064, 1.03840, 161.400, 0.77616,		16
2 1.07680, 155.100, 0.80256, 1.12000, 145.800, 0.82808,		17
3 1.17400, 129.900, 0.84392, 1.19800, 120.000, 0.82808,		18
4 1.22200, 106.800, 0.77616/		19
DATA (PR( 4,J),WAC( 4,J),ETA( 4,J),J=1, 7)/		20
1 1.00000, 191.700, 0.74536, 1.05520, 188.100, 0.77616,		21
2 1.13200, 179.100, 0.82808, 1.18600, 170.100, 0.85448,		22
3 1.24000, 156.600, 0.88000, 1.28440, 138.300, 0.82808,		23
4 1.29280, 133.200, 0.80784/		24
DATA (PR( 5,J),WAC( 5,J),ETA( 5,J),J=1,10)/		25
1 1.00000, 219.900, 0.72512, 1.09600, 218.400, 0.77616,		26
2 1.17760, 214.200, 0.82808, 1.22200, 210.300, 0.85448,		27
3 1.27600, 203.400, 0.88000, 1.31440, 196.800, 0.90112,		28
4 1.32640, 194.100, 0.90376, 1.33600, 191.700, 0.90112,		29
5 1.36600, 184.200, 0.88000, 1.40080, 171.300, 0.82808/		30
DATA (PR( 6,J),WAC( 6,J),ETA( 6,J),J=1,10)/		31
1 1.00000, 249.900, 0.68816, 1.15000, 249.900, 0.77616,		32
2 1.24000, 246.600, 0.82808, 1.30000, 242.700, 0.85448,		33
3 1.34200, 238.200, 0.88000, 1.38280, 233.400, 0.90112,		34
4 1.40800, 228.300, 0.91080, 1.42960, 224.100, 0.90112,		35
5 1.45360, 216.600, 0.88000, 1.49800, 203.400, 0.82720/		36
DATA (PR( 7,J),WAC( 7,J),ETA( 7,J),J=1,10)/		37
1 1.00000, 283.200, 0.64152, 1.11400, 283.200, 0.72512,		38
2 1.22800, 283.200, 0.77616, 1.32880, 279.900, 0.82808,		39
3 1.39000, 276.600, 0.85888, 1.43440, 272.400, 0.88000,		40
4 1.49680, 264.300, 0.90112, 1.54240, 254.700, 0.88000,		41
5 1.58680, 241.800, 0.82808, 1.60000, 237.000, 0.81752/		42
DATA (PR( 8,J),WAC( 8,J),ETA( 8,J),J=1,10)/		43
1 1.00000, 316.800, 0.60016, 1.06600, 316.800, 0.64152,		44
2 1.20280, 316.800, 0.72512, 1.33120, 316.500, 0.77616,		45
3 1.44160, 312.900, 0.82808, 1.51000, 308.400, 0.85888,		46
4 1.60000, 300.000, 0.88000, 1.64200, 293.400, 0.85888,		47
5 1.67200, 288.300, 0.82808, 1.72000, 276.600, 0.78672/		48
DATA (PR( 9,J),WAC( 9,J),ETA( 9,J),J=1,10)/		49
1 1.00000, 350.100, 0.56936, 1.15600, 350.100, 0.64152,		50
2 1.33000, 350.100, 0.72512, 1.48600, 350.100, 0.77616,		51
3 1.60000, 350.100, 0.80256, 1.67200, 349.200, 0.80784,		52
4 1.75000, 346.800, 0.80256, 1.80040, 341.700, 0.77616,		53
5 1.85200, 333.300, 0.74536, 1.87600, 328.200, 0.72512/		54
DATA (PR(10,J),WAC(10,J),ETA(10,J),J=1, 8)/		55
1 1.00000, 375.000, 0.51744, 1.24480, 375.000, 0.64152,		56
2 1.46800, 375.000, 0.72512, 1.60000, 375.000, 0.75592,		57
3 1.72000, 375.000, 0.76120, 1.81000, 375.000, 0.75064,		58
4 1.87000, 374.700, 0.72512, 1.99000, 368.400, 0.64152/		59
END		60

\$IBFTC CMBDT		1
BLOCK DATA		2
COMMON / COMB/PSI(15),DELT(15,15),ETA(15,15),N,NP(15)		3
DATA N,NP / 15,15*15 /		4
DATA PSI/4.9116,9.8232,14.735,19.646,24.558,29.470,34.381,		5
139.293,44.207,73.674,100.,200.,300.,400.,500./		6
DATA DELT/15*200.,15*300.,15*400.,15*500.,15*600.,15*700.,15*800.,		7
115*900.,15*1000.,15*1100.,15*1200.,15*1300.,15*1400.,15*1500.,		8
215*1600./		9
DATA ETA/		10
1.600,.758,.868,.925,.960,.988,9*1.00,		11
2.726,.825,.893,.936,.966,.991,9*1.00,		12
3.777,.858,.911,.946,.972,.992,9*1.00,		13
4.806,.875,.925,.955,.977,.994,9*1.00,		14
5.826,.888,.935,.933,.982,.995,9*1.00,		15
6.843,.898,.942,.969,.985,.997,9*1.00,		16
7.855,.906,.947,.974,.990,.998,9*1.00,		17
8.865,.912,.951,.977,.992,.999,9*1.00,		18
9.870,.914,.953,.978,.993,.999,.999,8*1.00,		19
A.870,.915,.953,.979,.995,.999,.999,8*1.00,		20
B.870,.915,.953,.979,.995,.999,.999,8*1.00,		21
C.870,.915,.953,.979,.995,.999,.999,8*1.00.		

D.870,.915,.953,.979,.995,.999,.999,8\*1.00,  
 E.870,.915,.953,.979,.995,.999,.999,8\*1.00,  
 F.870,.915,.953,.979,.995,.999,.999,8\*1.00/  
 END

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 23  
 24  
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\$IBFTC HPTDAT

BLOCK DATA  
 COMMON / HTURB/TFF(15),CN(15,15),DH(15,15),ETA(15,15),N,NP(15)  
 DATA N,NP/10,9\*15,12,5\*0/  
 DATA TFF / 39.670, 42.990, 47.460, 48.610, 49.175,  
 1 49.600, 50.000, 50.425, 50.920, 51.575, 5\*0./  
 DATA (CN( 1,J),DH( 1,J),ETA( 1,J),J=1,15)/  
 1 0.1872, 0.0032, 0.6219, 0.3372, 0.0057, 0.7078,  
 2 0.5156, 0.0084, 0.7868, 0.7128, 0.0108, 0.8090,  
 3 0.9382, 0.0133, 0.8090, 1.1442, 0.0152, 0.7963,  
 4 1.3138, 0.0164, 0.7779, 1.5382, 0.0174, 0.7422,  
 5 1.7264, 0.0179, 0.7078, 1.9324, 0.0176, 0.7635,  
 6 2.1500, 0.0167, 0.6068, 2.4058, 0.0144, 0.5309,  
 7 2.5892, 0.0120, 0.4773, 2.7862, 0.0082, 0.4045,  
 8 2.9460, 0.0034, 0.3034/  
 DATA (CN( 2,J),DH( 2,J),ETA( 2,J),J=1,15)/  
 1 0.1872, 0.0038, 0.6068, 0.3942, 0.0080, 0.7078,  
 2 0.5814, 0.0113, 0.8090, 0.7128, 0.0136, 0.8292,  
 3 0.8442, 0.0156, 0.8363, 0.9804, 0.0176, 0.8393,  
 4 1.1068, 0.0192, 0.8368, 1.2754, 0.0212, 0.8302,  
 5 1.4450, 0.0228, 0.8254, 1.7068, 0.0248, 0.8090,  
 6 1.9696, 0.0260, 0.7696, 2.2706, 0.0261, 0.7078,  
 7 2.6970, 0.0241, 0.6068, 3.0960, 0.0188, 0.5056,  
 8 3.3774, 0.0128, 0.4197/  
 DATA (CN( 3,J),DH( 3,J),ETA( 3,J),J=1,15)/  
 1 0.1872, 0.0046, 0.5764, 0.4362, 0.0100, 0.7078,  
 2 0.6568, 0.0144, 0.8090, 0.8726, 0.0184, 0.8494,  
 3 1.0696, 0.0216, 0.8543, 1.2382, 0.0240, 0.8515,  
 4 1.4638, 0.0268, 0.8494, 1.6882, 0.0292, 0.8409,  
 5 1.9696, 0.0316, 0.8262, 2.2138, 0.0331, 0.8090,  
 6 2.5520, 0.0344, 0.7579, 2.8050, 0.0346, 0.7078,  
 7 3.0392, 0.0340, 0.6652, 3.2648, 0.0324, 0.6068,  
 8 3.3774, 0.0312, 0.5865/  
 DATA (CN( 4,J),DH( 4,J),ETA( 4,J),J=1,15)/  
 1 0.1872, 0.0052, 0.5643, 0.2550, 0.0068, 0.6068,  
 2 0.4784, 0.0120, 0.7078, 0.6942, 0.0164, 0.8090,  
 3 0.9148, 0.0204, 0.8494, 1.1442, 0.0244, 0.8596,  
 4 1.3882, 0.0280, 0.8596, 1.5618, 0.0304, 0.8575,  
 5 1.8010, 0.0336, 0.8535, 1.9794, 0.0356, 0.8494,  
 6 2.2794, 0.0388, 0.8363, 2.5138, 0.0412, 0.8262,  
 7 2.8334, 0.0441, 0.8090, 3.1422, 0.0472, 0.7797,  
 8 3.3774, 0.0494, 0.7584/  
 DATA (CN( 5,J),DH( 5,J),ETA( 5,J),J=1,15)/  
 1 0.1872, 0.0056, 0.5562, 0.3000, 0.0088, 0.6068,  
 2 0.5254, 0.0144, 0.7078, 0.7500, 0.0192, 0.8090,  
 3 0.9754, 0.0236, 0.8494, 1.2754, 0.0288, 0.8697,  
 4 1.4824, 0.0321, 0.8696, 1.7638, 0.0360, 0.8662,  
 5 2.0450, 0.0400, 0.8615, 2.3362, 0.0444, 0.8555,  
 6 2.6450, 0.0496, 0.8520, 2.8706, 0.0540, 0.8494,  
 7 3.0764, 0.0596, 0.8494, 3.1520, 0.0640, 0.8532,  
 8 3.1618, 0.0661, 0.8570/  
 DATA (CN( 6,J),DH( 6,J),ETA( 6,J),J=1,15)/  
 1 0.1872, 0.0068, 0.5309, 0.3568, 0.0120, 0.6068,  
 2 0.6196, 0.0192, 0.7078, 0.8628, 0.0252, 0.8090,  
 3 1.0932, 0.0300, 0.8494, 1.2852, 0.0340, 0.8697,  
 4 1.5010, 0.0384, 0.8819, 1.6882, 0.0421, 0.8899,  
 5 1.9138, 0.0472, 0.8940, 2.1246, 0.0524, 0.8969,  
 6 2.2706, 0.0564, 0.8975, 2.4226, 0.0612, 0.8976,  
 7 2.4950, 0.0640, 0.8968, 2.5372, 0.0668, 0.8937,  
 8 2.5558, 0.0698, 0.8896/  
 DATA (CN( 7,J),DH( 7,J),ETA( 7,J),J=1,15)/  
 1 0.1872, 0.0080, 0.5062, 0.4314, 0.0164, 0.6068,  
 2 0.6844, 0.0236, 0.7078, 0.9568, 0.0308, 0.8090,  
 3 1.2010, 0.0372, 0.8494, 1.3834, 0.0416, 0.8697,

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4	1.5108,	0.0448,	0.8797,	1.6186,	0.0476,	0.8899,	64
5	1.7450,	0.0510,	0.8954,	1.8618,	0.0544,	0.9000,	65
6	1.9558,	0.0576,	0.9010,	2.0000,	0.0600,	0.9000,	66
7	2.0450,	0.0624,	0.8980,	2.0824,	0.0660,	0.8925,	67
8	2.1010,	0.0700,	0.8793/				68
	DATA (CN( 8,J),DH( 8,J),ETA( 8,J),J=1,15)/						69
1	0.1872,	0.0088,	0.5051,	0.4834,	0.0196,	0.6068,	70
2	0.7314,	0.0272,	0.7078,	0.8814,	0.0316,	0.7665,	71
3	1.0226,	0.0356,	0.8090,	1.1442,	0.0392,	0.8292,	72
4	1.2804,	0.0432,	0.8494,	1.3696,	0.0460,	0.8596,	73
5	1.4638,	0.0488,	0.8697,	1.5950,	0.0528,	0.8808,	74
6	1.6746,	0.0560,	0.8848,	1.7450,	0.0596,	0.8848,	75
7	1.8010,	0.0640,	0.8788,	1.8156,	0.0664,	0.8697,	76
8	1.8196,	0.0693,	0.8590/				77
	DATA (CN( 9,J),DH( 9,J),ETA( 9,J),J=1,15)/						78
1	0.1872,	0.0093,	0.4909,	0.3372,	0.0159,	0.5380,	79
2	0.5344,	0.0232,	0.6068,	0.6754,	0.0284,	0.6573,	80
3	0.8068,	0.0330,	0.7078,	0.9196,	0.0368,	0.7463,	81
4	1.0128,	0.0400,	0.7776,	1.1254,	0.0442,	0.8090,	82
5	1.2196,	0.0480,	0.8191,	1.3138,	0.0524,	0.8302,	83
6	1.3696,	0.0556,	0.8347,	1.4068,	0.0580,	0.8363,	84
7	1.4450,	0.0612,	0.8322,	1.4638,	0.0640,	0.8241,	85
8	1.4676,	0.0668,	0.8090/				86
	DATA (CN(10,J),DH(10,J),ETA(10,J),J=1,12)/						87
1	0.1872,	0.0132,	0.4257,	0.2814,	0.0180,	0.4747,	88
2	0.3804,	0.0228,	0.5056,	0.4686,	0.0268,	0.5359,	89
3	0.5628,	0.0314,	0.5683,	0.6382,	0.0352,	0.5941,	90
4	0.6892,	0.0380,	0.6068,	0.7362,	0.0412,	0.6178,	91
5	0.7696,	0.0440,	0.6240,	0.8068,	0.0476,	0.6310,	92
6	0.8254,	0.0504,	0.6265,	0.8304,	0.0530,	0.6118/	93
	END						94

\$IBFTC IPTDAT

	BLOCK DATA						1
	COMMON / ITURB / TFF(15),CN(15,15),DH(15,15),ETA(15,15),N,NP(15)						2
	DATA N,NP/11,9*15,12,9,4*0/						3
	DATA TFF / 70.776, 82.236, 93.468, 103.464, 112.836,						4
1	116.580, 120.000, 122.676, 125.124, 127.824, 130.536,4*0./						5
	DATA (CN( 1,J),DH( 1,J),ETA( 1,J),J=1,15)/						6
1	0.3522,	0.0016,	0.7120,	0.5104,	0.0023,	0.7300,	7
2	0.7044,	0.0031,	0.7472,	0.9330,	0.0038,	0.7300,	8
3	1.1618,	0.0045,	0.7140,	1.3556,	0.0049,	0.7000,	9
4	1.5497,	0.0052,	0.6850,	1.6905,	0.0054,	0.6730,	10
5	1.9367,	0.0055,	0.6452,	2.1835,	0.0054,	0.6200,	11
6	2.3593,	0.0051,	0.6000,	2.5001,	0.0047,	0.5750,	12
7	2.6941,	0.0038,	0.5310,	2.8175,	0.0031,	0.5000,	13
8	3.1698,	0.0001,	0.3850/				14
	DATA (CN( 2,J),DH( 2,J),ETA( 2,J),J=1,15)/						15
1	0.3522,	0.0023,	0.8000,	0.5278,	0.0035,	0.8100,	16
2	0.7575,	0.0047,	0.8200,	1.0208,	0.0061,	0.8300,	17
3	1.2322,	0.0070,	0.8300,	1.3818,	0.0076,	0.8290,	18
4	1.6201,	0.0084,	0.8100,	1.8130,	0.0089,	0.8000,	19
5	1.9723,	0.0092,	0.7850,	2.1305,	0.0094,	0.7600,	20
6	2.2715,	0.0095,	0.7450,	2.5089,	0.0093,	0.7000,	21
7	2.7471,	0.0089,	0.6800,	2.9227,	0.0083,	0.6450,	22
8	3.1698,	0.0068,	0.5900/				23
	DATA (CN( 3,J),DH( 3,J),ETA( 3,J),J=1,15)/						24
1	0.3522,	0.0027,	0.8000,	0.5654,	0.0045,	0.8300,	25
2	0.8279,	0.0063,	0.8600,	1.0296,	0.0076,	0.8630,	26
3	1.1975,	0.0087,	0.8670,	1.3730,	0.0098,	0.8700,	27
4	1.5497,	0.0107,	0.8720,	1.7609,	0.0118,	0.8720,	28
5	1.9367,	0.0126,	0.8700,	2.1479,	0.0134,	0.8670,	29
6	2.3245,	0.0139,	0.8600,	2.4827,	0.0142,	0.8500,	30
7	2.6583,	0.0146,	0.8300,	2.9227,	0.0147,	0.8000,	31
8	3.1698,	0.0145,	0.7600/				32
	DATA (CN( 4,J),DH( 4,J),ETA( 4,J),J=1,15)/						33
1	0.3522,	0.0029,	0.7995,	0.4052,	0.0034,	0.8000,	34
2	0.6514,	0.0054,	0.8400,	0.8452,	0.0069,	0.8600,	35
3	1.0567,	0.0084,	0.8680,	1.2322,	0.0097,	0.8730,	36

4	1.4434,	0.0111,	0.8800,	1.6722,	0.0124,	0.8830,	37	
5	1.9540,	0.0140,	0.8835,	2.1131,	0.0146,	0.8830,	38	
6	2.2715,	0.0153,	0.8800,	2.4915,	0.0161,	0.8740,	39	
7	2.7471,	0.0168,	0.8600,	2.9931,	0.0172,	0.8350,	40	
8	3.1698,	0.0173,	0.8200/				41	
	DATA (CN( 5,J),DH( 5,J),ETA( 5,J),J=1,15)/							42
1	0.3522,	0.0031,	0.7750,	0.4844,	0.0043,	0.8000,	43	
2	0.7044,	0.0062,	0.8480,	0.9330,	0.0081,	0.8600,	44	
3	1.2322,	0.0105,	0.8750,	1.4967,	0.0124,	0.8900,	45	
4	1.6548,	0.0136,	0.8912,	1.8834,	0.0152,	0.8940,	46	
5	2.0071,	0.0159,	0.8955,	2.1652,	0.0169,	0.8970,	47	
6	2.3274,	0.0178,	0.8961,	2.5531,	0.0189,	0.8900,	48	
7	2.8175,	0.0199,	0.8790,	3.0461,	0.0207,	0.8671,	49	
8	3.1698,	0.0210,	0.8600/				50	
	DATA (CN( 6,J),DH( 6,J),ETA( 6,J),J=1,15)/							51
1	0.3522,	0.0034,	0.7600,	0.5896,	0.0057,	0.8000,	52	
2	0.8008,	0.0076,	0.8450,	1.0567,	0.0100,	0.8600,	53	
3	1.2322,	0.0114,	0.8730,	1.4619,	0.0134,	0.8900,	54	
4	1.6722,	0.0150,	0.8950,	1.8660,	0.0165,	0.9000,	55	
5	2.1171,	0.0184,	0.9005,	2.3245,	0.0199,	0.9010,	56	
6	2.5357,	0.0214,	0.9004,	2.7375,	0.0228,	0.9000,	57	
7	3.0019,	0.0251,	0.8900,	3.1167,	0.0267,	0.8800,	58	
8	3.1698,	0.0280,	0.8735/				59	
	DATA (CN( 7,J),DH( 7,J),ETA( 7,J),J=1,15)/							60
1	0.3522,	0.0038,	0.7310,	0.7392,	0.0078,	0.8000,	61	
2	0.9689,	0.0101,	0.8300,	1.2109,	0.0124,	0.8600,	62	
3	1.4089,	0.0142,	0.8750,	1.6056,	0.0159,	0.8900,	63	
4	1.7609,	0.0173,	0.8930,	1.9367,	0.0190,	0.8975,	64	
5	2.0948,	0.0207,	0.8999,	2.2000,	0.0220,	0.9000,	65	
6	2.2889,	0.0233,	0.8980,	2.3949,	0.0250,	0.8937,	66	
7	2.4471,	0.0261,	0.8900,	2.5001,	0.0276,	0.8799,	67	
8	2.5175,	0.0290,	0.8710/				68	
	DATA (CN( 8,J),DH( 8,J),ETA( 8,J),J=1,15)/							69
1	0.3522,	0.0042,	0.7100,	0.5808,	0.0069,	0.7450,	70	
2	0.7575,	0.0090,	0.7680,	0.9330,	0.0109,	0.8000,	71	
3	1.1801,	0.0135,	0.8380,	1.3915,	0.0156,	0.8600,	72	
4	1.5671,	0.0177,	0.8712,	1.7609,	0.0199,	0.8780,	73	
5	1.8660,	0.0213,	0.8800,	1.9897,	0.0230,	0.8775,	74	
6	2.0601,	0.0241,	0.8760,	2.1131,	0.0251,	0.8722,	75	
7	2.1652,	0.0263,	0.8660,	2.2009,	0.0276,	0.8600,	76	
8	2.2048,	0.0283,	0.8480/				77	
	DATA (CN( 9,J),DH( 9,J),ETA( 9,J),J=1,15)/							78
1	0.3522,	0.0047,	0.6780,	0.5278,	0.0070,	0.7000,	79	
2	0.6340,	0.0084,	0.7125,	0.7922,	0.0104,	0.7350,	80	
3	0.9689,	0.0124,	0.7690,	1.1183,	0.0141,	0.8000,	81	
4	1.1801,	0.0148,	0.8060,	1.3209,	0.0166,	0.8225,	82	
5	1.4619,	0.0184,	0.8395,	1.5497,	0.0196,	0.8450,	83	
6	1.6722,	0.0214,	0.8470,	1.7609,	0.0232,	0.8445,	84	
7	1.8130,	0.0245,	0.8330,	1.8315,	0.0255,	0.8235,	85	
8	1.8401,	0.0267,	0.8080/				86	
	DATA (CN(10,J),DH(10,J),ETA(10,J),J=1,12)/							87
1	0.3522,	0.0054,	0.6380,	0.4574,	0.0069,	0.6550,	88	
2	0.6167,	0.0092,	0.6700,	0.7218,	0.0107,	0.6850,	89	
3	0.8279,	0.0123,	0.7000,	0.9330,	0.0138,	0.7110,	90	
4	1.0567,	0.0159,	0.7180,	1.1493,	0.0177,	0.7180,	91	
5	1.2148,	0.0191,	0.7170,	1.2505,	0.0202,	0.7140,	92	
6	1.2784,	0.0214,	0.7000,	1.2824,	0.0221,	0.6890/	93	
	DATA (CN(11,J),DH(11,J),ETA(11,J),J=1, 9)/							94
1	0.3522,	0.0061,	0.6000,	0.4226,	0.0075,	0.6000,	95	
2	0.5278,	0.0093,	0.6120,	0.6167,	0.0108,	0.6170,	96	
3	0.7044,	0.0124,	0.6210,	0.7922,	0.0140,	0.6258,	97	
4	0.8452,	0.0151,	0.6250,	0.8983,	0.0164,	0.6230,	98	
5	0.9293,	0.0177,	0.6009/				99	
	END							100

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$IBFTC LPTDAT
BLOCK DATA
COMMON / LTURB/TFF(15),CN(15,15),DH(15,15),ETA(15,15),N,NP(15)
DATA N,NP/11,9*15,12,9,4*0/

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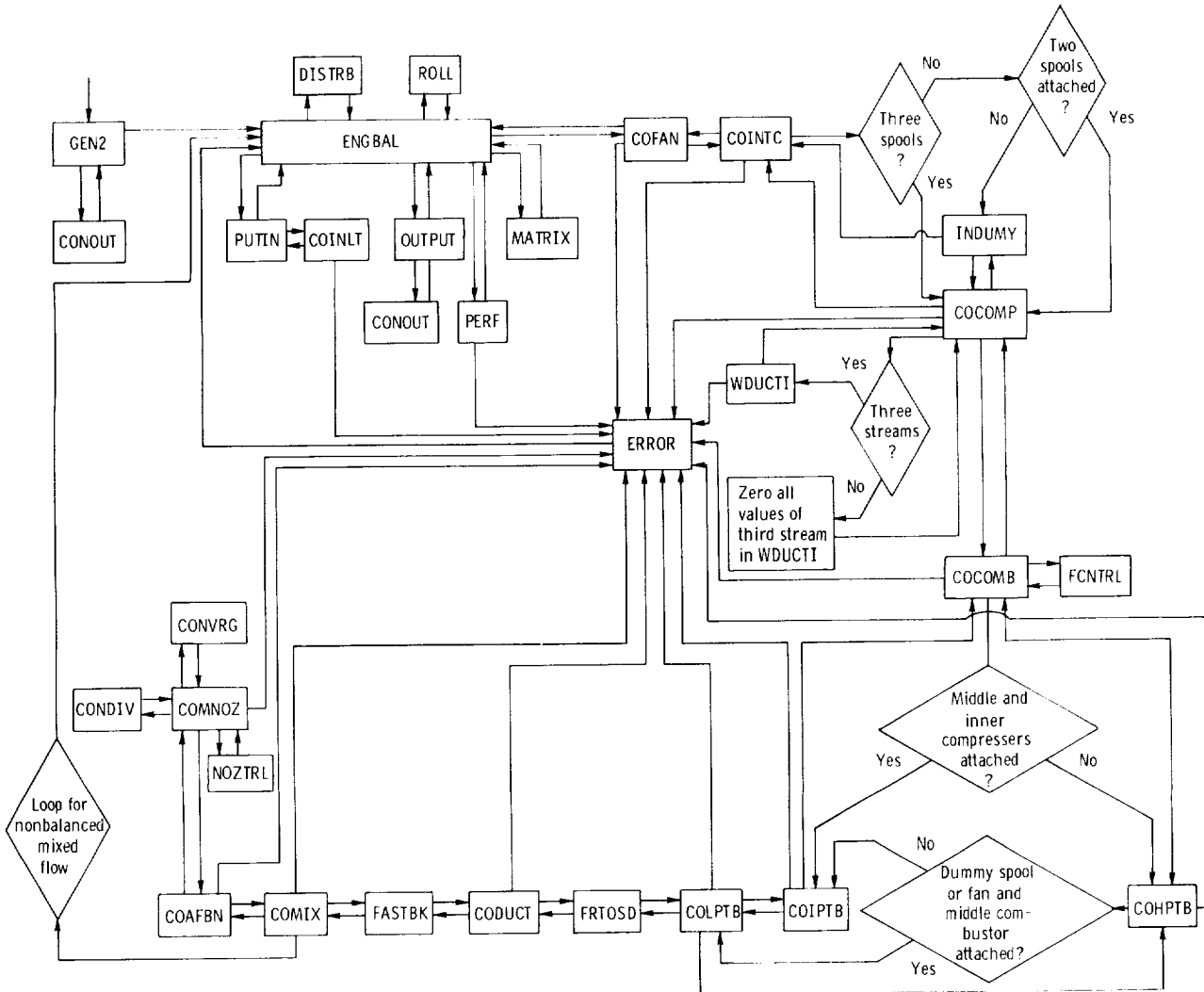
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DATA TFF /	88.470,	102.795,	116.835,	129.330,	141.045,		4
1 145.725,	150.000,	153.345,	156.405,	159.780,	163.170,4*0- /		5
DATA (CN( 1,J),DH( 1,J),ETA( 1,J),J=1,15) /							6
1 0.3682,	0.0018,	0.7120,	0.5336,	0.0026,	0.7300,		7
2 0.7365,	0.0035,	0.7472,	0.9754,	0.0044,	0.7300,		8
3 1.2146,	0.0051,	0.7140,	1.4173,	0.0056,	0.7000,		9
4 1.6201,	0.0059,	0.6850,	1.7673,	0.0061,	0.6730,		10
5 2.0247,	0.0062,	0.6452,	2.2827,	0.0061,	0.6200,		11
6 2.4665,	0.0057,	0.6000,	2.6137,	0.0053,	0.5750,		12
7 2.8166,	0.0044,	0.5310,	2.9456,	0.0035,	0.5000,		13
8 3.3138,	0.0001,	0.3850 /					14
DATA (CN( 2,J),DH( 2,J),ETA( 2,J),J=1,15) /							15
1 0.3682,	0.0026,	0.8000,	0.5518,	0.0039,	0.8100,		16
2 0.7919,	0.0054,	0.8200,	1.0672,	0.0069,	0.8300,		17
3 1.2882,	0.0080,	0.8300,	1.4446,	0.0087,	0.8290,		18
4 1.6937,	0.0096,	0.8100,	1.8954,	0.0101,	0.8000,		19
5 2.0619,	0.0104,	0.7850,	2.2273,	0.0107,	0.7600,		20
6 2.3747,	0.0108,	0.7450,	2.6229,	0.0106,	0.7000,		21
7 2.8720,	0.0101,	0.6800,	3.0555,	0.0094,	0.6450,		22
8 3.3138,	0.0077,	0.5900 /					23
DATA (CN( 3,J),DH( 3,J),ETA( 3,J),J=1,15) /							24
1 0.3682,	0.0031,	0.8000,	0.5911,	0.0051,	0.8300,		25
2 0.8655,	0.0071,	0.8600,	1.0764,	0.0087,	0.8630,		26
3 1.2519,	0.0099,	0.8670,	1.4354,	0.0111,	0.8700,		27
4 1.6201,	0.0122,	0.8720,	1.8409,	0.0134,	0.8720,		28
5 2.0247,	0.0143,	0.8700,	2.2455,	0.0152,	0.8670,		29
6 2.4302,	0.0157,	0.8600,	2.5956,	0.0162,	0.8500,		30
7 2.7791,	0.0166,	0.8300,	3.0555,	0.0167,	0.8000,		31
8 3.3138,	0.0164,	0.7600 /					32
DATA (CN( 4,J),DH( 4,J),ETA( 4,J),J=1,15) /							33
1 0.3682,	0.0033,	0.7995,	0.4237,	0.0038,	0.8000,		34
2 0.6810,	0.0061,	0.8400,	0.8837,	0.0078,	0.8600,		35
3 1.1047,	0.0096,	0.8680,	1.2882,	0.0110,	0.8730,		36
4 1.5090,	0.0126,	0.8800,	1.7482,	0.0141,	0.8830,		37
5 2.0429,	0.0159,	0.8835,	2.2091,	0.0166,	0.8830,		38
6 2.3747,	0.0174,	0.8800,	2.6047,	0.0183,	0.8740,		39
7 2.8720,	0.0191,	0.8600,	3.1291,	0.0195,	0.8350,		40
8 3.3138,	0.0197,	0.8200 /					41
DATA (CN( 5,J),DH( 5,J),ETA( 5,J),J=1,15) /							42
1 0.3682,	0.0036,	0.7750,	0.5065,	0.0049,	0.8000,		43
2 0.7365,	0.0071,	0.8480,	0.9754,	0.0092,	0.8600,		44
3 1.2882,	0.0119,	0.8750,	1.5647,	0.0141,	0.8900,		45
4 1.7301,	0.0155,	0.8912,	1.9690,	0.0172,	0.8940,		46
5 2.0983,	0.0181,	0.8955,	2.2637,	0.0192,	0.8970,		47
6 2.4332,	0.0202,	0.8961,	2.6691,	0.0214,	0.8900,		48
7 2.9456,	0.0226,	0.8790,	3.1846,	0.0235,	0.8671,		49
8 3.3138,	0.0239,	0.8600 /					50
DATA (CN( 6,J),DH( 6,J),ETA( 6,J),J=1,15) /							51
1 0.3682,	0.0038,	0.7600,	0.6164,	0.0064,	0.8000,		52
2 0.8372,	0.0087,	0.8450,	1.1047,	0.0113,	0.8600,		53
3 1.2882,	0.0130,	0.8730,	1.5283,	0.0152,	0.8900,		54
4 1.7482,	0.0171,	0.8950,	1.9509,	0.0187,	0.9000,		55
5 2.2133,	0.0209,	0.9005,	2.4302,	0.0226,	0.9010,		56
6 2.6510,	0.0244,	0.9004,	2.8619,	0.0259,	0.9000,		57
7 3.1384,	0.0286,	0.8900,	3.2584,	0.0303,	0.8800,		58
8 3.3138,	0.0319,	0.8735 /					59
DATA (CN( 7,J),DH( 7,J),ETA( 7,J),J=1,15) /							60
1 0.3682,	0.0044,	0.7310,	0.7728,	0.0089,	0.8000,		61
2 1.0129,	0.0115,	0.8300,	1.2659,	0.0141,	0.8600,		62
3 1.4729,	0.0162,	0.8750,	1.6785,	0.0181,	0.8900,		63
4 1.8409,	0.0197,	0.8930,	2.0247,	0.0216,	0.8975,		64
5 2.1901,	0.0235,	0.8999,	2.3000,	0.0250,	0.9000,		65
6 2.3929,	0.0265,	0.8980,	2.5038,	0.0284,	0.8937,		66
7 2.5583,	0.0296,	0.8900,	2.6137,	0.0314,	0.8799,		67
8 2.6319,	0.0329,	0.8710 /					68
DATA (CN( 8,J),DH( 8,J),ETA( 8,J),J=1,15) /							69
1 0.3682,	0.0048,	0.7100,	0.6072,	0.0078,	0.7450,		70
2 0.7919,	0.0102,	0.7680,	0.9754,	0.0124,	0.8000,		71
3 1.2337,	0.0153,	0.8380,	1.4548,	0.0177,	0.8600,		72
4 1.6383,	0.0201,	0.8712,	1.8409,	0.0226,	0.8780,		73
5 1.9509,	0.0242,	0.8800,	2.0801,	0.0261,	0.8775,		74
6 2.1537,	0.0274,	0.8760,	2.2091,	0.0285,	0.8722,		75
7 2.2637,	0.0299,	0.8660,	2.3009,	0.0314,	0.8600,		76
8 2.3051,	0.0321,	0.8480 /					77

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DATA (CN( 9,J),DH( 9,J),ETA( 9,J),J=1,15)/							78
1	0.3682,	0.0054,	0.6780,	0.5518,	0.0080,	0.7000,	79
2	0.6629,	0.0096,	0.7125,	0.8282,	0.0119,	0.7350,	80
3	1.0129,	0.0141,	0.7690,	1.1691,	0.0160,	0.8000,	81
4	1.2337,	0.0169,	0.8060,	1.3809,	0.0188,	0.8225,	82
5	1.5283,	0.0209,	0.8395,	1.6201,	0.0223,	0.8450,	83
6	1.7482,	0.0244,	0.8470,	1.8409,	0.0263,	0.8445,	84
7	1.8954,	0.0279,	0.8330,	1.9147,	0.0289,	0.8235,	85
8	1.9237,	0.0303,	0.8080/				86
DATA (CN(10,J),DH(10,J),ETA(10,J),J=1,12)/							87
1	0.3682,	0.0061,	0.6380,	0.4782,	0.0078,	0.6550,	88
2	0.6447,	0.0104,	0.6700,	0.7546,	0.0122,	0.6850,	89
3	0.8655,	0.0139,	0.7000,	0.9754,	0.0157,	0.7110,	90
4	1.1047,	0.0181,	0.7180,	1.2015,	0.0201,	0.7180,	91
5	1.2701,	0.0217,	0.7170,	1.3073,	0.0230,	0.7140,	92
6	1.3365,	0.0244,	0.7000,	1.3407,	0.0251,	0.6890/	93
DATA (CN(11,J),DH(11,J),ETA(11,J),J=1, 9)/							94
1	0.3682,	0.0069,	0.6000,	0.4418,	0.0086,	0.6000,	95
2	0.5518,	0.0106,	0.6120,	0.6447,	0.0123,	0.6170,	96
3	0.7365,	0.0141,	0.6210,	0.8282,	0.0159,	0.6258,	97
4	0.8837,	0.0172,	0.6250,	0.9391,	0.0186,	0.6230,	98
5	0.9715,	0.0201,	0.6009/				99
END							100

# Flow Chart of DYNGEN



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## DYNGEN Subroutine Functions and Their Descriptions

AFQUIR	general quadratic interpolation routine
ATMOS	1962 U.S. Standard Atmosphere Table
BLKCOMP	performance data for inner-compressor map (BLOCK DATA)
BLKFAN	performance data for fan map (BLOCK DATA)
BLKINT	performance data for intermediate-compressor map (BLOCK DATA)
CMBDT	BLOCK DATA for combustor
COAFBN	performs afterburning calculations; may use either T7 or WFA as main parameter
COCOMB	uses BLOCK DATA to perform combustor calculations; may use either T <sub>4</sub> or WFB as main parameter
COCOMP	uses BLOCK DATA to perform inner-compressor calculations
CODUCT	performs duct and ductburning calculations for turbofans; may use either T24 or WFD as main parameter
COFAN	uses BLOCK DATA to perform fan calculations
COHPTB	uses BLOCK DATA to perform inner-turbine calculations (not used in engine configurations c and g)
COINLT	determines ram recovery and performs inlet calculations
COINTC	uses BLOCK DATA to perform intermediate-compressor calculations
COIPTB	uses BLOCK DATA to perform intermediate-turbine calculations (not used in engine configurations b, e, and h)
COLPTB	uses BLOCK DATA to perform outer-turbine calculations
COMIX	performs gas-mixing calculations if in mixed-flow mode; at design points, calculates areas either from an input static pressure PS55 or from an input Mach number AM55 if PS55=0; at off-design points, calculates static pressures and Mach numbers from design areas; calculates ERR (5); rescales pressure ratios for mixed-flow turbofans to match duct and core static pressures just prior to mixing; also calculates afterburner entrance area A6 as a function of afterburner entrance Mach number AM6
COMNOZ	performs main nozzle calculations
CONDIV	performs nozzle calculations for a convergent-divergent (C-D) nozzle

CONOUT	controls and prints the controlled output variables
CONVRG	performs nozzle calculations for a convergent nozzle
DERIV	computes time derivatives
DISTRB	user-written subroutine which provides transient inputs
ENGBAL	main subroutine; controls all engine balancing loops; checks tolerances and number of loops and loads matrix; calls PUTIN
ERROR	controls all printouts if an error occurs; prints names of subroutine where error occurred and also prints values of all variables in main commons
ETAAB	generalized afterburner performance BLOCK DATA as a function of fuel-air ratio with correction factors for off-design afterburner entrance pressure and Mach number
FASTBK	dummy routine to transfer values
FCNTRL	user-written fuel control subroutine
FRTOSD	dummy routine to transfer values
GEN2	dummy main program to initiate calculations and cause input of controlled output variables (Because of looping between subroutines, control is never transferred back to this routine.)
GUESS	determines initial values of independent variables at each point
HPTDAT	performance data for inner-turbine map (BLOCK DATA)
INDUMY	makes intermediate compressor not change air conditions for engine configurations e and h
IPTDAT	performance data for intermediate-turbine map (BLOCK DATA)
LPTDAT	performance data for outer-turbine map (BLOCK DATA)
MATRIX	solves error matrix
NOZCTR	user-written nozzle control subroutine
OUTPUT	prints output except for controlled output; prints main commons after design point
OVERFL	IBM 7094 system routine for flagging overflows (User's system may have similar routine with different name. This routine is called in ATMOS as OVERFL(J), where if J=1 there is overflow and if J=2 there is no overflow.)
PARABO	parabolic curve-fit routine

PERF	calculates performance after engine is balanced
PROCOM	calculates thermodynamic gas properties for either air or a fuel-air mixture based on JP-4
PUTIN	reads input data; controls loop on static pressures for mixed-flow turbofan
RAM	calculates ram recovery defined by MIL-E-5008B specifications
RAM2	calculates special cases of input ram recovery as a function of flight Mach number
ROLL	saves past values of dynamic variables needed for calculating derivatives, etc.
SEARCH	general table lookup and interpolation routine to obtain data from BLOCK DATA subroutines
SYG	controls printing from UNIT08 (Throughout the program and particularly in ENGBAL, certain messages, variables, and matrix values are written on UNIT08 as an aid in determining why an error occurred or why a point did not balance. These values are printed out if subroutine ERROR is called and IDUMP is greater than zero, or after a good point if IDUMP=2.)
THERMO	provides thermodynamic conditions using PROCOM
THCOMP	performs isentropic calculations for compressors
THTURB	performs isentropic calculations for turbines
WDUCTI	performs third-stream (wing) duct calculations (not used in two-stream engines)
ZERO	zeros nearly all of common and certain controls

#### Example Case - Three-Spool Turbofan

In order to aid the user in understanding all that must be provided so that DYNGEN can be used, a three-spool turbofan example case is shown. As indicated in table I, all BLOCK DATA subroutines are needed for this engine configuration (a). The BLOCK DATA for the engine simulated are listed on pages 93 to 100. Next, subroutines DISTRB, FCNTRL, and NOZCTR must be written. For this example, an open-loop fuel flow step is to be simulated. Subroutine DISTRB is written as follows:



\$IBFTC DISTRB

SUBROUTINE DISTRB

COMMON /WORDS/ WORD

COMMON /DESIGN/

1IDFS ,JDES ,KDES ,MODE ,INIT ,IDUMP ,IAMTP ,IGASMX,  
2IDBURN,IAFTBN,IDCD ,IMCO ,IDSHOC,IMSHOC,NOZFLT,ITRYS ,  
3LOOPER,NOMAP ,NUMMAP,MAPEOG,TOLALL,ERR(9)

COMMON /ALL1/

1PCNFGU,PCNCGU,T4GU ,DUMD1 ,DUMD2 ,DELFG ,DELFN ,DELSFC,  
2ZFDS ,PCNFDS,PRFDS ,ETAFDS,WAFFDS ,PRFCF ,ETAFCF,WAFCF ,  
3ZCDS ,PCNCDS,PRCDS ,ETACDS,WACDS ,PRCCF ,ETACCF,WACCF ,  
4T4DS ,WFBDS ,DTCODS,ETABDS,WA3CDS,CPCODS,DTCOCF,ETABCF,  
5TFHPDS,CNHPS,ETHPDS,TFHPCF,CNHPCF,ETHPCF,DHHPCF,T2DS ,  
6TFLPDS,CNLPDS,ETLPDS,TFLPCF,CNLPDF,ETLPDF,DHLPDF,T2IDS ,  
7T24DS ,WFDOS ,DTDUDS,ETADDS,WA23DS,DPDUDS,DTDUCF,ETADCF,  
8T7DS ,WFAOS ,DTAFOS,ETAADS,WG6CDS,CPAFOS,DTAFCF,ETAACF,  
9A55 ,A25 ,A6 ,A7 ,A8 ,A9 ,A28 ,A29 ,  
\$PS55 ,AM55 ,CVDNOZ,CVMNOZ,A8SAV ,A9SAV ,A28SAV,A29SAV

COMMON /ALL2/

1T1 ,P1 ,H1 ,S1 ,T2 ,P2 ,H2 ,S2 ,  
2T21 ,P21 ,H21 ,S21 ,T3 ,P3 ,H3 ,S3 ,  
3T4 ,P4 ,H4 ,S4 ,T5 ,P5 ,H5 ,S5 ,  
4T55 ,P55 ,H55 ,S55 ,BLF ,BLC ,BLDU ,BLOB ,  
5CNF ,PRF ,ETAF ,WAF ,WAF ,WA3 ,WG4 ,FAR4 ,  
6CNC ,PRC ,ETAC ,WACC ,WAC ,ETAB ,DPCOM ,DUMP ,  
7CNHP ,ETATHP,DHTCHP,DHTC ,BLHP ,WG5 ,FAR5 ,CS ,  
8CNLP ,ETATLP,DHTCLP,DHTF ,BLLP ,WG55 ,FAR55 ,HPEXT ,  
9AM ,ALTP ,ETAR ,ZF ,PCNF ,ZC ,PCNC ,WFB ,  
\$TFFHP ,TFFLP ,PCBLF ,PCBLC ,PCBLDU,PCBLOB,PCBLHP,PCBLLP

COMMON /ALL3/

1XP1 ,XWAF ,XWAC ,XBLF ,XBLDU ,XH3 ,DUMS1 ,DUMS2 ,  
2XT21 ,XP21 ,XH21 ,XS21 ,T23 ,P23 ,H23 ,S23 ,  
3T24 ,P24 ,H24 ,S24 ,T25 ,P25 ,H25 ,S25 ,  
4T28 ,P28 ,H28 ,S28 ,T29 ,P29 ,H29 ,S29 ,  
5WAD ,WFD ,WG24 ,FAR24 ,ETAD ,DPDUC ,BYPASS,DUMS3 ,  
6TS28 ,PS28 ,V28 ,AM28 ,TS29 ,PS29 ,V29 ,AM29 ,  
7XT55 ,XP55 ,XH55 ,XS55 ,XT25 ,XP25 ,XH25 ,XS25 ,  
8XWFB ,XWG55 ,XFAR55,XWFD ,XWG24 ,XFAR24,XXP1 ,DUMB ,  
9T6 ,P6 ,H6 ,S6 ,T7 ,P7 ,H7 ,S7 ,  
\$T8 ,P8 ,H8 ,S8 ,T9 ,P9 ,H9 ,S9

COMMON /ALL4/

1WG6 ,WFA ,WG7 ,FAR7 ,ETAA ,CPAFT ,V55 ,V25 ,  
2PS6 ,V6 ,AM6 ,TS7 ,PS7 ,V7 ,AM7 ,AM25 ,  
3TS8 ,PS8 ,V8 ,AM8 ,TS9 ,PS9 ,V9 ,AM9 ,  
4VA ,FRD ,VJD ,FGMD ,VJM ,FGMM ,FGPD ,FGPM ,  
5FGM ,FGP ,WFT ,WGT ,FART ,FG ,FN ,SFC ,  
6WA32 ,DPWGD,DPWING,WA32DS,A38 ,AM38 ,V38 ,T38 ,  
7H38 ,P38 ,TS38 ,PS38 ,T39 ,H39 ,P39 ,TS39 ,  
8V39 ,AM39 ,A39 ,BPRINT,WG37 ,CVDWNG,FGMWNG,FGPWNG,  
9FNWING,FNMAIN,FWOVFN,PS39 ,FFOVFN,FCOVFN,FMNOFN,FNOVFD,  
\$VJW ,T22 ,P22 ,H22 ,S22 ,T50 ,P50 ,H50

COMMON /ALL5/

1S50 ,WA22 ,ZI ,PCNI ,CNI ,PRI ,ETAI ,WACI ,  
2TFFIP ,CNIP ,ETATIP,DHTCIP,DHTI ,BLIP ,PCBLIP,PCNIGU,  
3ZIDS ,PCNIDS,PRIDS ,ETAICS,WAIDS ,PRICF ,ETAICF,WAICF ,  
4TFIPDS,CNIPDS,ETIPDS,TFIPCF,CNIPCF,ETIPCF,DHIPCF,WAICDS,  
5WAI ,PCBLI ,BLI ,T22DS ,WA21 ,WG50 ,FAR50 ,A24 ,  
6AM23 ,DUMSPL,FXFN2M,FXM2CP,AFTFAN,PUNT ,PCBLID,P6DSAV,  
7AM6DSV,ETAASV,FAR7SV,T4PBL ,T41 ,FAN ,ISPOOL

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COMMON /DYN/ ITRAN,TIME,DT,TF,JTRAN,NSTEP,TPRINT,DTPRNT
COMMON /RPMS/ XNHPDS,XNIPDS,XNLPDS,PMIHP,PMIIP,PMILP
WFB=1.858
RETURN
END

```

Shown in subroutine DISTRB are COMMON blocks ALL1, ALL2, ALL3, ALL4, ALL5, DYN, and RPMS. All these COMMON blocks can be used to transfer information to DYNGEN. COMMON block WORDS can be used to transfer the subroutine name to subroutine ERROR if an error occurs. COMMON block DESIGN transfers program indices (table III) into DYNGEN if a change is required as a transient is run. An example of this will be shown later. COMMON blocks ALL1 to ALL5 transfer time-varying variables into DYNGEN as discussed earlier. COMMON blocks DYN and RPMS transfer data about the transient solution to be run (table V). All these COMMON blocks are shown here for illustration purposes although in this example only fuel flow is changed; thus, only COMMON block ALL2 is needed.

Since this example is an open-loop fuel flow step, the fuel control (FCNTRL) and main nozzle control (NOZTR) subroutines are not used. However, they must be written as shown here since they will be called by DYNGEN when it is running in the transient mode.

```

$IBFTC FCNTRL
  SUBROUTINE FCNTRL
  RETURN
  END

```

```

$IBFTC NOZCTR
  SUBROUTINE NOZCTR
  RETURN
  END

```

Next, the NAMELIST input is shown. The first case in DYNGEN, as in GENENG, must always be a design case (thus, IDES=1). All design inputs are shown; their explanation is found in tables II and III. The last four lines of the NAMELIST input contain the data that must be added to provide information to DYNGEN for transient capability.

(These variables are explained in table V.) Note also that SI=.TRUE.; thus, the output will be in SI units. The user must be careful here if he specifies SI units to be used. Since DYNGEN does most of its calculations in SI units if this system of units is specified, the NAMELIST data must also be in SI units. The BLOCK DATA for the components, however, can be in either set of units since the maps are scaled by DYNGEN; however, if the BLOCK DATA are in English units and the simulation is run in SI units (or conversely) the correction factors for the weight flows may be quite large.

```
$DATA IN AM=0.0,ALTP=0.0,IAFTBN=0,IDBURN=0,AM23=.18,AM55=.238,/
NOZFLT=0,IDUMP=1,IDCO=0,IMCD=0,IGASMX=0,MODE=0,TOLALL=.010,ITRYS=400,IDES=1,/
FXFN2M=.FALSE.,FXM2CP=.FALSE.,AFTFAN=.FALSE.,DUMSPL=.FALSE.,PRFDS=1.4,/
ETA FDS=.88,WAFCDS=280.1707,PCNFDS=100.0,PCBLF=0.0,PRIDS=1.571,WAICDS=140.8,/
ETAIDS=.87,PCNIDS=100.0,PCBLID=.5,ETABDS=.983,DPCODS=.05,DPWGDS=.10,/
PRCDS=7.273,PCNCD S=100.0,ETACDS=.86,PCBLC=0.0,DPDU DS=.05,ETHPDS=.9,ETIPDS=.9,/
ETLPDS=.9,DELSFC=1.0,DELFN=1.0,DELFG=1.0,PCBLOB=0.0,T4DS=1422.22,IAMTP=2,/
DELT1=17.2,TFHPDS=50.0,CNHPDS=2.0,TFIPDS=120.0,CNIPDS=2.2,TFLPDS=130.0,/
CNLPDS=2.3,ZFDS=.83333333,ZIDS=.83333333,ZCDS=.81433225,CVDNOZ=.985,/
CVMNOZ=.985,CVDWNG=.985,FAN=.TRUE.,ISPOOL=3,XNHPDS=10000.,XNLPDS=5000.,/
XNIPDS=7500.,PMIHP=35.25,PMILP=70.50,PMIIP=52.88,VFAN=.142,VINTC=.142,/
VCOMB=.142,VHPTRB=.057,VLPTRB=.057,VIPTRB=.057,VAFTBN=.283,VFDUCT=.283,/
VWDUCT=.283,VCOMP=.142,SI=.TRUE.,DPAFDS=0.0$/
```

The first output DYNGEN provides is shown next. This is the design case for the three-spool turbofan. The fuel flow (WFB) is 1.858 kg/sec. The means of specifying the output shown is discussed in the main-text section Output Specification. This is the same output given by GENENG. One difference is that DYNGEN tells the user that "THE OUTPUT IS IN SI UNITS." (If SI had been set .FALSE. in the NAMELIST input, DYNGEN would specify that "THE OUTPUT IS IN ENGLISH UNITS.")

FAN DESIGN	PRFCF = 0.10000000E+01	ETAFCF = 0.10000000E+01	WAFCF = 0.46695116E+00	T2DS = 0.30534883E+03
MIDDLE SPOOL DESIGN	PRICF = 0.95166666E+00	ETACF = 0.98863635E+00	WAICF = 0.46933333E+00	T22DS = 0.34035630E+03
COMPRESSOR DESIGN	PRCCF = 0.89614286E+00	ETACCF = 0.10000000E+01	WACCF = 0.48218785E+00	T21DS = 0.35406999E+03
INTER DUCT DESIGN	A38 = 0.22159284E+00	AM38 = 0.10000000E+01	A39 = 0.22159284E+00	AM39 = 0.10000000E+01
COMBUSTOR DESIGN	WA3CDS = 0.15101303E-02	ETABC F = 0.98300000E+00		
H.P. TURBINE DESIGN	CNHPCF = 0.75424662E+00	TFHPCF = 0.22059431E+05	ETHPCF = 0.10000000E+01	DHHPCF = 0.40061476E+04
I.P. TURBINE DESIGN	CNIPCF = 0.74420217E+00	TFIPCF = 0.20704784E+05	ETIPCF = 0.10000000E+01	DHIPCF = 0.42148784E+04
L.P. TURBINE DESIGN	CNLP CF = 0.74736389E+00	TFLPCF = 0.16049822E+05	ETLPCF = 0.10201339E+01	DHLP CF = 0.56982800E+04
DUCT NOZZLE DESIGN	A28 = 0.34868393E+00	AM28 = 0.65148608E+00	A29 = 0.34868393E+00	AM29 = 0.65148608E+00
TURBINE AREA DESIGN	A55 = 0.73676639E+00	AM55 = 0.23826636E+00		
NOZZLE DESIGN	A8 = 0.28800043E+00	AM8 = 0.10000000E+01	A9 = 0.28800043E+00	AM9 = 0.10000000E+01
OUTPUT	AM = 0.	ALTP = 0.	T4 = 1422.22	ETAR = 1.0000

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THE OUTPUT IS IN SI UNITS

PCNF	CNF	ZF	PRF	WAFB	WAF
0.100000E+03	0.100000E+01	0.833333E+00	0.140000E+01	0.280171E+03	0.272166E+03
PCNI	CNI	ZI	PRI	WACI	WAI
0.100000E+03	0.100000E+01	0.833333E+00	0.157100E+01	0.140800E+03	0.181373E+03
PCNC	CNC	ZC	PRC	WACC	WAC
0.100000E+03	0.100000E+01	0.814332E+00	0.727300E+01	0.482188E+02	0.906864E+02
T2	P2	T22	P22	T21	P21
0.305349E+03	0.101325E+06	0.340356E+03	0.141855E+06	0.394070E+03	0.222854E+06
T3	P3	PCBLF	BLF	PCBLC	BLC
0.728472E+03	0.162082E+07	0.	0.	0.	0.
PCBLHP	BLHP	PCBLIP	BLIP	PCBLLP	BLLP
0.	0.	0.	0.	0.	0.
WA3	WFB	WG4	FAR4	T4	P4
0.906864E+02	0.185800E+01	0.925444E+02	0.204882E-01	0.142222E+04	0.153978E+07
FFFHP	CNHP	DHTCHP	DHTC	T50	P50
0.500000E+02	0.200000E+01	0.240369E+03	0.341857E+06	0.114429E+04	0.540142E+06
FFFIP	CNIP	DHTCIP	DHTI	T5	P5
0.120000E+03	0.220000E+01	0.927273E+02	0.106107E+06	0.125587E+04	0.371263E+06
FFFIP	CNLP	DHTCLP	DHTF	T55	P55
0.130000E+03	0.230000E+01	0.978677E+02	0.103335E+06	0.968474E+03	0.249603E+06
ETAB	PCBLDU	ETAD	DPDUC	T24	P24
0.983000E+00	0.	0.	0.500000E-01	0.340355E+03	0.134762E+06
WAD	WFD	WG24	FAR24	T25	P25
0.907927E+02	0.	0.907927E+02	0.	0.340355E+03	0.134762E+06
ETAF	ETAI	ETAC	ETATHP	ETATIP	ETATLP
0.880000E+00	0.870000E+00	0.860000E+00	0.900000E+00	0.900000E+00	0.900000E+00
T6	P6	P56	AM6	V6	WG6
0.968474E+03	0.249603E+06	0.240433E+06	0.238266E+00	0.143982E+03	0.925444E+02
T7	WFA	WG7	FAR7	ETAA	DPAFT
0.968474E+03	0.	0.925444E+02	0.204882E-01	0.	0.
PS8	AM8	V8	PS9	AM9	V9
0.135759E+06	0.100000E+01	0.564732E+03	0.135759E+06	0.100000E+01	0.564732E+03
PS28	AM28	V28	AM29	AM29	V29
0.101325E+06	0.651486E+00	0.231367E+03	0.101325E+06	0.651486E+00	0.231367E+03
BPPINT	DPCCM	DPWING	PS38	AM38	V38
0.100000E+01	0.500000E-01	0.100000E+00	0.106207E+06	0.100000E+01	0.363392E+03
BYPASS	HPEXT	WFT	WGT	VA	FRD
0.500586E+00	0.	0.185800E+01	0.274024E+03	0.	0.
PCBLI	WG37	VJW	PS39	AM39	V39
0.500000E+00	0.906864E+02	0.357941E+03	0.106207E+06	0.100000E+01	0.363392E+03
CVDWNG	FGMWNG	FGPWNG	FNWING	FNMAIN	P28
0.985000E+00	0.324604E+05	0.108184E+04	0.335422E+05	0.820871E+05	0.134762E+06
FFOVFN	FWDVFN	FCDVFN	FMNOFN	FNOVFD	P38
0.178945E+00	0.290084E+00	0.530971E+00	0.709916E+00	0.100000E+01	0.200569E+06
CVMNOZ	VJM	CVDNOZ	VJD	FGM	FGP
0.985000E+00	0.556261E+03	0.985000E+00	0.227896E+03	0.104630E+06	0.109988E+05

ORIGINAL PAGE IS OF POOR QUALITY

MAIN SONIC CONVERGENT NOZZLE  
 DUCT SUBSONIC CONVERG. NOZZLE  
 CONVERGED AFTER 1 LOOPS

FG=115629.31

FN=115629.31

SFC= 0.05785

Following the design-case output, a list of COMMON blocks ALL1 to ALL5 is given. The numbers presented in this printout can be associated with their variable names by comparing the output locations with the list of COMMON blocks ALL1 to ALL5 in subroutine DISTRB. The COMMON block printout occurs only at the design point. Also, on the same line as the word COMMON, eight variables are printed; they are ZF, PCNF, ZI, PCNI, ZC, PCNC, T4, and MODE.

COMMON	0.833333E+00	0.100000E+03	0.833333E+00	0.100000E+03	0.814332E+00	0.100000E+03	0.142222E+04
0.100000E+03	0.100000E+03	0.142222E+04	0.100000E+03	0.	0.100000E+01	0.100000E+01	0.100000E+01
0.833333E+00	0.100000E+03	0.140000E+01	0.880000E+00	0.272166E+03	0.100000E+01	0.100000E+01	0.466951E+03
0.814332E+00	0.100000E+03	0.727300E+01	0.860000E+00	0.906864E+02	0.896143E+00	0.100000E+01	0.482188E+00
0.142222E+04	0.185800E+01	0.	0.983000E+00	0.151013E-02	0.500000E-01	0.	0.983000E+00
0.500000E+02	0.200000E+01	0.900000E+00	0.220594E+05	0.754247E+00	0.100000E+01	0.400615E+04	0.305349E+03
0.130000E+03	0.230000E+01	0.900000E+00	0.160498E+05	0.747364E+00	0.102013E+01	0.569828E+04	0.394070E+03
0.	0.	0.	0.	0.118079E-01	0.500000E-01	0.	0.
0.	0.	0.	0.	0.115384E-01	0.	0.	0.
0.736766E+00	0.	0.736766E+00	0.736766E+00	0.288000E+00	0.288000E+00	0.348684E+00	0.348684E+00
0.240433E+06	0.238266E+00	0.985000E+00	0.985000E+00	0.	0.	0.	0.
0.305350E+03	0.101325E+06	0.305399E+06	0.671778E+04	0.305349E+03	0.101325E+06	0.305399E+06	0.671777E+04
0.394070E+03	0.222854E+06	0.394677E+06	0.674817E+04	0.728472E+03	0.162082E+07	0.743538E+06	0.681738E+04
0.142222E+04	0.153978E+07	0.158403E+07	0.764712E+04	0.105587E+04	0.371263E+06	0.113606E+07	0.769198E+04
0.968474E+03	0.249603E+06	0.103273E+07	0.770389E+04	0.	0.	0.	0.
0.100000E+01	0.140000E+01	0.880000E+00	0.280171E+03	0.272166E+03	0.906864E+02	0.925444E+02	0.204882E-01
0.100000E+01	0.727300E+01	0.860000E+00	0.482188E+02	0.906864E+02	0.983000E+00	0.500000E-01	0.

0.200000E+01	0.900000E+00	0.240369E+03	0.341857E+06	0.	0.925444E+02	0.204882E-01	0.350415E+03
0.230000E+01	0.900000E+00	0.978677E+02	0.103335E+06	0.	0.925444E+02	0.204882E-01	0.
0.	0.	0.100000E+01	0.833333E+00	0.100000E+03	0.814332E+00	0.100000E+02	0.185800E+01
0.500000E+02	0.130000E+03	0.	0.	0.	0.	0.	0.
0.101325E+06	0.272166E+03	0.906864E+02	0.	0.	0.743538E+06	0.	0.
0.394070E+03	0.222854E+06	0.394677E+06	0.674817E+04	0.340355E+03	0.141855E+06	0.340537E+06	0.673013E+04
0.340355E+03	0.134762E+06	0.340535E+06	0.674485E+04	0.340355E+03	0.134762E+06	0.340535E+06	0.674485E+04
0.340355E+03	0.134762E+06	0.340535E+06	0.674485E+04	0.340355E+03	0.134762E+06	0.340535E+06	0.674485E+04
0.907927E+02	0.	0.907927E+02	0.	0.	0.500000E-01	0.500586E+00	0.
0.313697E+03	0.101325E+06	0.231367E+03	0.651486E+00	0.313697E+03	0.101325E+06	0.231367E+03	0.651486E+00
0.968474E+03	0.249603E+06	0.103273E+07	0.770389E+04	0.340355E+03	0.134762E+06	0.340535E+06	0.674485E+04
0.185800E+01	0.925444E+02	0.204882E-01	0.	0.907927E+02	0.	0.101325E+06	0.
0.968474E+03	0.249603E+06	0.103273E+07	0.770389E+04	0.968474E+03	0.249603E+06	0.103273E+07	0.770389E+04
0.968474E+03	0.249603E+06	0.103273E+07	0.770389E+04	0.968474E+03	0.249603E+06	0.103273E+07	0.770389E+04
0.925444E+02	0.	0.925444E+02	0.204882E-01	0.	0.	0.143982E+03	0.
0.240433E+06	0.143982E+03	0.238266E+00	0.968481E+03	0.249611E+06	0.138141E-02	0.227615E-05	0.189884E+00
0.830758E+03	0.135759E+06	0.564732E+03	0.100000E+01	0.830758E+03	0.135759E+06	0.564732E+03	0.100000E+01
0.	0.	0.227896E+03	0.206913E+05	0.556261E+03	0.514788E+05	0.	0.991697E+04
0.104630E+06	0.109989E+05	0.185800E+01	0.274024E+03	0.682674E-02	0.115629E+06	0.115629E+06	0.57847CE-01
0.906864E+02	0.100000E+00	0.100000E+00	0.807808E-02	0.221593E+00	0.100000E+01	0.363392E+03	0.394070E+03
0.394677E+06	0.200569E+06	0.328590E+03	0.106207E+06	0.394070E+03	0.394677E+06	0.320056E+06	0.328590E+03
0.363392E+03	0.100000E+01	0.221593E+00	0.100000E+01	0.906864E+02	0.985000E+00	0.324604E+05	0.108184E+04
0.335422E+05	0.820871E+05	0.290084E+00	0.106207E+06	0.178945E+00	0.530971E+00	0.709916E+00	0.100000E+01
0.357941E+03	0.340356E+03	0.141855E+06	0.340357E+06	0.673014E+04	0.114429E+04	0.540142E+06	0.124217E+07
0.768077E+04	0.181373E+03	0.833333E+00	0.100000E+03	0.100000E+01	0.157100E+01	0.870000E+00	0.140800E+03
0.120000E+03	0.220000E+01	0.900000E+00	0.927273E+02	0.106107E+06	0.	0.	0.100000E+03
0.833333E+00	0.100000E+03	0.157100E+01	0.870000E+00	0.181373E+03	0.951667E+00	0.988636E+00	0.469333E+00
0.120000E+03	0.220000E+01	0.900000E+00	0.207048E+05	0.744202E+00	0.100000E+01	0.421488E+04	0.140800E+03
0.181373E+03	0.500000E+00	0.906864E+02	0.340356E+03	0.906864E+02	0.925444E+02	0.204882E-01	0.94518E-05
0.180000E+00	0.	0.	0.	0.	0.	0.500000E+00	0.100000E+01
0.100000E+01	0.100000E+01	0.100000E+01	0.	0.	0.000000E-38	0.000000E-38	

Next, NAMELIST data are again supplied to DYNGEN so that an off-design case is run. Since ITRAN is set equal to 1, the off-design point is also the initial condition for the transient. In this case the WFB is set equal to 1.486 kg/sec and the off-design point is run by specifying MODE and WFB (table IV). Also specified are DT, DTPRINT, and TF (table V).

\$DATA IN MODE=2, ITRAN=1, DT=.100, DTPRNT=.100, TF=3.0, DELT1=17.2, WFB=1.486 \$/

The DYNGEN transient output is now given. The first point is the initial condition and is indicated by TIME=0. at the top of the printout. The fuel flow is 1.486 kg/sec as specified. Also DYNGEN again specifies that the output is in SI units.

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TIME= 0.
OUTPUT          AM= 0.          ALTP= 0.          T4= 1336.92          ETAR= 1.0000

THREE SPOOL ENGINE
THE OUTPUT IS IN SI UNITS
PCNF            CNF            ZF            PRF            WAFAC          WAF
0.935724E+02   0.935724E+00   0.826087E+00  0.135404E+01   0.258993E+03  0.251593E+03
PCNI            CNI            ZI            PRI            WACI          WAI
0.945018E+02   0.950729E+00   0.829649E+00  0.152179E+01   0.132555E+03  0.166145E+03
PCNC            CNC            ZC            PRC            WACC          WAC
0.947421E+02   0.958534E+00   0.793836E+00  0.663671E+01   0.449892E+02  0.802017E+02
T2              P2              T22           P22            T21           P21
0.305349E+03   0.101325E+06   0.336279E+03  0.137198E+06   0.384985E+03  0.208788E+06
T3              P3              PCBLF         BLF            PCBLC         BLC
0.699518E+03   0.138566E+07   0.          0.          0.          0.
PCBLHP         BLHP          PCBLIP        BLIP          PCBLLP        BLLP
0.          0.          0.          0.          0.          0.
WAF3           WFB           WG4           FAR4           T4            P4
0.802017E+02   0.148600E+01   0.816877E+02  0.185283E-01   0.133692E+04  0.131543E+07
TFFHP         CNHP          DHTCHP        DHTC           T50           P50
0.500680E+02   0.195436E+01   0.239087E+03  0.320899E+06   0.1077253E+04  0.459903E+06
TFFIP         CNIP          DHTCIP        DHTI           T5            P5
0.120510E+03   0.214746E+01   0.928167E+02  0.997759E+05   0.988154E+03  0.315046E+06
TFFLP         CNLP          DHTCLP        DHTF           T55           P55
0.130926E+03   0.222468E+01   0.967787E+02  0.956015E+05   0.906063E+03  0.212977E+06

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ORIGINAL PAGE IS  
OF POOR QUALITY

ETAB	PCBLDU	ETAD	DPDUC	T24	P24
C.983000E+00	0.	0.	0.483611E-01	0.336278E+03	0.130563E+06
WAD	WFD	WG24	FAR24	T25	P25
0.854474E+02	0.	0.854474E+02	0.	0.336278E+03	0.130563E+06
ETAF	ETAI	ETAC	ETATHP	ETATIP	ETATLP
0.892888E+00	0.879752E+00	0.843767E+00	0.897626E+00	0.895935E+00	0.902426E+00
T6	P6	PS6	AM6	V6	WG6
0.906063E+03	0.212977E+06	0.205461E+06	0.237785E+00	0.139343E+03	0.816877E+02
T7	WFA	WG7	FAR7	ETAA	DPAFT
0.906063E+03	0.	0.816877E+02	0.185283E-01	0.	0.
PS8	AMB	V8	PS9	AM9	V9
0.115430E+06	0.100000E+01	0.546833E+03	0.115430E+06	0.100000E+01	0.546833E+03
PS28	AM28	V28	PS29	AM29	V29
0.101325E+06	0.612208E+00	0.217096E+03	0.101325E+06	0.612208E+00	0.217096E+03
BPRINT	DPCOM	DPWING	PS38	AM38	V38
0.107159E+01	0.506851E-01	0.999821E-01	0.101325E+06	0.984277E+00	0.35447CE+03
8YPASS	HPEXT	WFT	WGT	VA	FRD
0.514293E+00	0.	0.148600E+01	0.253079E+03	0.	0.
PCBLI	WG37	VJW	PS39	AM39	V39
0.517280E+00	0.859436E+02	0.349153E+03	0.101325E+06	0.984277E+00	0.354470E+03
CVDWNG	FGMWNG	FGPWNG	FNWING	FNMA IN	P28
C.985000E+00	0.300074E+05	0.	0.300074E+05	0.663338E+05	0.130563E+06
FFDVFN	FWOVFN	FCOVFN	FMNOFN	FNOVFD	P38
0.189659E+00	0.311470E+00	0.498870E+00	0.688530E+00	0.833190E+00	0.187913E+06
CVMNOZ	VJM	CVDNOZ	VJD	FGM	FGP
0.985000E+00	0.538631E+03	0.985000E+00	0.213839E+03	0.922790E+05	0.406223E+04

MAIN SONIC CONVERGENT NOZZLE  
DUCT SUBSONIC CONVERG. NOZZLE

FG= 96341.23

FN= 96341.23

SFC= 0.05553

CONVERGED AFTER 12 LOOPS

After the initial time point is calculated, DYNGEN calls DISTRB. From DISTRB the fuel flow is stepped to 1.858 kg/sec. Note that this value is the design-point fuel flow (although it did not have to be). Also, in DYNGEN, subsequent calls are made to NOZCTR and FCNTRL to determine what controls are used on the main nozzle area and the fuel flow. For the case being presented, there are no controls. The next printout from DYNGEN, at TIME=.1 second indicates that the fuel flow is now 1.858 kg/sec, as specified by DISTRB.

TIME= 0.1000

OUTPUT AM= 0. ALTP= 0. T4= 1480.23 ETAR= 1.0000

THREE SPOOL ENGINE  
THE OUTPUT IS IN SI UNITS

PCNF	CNF	ZF	PRF	W AFC	WAF
0.939401E+02	0.939401E+00	0.826768E+00	0.135677E+01	0.260183E+03	0.252747E+03
PCNI	CNI	ZI	PRI	WACI	WAI
0.947623E+02	0.953013E+00	0.828907E+00	0.152349E+01	0.132976E+03	0.166943E+03
PCNC	CNC	ZC	PRC	WACC	WAC
0.952465E+02	0.963095E+00	0.831634E+00	0.696022E+01	0.451836E+02	0.803957E+02
T2	P2	T22	P22	T21	P21
0.305349E+03	0.101325E+06	0.336517E+03	0.137475E+06	0.385419E+03	0.209441E+06
T3	P3	PCBLF	BLF	PCBLC	BLC
0.709963E+03	0.145775E+07	0.	0.	0.	0.
PCBLHP	BLHP	PCBLIP	BLIP	PCBLLP	BLLP
0.	0.	0.	0.	0.	0.
W A3	WFB	WG4	FAR4	T4	P4
0.803957E+02	0.185800E+01	0.820832E+02	0.231107E-01	0.148023E+04	0.138683E+07
TFFHP	CNHP	DHTCHP	DHTC	T50	P50
0.502356E+02	0.186723E+01	0.241456E+03	0.354798E+06	0.119406E+04	0.483147E+06
TFFIP	CNIP	DHTCIP	DHTI	T5	P5
0.121398E+03	0.204086E+01	0.921327E+02	0.110029E+06	0.110284E+04	0.331369E+06
TFFLP	CNLP	DHTCLP	DHTF	T55	P55
0.131845E+03	0.211411E+01	0.947642E+02	0.104510E+06	0.101513E+04	0.226184E+06
ETAB	PCBLDU	ETAD	DPDUC	T24	P24
0.983000E+00	0.	0.	0.484824E-01	0.336516E+03	0.130809E+06
WAD	WFD	WG24	FAR24	T25	P25
0.858036E+02	0.	0.857984E+02	0.	0.336516E+03	0.130809E+06
ETAF	ETAI	ETAC	ETATHP	ETATIP	ETATLP
0.892210E+00	0.879302E+00	0.843843E+00	0.891106E+00	0.889029E+00	0.903776E+00
T6	P6	PS6	AM6	V6	WG6
0.101513E+04	0.226184E+06	0.218181E+06	0.239097E+00	0.147660E+03	0.820161E+02
T7	WFA	WG7	FAR7	ETAA	DPAFT
0.101315E+04	0.	0.819242E+02	0.231107E-01	0.	0.
PS8	AMB	V8	PS9	AM9	V9
0.123329E+06	0.100000E+01	0.577103E+03	0.123329E+06	0.100000E+01	0.577103E+03
PS28	AM28	V28	PS29	AM29	V29
0.101325E+06	0.614761E+00	0.218014E+03	0.101325E+06	0.614761E+00	0.218014E+03
BPRINT	DPCOM	DPWING	PS38	AM38	V38
0.106729E+01	0.486544E-01	0.100010E+00	0.101325E+06	0.987067E+00	0.355514E+03

ORIGINAL PAGE IS  
OF POOR QUALITY

BYPASS	HPEXT	WFT	WGT	VA	FRD
0.513969E+00	0.	0.185800E+01	0.254605E+03	0.	0.
PCBLI	WG37	VJM	PS39	AM39	V39
0.516274E+00	0.861776E+02	0.350181E+03	0.101325E+06	0.987067E+00	0.355514E+03
CVDWNG	FGMWNG	FGPWNG	FNWING	FNMAIN	P28
0.985000E+00	0.301778E+05	0.	0.301778E+05	0.713314E+05	0.130809E+06
FFOVFN	FNOVFN	FCOVFN	FMNOFN	FNOVFD	P38
0.181507E+00	0.297291E+00	0.521202E+00	0.702709E+00	0.877885E+00	0.188495E+06
CVMDNZ	VJM	CVMDNZ	VJD	FGM	FGP
0.985000E+00	0.568446E+03	0.985000E+00	0.214744E+03	0.951720E+05	0.633722E+04

MAIN SONIC CONVERGENT NOZZLE  
DUCT SUBSONIC CONVERG. NOZZLE

FG=101509.19

FN=101509.19

SFC= 0.06589

CONVERGED AFTER 15 LOOPS

Next, the DYNGEN output is given for a 3-second transient.

TIME= 0.2000

OUTPUT

AM= 0.

ALTP=

0.

T4= 1480.45

ETAR= 1.0000

THREE SPOOL ENGINE  
THE OUTPUT IS IN SI UNITS

PCNF	0.943149E+02	CNF	0.943149E+00	ZF	0.827059E+00	PRF	0.135937E+01	WAF	0.253953E+03
PCNI	0.950307E+02	CNI	0.950307E+00	ZI	0.826160E+00	PRI	0.152399E+01	WAI	0.167841E+03
PCNC	0.957213E+02	CNC	0.957213E+00	ZC	0.835857E+00	PRC	0.704346E+01	WAC	0.813925E+02
T2	0.305349E+03	P2	0.101325E+06	T22	0.336749E+03	P22	0.137738E+06	T21	0.209912E+06
T3	0.713110E+03	P3	0.147851E+07	PCBLF	0.	BLF	0.	PCBLC	0.
PCBLHP	0.	BLHP	0.	PCBLIP	0.	BLIP	0.	PCBLLP	0.
MA3	0.813925E+02	MFB	0.	WG4	0.	FAR4	0.	T4	0.
TFFHP	0.502072E+02	CNHP	0.185800E+01	DHTCHP	0.832034E+02	DHTC	0.228270E-01	T50	0.148045E+07
TFFIP	0.121311E+03	CNIP	0.187640E+01	DHTCIP	0.239770E+03	DHTI	0.354794E+06	T55	0.490942E+06
TFFLP	0.121311E+03	CNLP	0.204585E+01	DHTCLP	0.919082E+02	DHTF	0.110467E+04	T55	0.337415E+06
ETAB	0.179898E+03	PCBLDU	0.212078E+01	ETAD	0.946886E+02	DPDUC	0.101745E+04	T24	0.230517E+06
WAD	0.983000E+00	WFD	0.	WG24	0.	FAR24	0.485800E-01	T25	0.131047E+06
ETAF	0.861119E+02	ETAI	0.	ETAC	0.861069E+02	ETATHP	0.	T25	0.131047E+06
T6	0.891441E+00	P6	0.878487E+00	PS6	0.844006E+00	AM6	0.892432E+00	ETATLP	0.903491E+00
T7	0.101745E+04	WFA	0.230517E+06	WG7	0.222426E+06	FAR7	0.238139E+00	WG6	0.831803E+02
PS8	0.101745E+04	AM8	0.	V8	0.831503E+02	PS9	0.228270E-01	DPAFT	0.
PS28	0.125452E+06	AM28	0.100000E+01	V28	0.578307E+03	PS29	0.125452E+06	AM9	0.
BPRINT	0.101325E+06	DPCOM	0.617023E+00	DPMING	0.218834E+03	PS38	0.101325E+06	AM9	0.578307E+03
BYPASS	0.105952E+01	HPEXT	0.486737E-01	WFT	0.100014E+00	MGT	0.101325E+06	AM29	0.218834E+03
PCBLI	0.513056E+00	WG37	0.	VJW	0.185800E+01	PS39	0.255811E+03	AM38	0.356271E+03
CVDWNG	0.514449E+00	FGMNG	0.863379E+02	FGPWN	0.350927E+03	FMWING	0.101325E+06	AM39	0.989038E+00
FFOVFN	0.985000E+00	FMOVFN	0.302983E+05	FCDVFN	0.	FMNOFN	0.302983E+05	FMMAIN	0.989038E+00
CVMNOZ	0.179898E+00	VJM	0.293667E+00	CVDNDZ	0.526435E+00	VJD	0.706333E+00	FMNOFD	0.131047E+06
	0.985000E+00		0.569632E+03		0.985000E+00		0.215552E+03	FGM	0.188918E+06
								FGM	0.694858E+04

MAIN SONIC CONVERGENT NOZZLE  
DUCT SUBSONIC CONVERG. NOZZLE

FN=103172.46

SFC= 0.06483

CONVERGED AFTER 12 LOOPS

ORIGINAL PAGE IS  
OF POOR QUALITY



TIME= 0.3000

AM= 0.0 ALTP= 0.0

T4= 1475.36

ETAR= 1.0000

OUTPUT

THREE SPOOL ENGINE  
THE OUTPUT IS IN SI UNITS

C.946757E+02	PCNF	CNF	ZF	PRF	WAF	WAF
C.952952E+02	PCNI	CNI	ZI	PRI	WACI	WACI
C.961557E+02	PCNC	CNC	ZC	PRC	WACC	WACC
C.305349E+03	T2	P2	T22	P22	T21	P21
0.714466E+03	T3	P3	PCBLF	BLF	PCBLC	BLC
0.149059E+07	PCBLHP	BLHP	PCBLIP	BLIP	PCBLLP	BLLP
0.821515E+02	MA3	WFB	WG4	FAR4	T4	P4
0.185800E+01	TFFHP	CNHP	DHTCHP	DHTC	T50	P50
0.501880E+02	TFFIP	CNIP	DHTCIP	DHTI	T5	P5
0.121224E+03	TFFLP	CNLP	DHTCLP	DHTF	T55	P55
0.131461E+03	ETAB	PCBLDU	ETAD	DPDUC	T24	P24
C.983000E+00	WAD	WFD	WG24	FAR24	T25	P25
0.864049E+02	ETAF	ETAI	ETAC	ETATHP	ETATIP	ETATLP
0.890700E+00	T6	P6	PS6	AM6	V6	WG6
0.101313E+04	T7	MFA	WG7	FAR7	ETAA	DPAFT
0.101325E+04	PS8	AM8	V8	PS9	AM9	V9
0.126376E+06	PS28	AM28	V28	PS29	AM29	V29
0.101325E+06	BPRINT	DPCDM	DPWING	PS38	AM38	V38
0.105215E+01	BYPASS	HPEXT	WFT	MGT	VA	FRD
0.512152E+00	PCBLI	WG37	VJM	PS39	AM39	V39
0.512705E+00	CVDHNG	FGHNG	FGPWHG	PS39	AM39	V39
0.985000E+00	FDOVFN	FDOVFN	FDOVFN	FMNLF	FNMAIN	P28
0.179625E+00	CVMNDZ	VJM	CVDNOZ	VJD	FGM	FGP
C.985000E+00						

FN=104051.11

FG=104051.11

SFC= 0.06428

MAIN SONIC CONVERGENT NOZZLE  
DUCT SUBSONIC CONVERG. NOZZLE

CONVERGED AFTER 12 LOOPS

ORIGINAL PAGE IS  
OF POOR QUALITY

TIME= 0.4000

OUTPUT

AM= 0. ETAR= 1.0000

ALTP= 0. T4= 1470.58

THREE SPOOL ENGINE  
THE OUTPUT IS IN SI UNITS

PCNF	CNF	ZF	PRF	WAFAC	WAF
C.950161E+02	0.950161E+00	0.827591E+00	0.136425E+01	0.263750E+03	0.263750E+03
PCNI	CNI	ZI	PRI	WACI	WAI
C.955516E+02	0.960002E+00	0.821173E+00	0.152516E+01	0.134428E+03	0.169531E+03
PCNC	CNC	ZC	PRC	WACC	WAC
C.965489E+02	0.974938E+00	0.833512E+00	0.711715E+01	0.461295E+02	0.828288E+02
T2	P2	T22	P22	T21	P21
0.305349E+03	0.101325E+06	0.337183E+03	0.138232E+06	0.386469E+03	0.210826E+06
T3	P3	PCBLF	BLF	PCBLC	BLC
C.715453E+03	0.150048E+07	0.	0.	0.	0.
PCBLHP	BLHP	PCBLIP	BLIP	PCBLLP	BLLP
0.	0.	0.	0.	0.	0.
WA3	WFB	WG4	FAR4	T4	P4
C.828288E+02	0.185800E+01	0.846646E+02	0.224308E-01	0.147058E+04	0.142713E+07
TFFHP	CNHP	DHTCHP	DHTC	T50	P50
C.501693E+02	0.189869E+01	0.239869E+03	0.352596E+06	0.118639E+04	0.498628E+06
TFFIP	CNIP	DHTCIP	DHTI	T5	P5
0.121139E+03	0.206450E+01	0.919387E+02	0.108862E+06	0.109653E+04	0.342848E+06
TFFLP	CNLP	DHTCLP	DHTF	T55	P55
0.131360E+03	0.214446E+01	0.950931E+02	0.104075E+06	0.100941E+04	0.233803E+06
ETAB	PCBLDU	ETAD	DPDUC	T24	P24
C.983000E+00	0.	0.	0.487576E-01	0.337182E+03	0.131492E+06
WAD	WFD	WG24	FAR24	T25	P25
0.866806E+02	0.	0.866761E+02	0.	0.337182E+03	0.131492E+06
ETAF	ETAI	ETAC	ETATHP	ETATIP	ETATLP
0.889998E+00	0.876584E+00	0.846777E+00	0.893800E+00	0.891064E+00	0.903226E+00
T6	P6	PS6	AM6	V6	WG6
C.100941E+04	0.233803E+06	0.225607E+06	0.237917E+00	0.146568E+03	0.846544E+02
T7	WFA	WG7	FAR7	ETAA	DPAFT
C.100953E+04	0.	0.846428E+02	0.224308E-01	0.	0.
PS8	AM8	V8	PS9	AM9	V9
0.127136E+06	0.100000E+01	0.576136E+03	0.127136E+06	0.100000E+01	0.576136E+03
PS28	AM28	V28	PS29	AM29	V29
0.101325E+06	0.621202E+00	0.220351E+03	0.101325E+06	0.621202E+00	0.220351E+03
BPRINT	DPCOM	DPWING	PS38	AM38	V38
0.104555E+01	0.488875E-01	0.100025E+00	0.101325E+06	0.992847E+00	0.357744E+03
BPASS	HPEXT	WFT	MGT	VA	FRD
C.511297E+00	0.	0.185800E+01	0.258069E+03	0.	0.
PCBLI	WG37	VJM	PS39	AM39	V39
0.511135E+00	0.866455E+02	0.352378E+03	0.101325E+06	0.992847E+00	0.357744E+03
CVDWNG	FGWING	FGPWNG	FNFWING	FNMAIN	P28
0.985000E+00	0.305320E+05	0.305320E+05	0.305320E+05	0.742805E+05	0.131492E+06
FDFVFN	FMDVFN	FMDVFN	FMDVFN	FNOVFD	P38
0.179489E+00	0.291301E+00	0.529210E+00	0.708699E+00	0.906453E+00	0.189738E+06
CVMNDZ	VJM	CVDNDZ	VJD	FGM	FGP
C.985000E+00	0.567494E+03	0.985000E+00	0.217046E+03	0.973790E+05	0.743353E+04

MAIN SONIC CONVERGENT NOZZLE FG=104812.52

DUCT SUBSONIC CONVERG. NOZZLE FN=104812.52

SFC= 0.06382

CONVERGED AFTER 12 LOOPS

TIME= 0.5000

ETAR= 1.0000

OUTPUT

T4= 1466.43

ALTP= 0.

AM= 0.

THREE SPOOL ENGINE  
THE OUTPUT IS IN SI UNITS

PCNF	0.953155E+02	CNF	0.953155E+00	ZF	0.827730E+00	PRF	0.136629E+01	MAFC	0.264749E+03	MAF	0.257182E+03
PCNI	0.962074E+00	CNI	0.962074E+00	ZI	0.819222E+00	PRI	0.152585E+01	MACI	0.134843E+03	MAI	0.170263E+03
PCNC	0.978084E+00	CNC	0.978084E+00	ZC	0.832122E+00	PRC	0.714499E+01	WACC	0.463886E+02	WAC	0.834290E+02
T2	0.305349E+03	P2	0.101325E+06	T2	0.337366E+03	P22	0.138439E+06	T21	0.386779E+03	P21	0.211238E+06
T3	0.716322E+03	P3	0.150929E+07	PCBLF	0.150929E+07	BLF	0.150929E+07	PCBLC	0.150929E+07	BLC	0.150929E+07
PCBLHP	0.983000E+00	BLHP	0.983000E+00	PCBLIP	0.983000E+00	BLIP	0.983000E+00	PCBLLP	0.983000E+00	BLLP	0.983000E+00
MA3	0.834290E+02	WFB	0.185800E+01	WG4	0.852671E+02	FAR4	0.222704E-01	T4	0.146643E+04	P4	0.143536E+07
TFHP	0.501558E+02	CNHP	0.501558E+01	DHTCHP	0.240239E+03	DHTC	0.351288E+06	T50	0.118310E+04	P50	0.502279E+06
TFIP	0.121086E+03	CNIP	0.207240E+01	DHTCIP	0.920615E+02	DHTI	0.107913E+06	T5	0.109395E+04	P5	0.346220E+06
TFPL	0.131248E+03	CNLP	0.215375E+01	DHTCLP	0.952236E+02	DHTF	0.103396E+06	T55	0.100735E+04	P55	0.236481E+06
ETAB	0.983000E+00	PCBLDU	0.983000E+00	ETAD	0.983000E+00	OPDUC	0.488316E-01	T24	0.337365E+03	P24	0.131679E+06
MAD	0.869186E+02	WFD	0.869147E+02	WG24	0.869147E+02	FAR24	0.222704E-01	T25	0.337365E+03	P25	0.131679E+06
ETAF	0.889365E+00	ETAI	0.875787E+00	ETAC	0.848071E+00	ETATHP	0.894240E+00	ETATIP	0.891465E+00	ETATLP	0.903092E+00
T6	0.100735E+04	P6	0.236481E+06	PS6	0.228285E+06	AM6	0.236536E+00	V6	0.145589E+03	MG6	0.852546E+02
T7	0.100745E+04	WFA	0.236481E+06	WG7	0.852359E+02	FAR7	0.222704E-01	ETAA	0.145589E+03	DPAFT	0.852546E+02
PS8	0.127873E+06	AM8	0.100000E+01	V8	0.575568E+03	PS9	0.127873E+06	AM9	0.100000E+01	V9	0.575568E+03
PS28	0.101325E+06	AM28	0.622954E+00	V28	0.220988E+03	PS29	0.101325E+06	AM29	0.622954E+00	V29	0.220988E+03
BPRINT	0.103975E+01	DPCOM	0.489839E-01	DPWING	0.100029E+00	PS38	0.101325E+06	AM38	0.994559E+00	V38	0.358405E+03
BYPASS	0.510495E+00	HPEXT	0.510495E+00	WFT	0.185800E+01	WGT	0.259040E+03	VA	0.994559E+00	FRD	0.358405E+03
PCBLI	0.509745E+00	MG37	0.867841E+02	VJM	0.353029E+03	PS39	0.101325E+06	AM39	0.994559E+00	V39	0.358405E+03
CVDWNG	0.985000E+00	FGWNG	0.306373E+05	FGPWNG	0.306373E+05	FNMING	0.748881E+05	FNMAIN	0.748881E+05	P28	0.131679E+06
FFOVFN	0.179284E+00	FMOVFN	0.290331E+00	FCOVFN	0.530385E+00	FMNOFN	0.306373E+05	FNOVFN	0.912618E+00	P38	0.190108E+06
CVMNDZ	0.985000E+00	VJM	0.566935E+03	CVDNOZ	0.985000E+00	VJD	0.217673E+03	FGM	0.978795E+05	FGP	0.764592E+04

SFC= 0.06339

FN=105525.37

FG=105525.37

MAIN SONIC CONVERGENT NOZZLE  
DUCT SUBSONIC CONVERG. NOZZLE

CONVERGED AFTER 11 LOOPS

TIME= 0.6000

OUTPUT

AM= 0.

ALTP=

0.

T4= 1462.67

ETAR= 1.0000

THREE SPOOL ENGINE  
THE OUTPUT IS IN SI UNITS

PCNF	CNF	ZF	PRF	MAFC	MAF
0.956018E+02	0.956018E+00	0.827894E+00	0.136826E+01	0.265701E+03	0.258108E+03
PCNI	CNI	ZI	PRI	WACI	MAI
0.960105E+02	0.960105E+00	0.817668E+00	0.135237E+01	0.135237E+03	0.170962E+03
PCNC	CNC	ZC	PRC	WACC	MAC
0.972195E+02	0.980915E+00	0.830965E+00	0.717065E+01	0.466214E+02	0.839854E+02
T2	P2	T22	P22	T21	P21
0.305349E+03	0.101325E+06	0.337542E+03	0.138639E+06	0.387094E+03	0.211666E+06
T3	P3	PCBLF	BLF	PCBLC	BLC
0.717185E+03	0.151778E+07	0.	0.	0.	0.
PCBLHP	BLHP	PCBLIP	BLIP	PCBLLP	BLLP
0.	0.	0.	0.	0.	0.
WA3	WFB	WG4	FAR4	T4	P4
0.839854E+02	0.165800E+01	0.858241E+02	0.221229E-01	0.146267E+04	0.144331E+07
TFHP	CNHP	DHTCHP	DHTC	T50	P50
0.501410E+02	0.191732E+01	0.240261E+03	0.350546E+06	0.117975E+04	0.505107E+06
TFIP	CNIP	DHTCIP	DHTI	T5	P5
0.121022E+03	0.208025E+01	0.921198E+02	0.107713E+06	0.109071E+04	0.348107E+06
TFLLP	CNLP	DHTCLP	DHTF	T55	P55
0.131162E+03	0.216343E+01	0.953898E+02	0.103337E+06	0.100408E+04	0.237526E+06
ETAB	PCBLDU	ETAD	DPOUC	T24	P24
0.983000E+00	0.	0.	0.489017E-01	0.337541E+03	0.131859E+06
WAD	WFD	WG24	FAR24	T25	P25
0.871461E+02	0.	0.871423E+02	0.	0.337541E+03	0.131859E+06
ETAF	ETAI	ETAC	ETATHP	ETATIP	ETATLP
0.888765E+00	0.875074E+00	0.849220E+00	0.894780E+00	0.891959E+00	0.902985E+00
T6	P6	PS6	AM6	V6	WG6
0.100408E+04	0.237526E+06	0.229285E+06	0.236639E+00	0.145434E+03	0.858168E+02
T7	WFA	WG7	FAR7	ETAA	DPAFT
0.100417E+04	0.	0.858095E+02	0.221229E-01	0.	0.
PS8	AM8	V8	PS9	AM9	V9
0.128496E+06	0.100000E+01	0.574667E+03	0.128496E+06	0.100000E+01	0.574667E+03
PS28	AM28	V28	PS29	AM29	V29
0.101325E+06	0.624627E+00	0.221596E+03	0.101325E+06	0.624627E+00	0.221596E+03
BPRINT	DPCOM	DPWING	PS38	AM38	V38
0.103460E+01	0.490643E-01	0.100032E+00	0.101325E+06	0.996321E+00	0.359082E+03
BYPASS	HPEXT	WFT	WGT	VA	FRD
0.509741E+00	0.	0.185800E+01	0.259966E+03	0.	0.
PCBLI	MG37	VJM	PS39	AM39	V39
0.508502E+00	0.869274E+02	0.353696E+03	0.101325E+06	0.996321E+00	0.359082E+03
CVDWNG	FGMNG	FGPWNG	FMING	FNMAIN	P28
0.985000E+00	0.307459E+05	0.	0.307459E+05	0.754181E+05	0.131859E+06
FFOVFN	FMOVFN	FCOVFN	FMNOFN	FNOVFD	P38
0.179164E+00	0.289607E+00	0.531229E+00	0.710393E+00	0.918141E+00	0.190492E+06
CVMNOZ	VJM	CVDNOZ	VJD	FGM	FGP
0.985000E+00	0.566047E+03	0.985000E+00	0.218272E+03	0.983387E+05	0.782522E+04

MAIN SONIC CONVERGENT NOZZLE  
DUCT SUBSONIC CONVERG. NOZZLE

FN=106163.96

FG=106163.96

SFC= 0.06300

CONVERGED AFTER 11 LOOPS

TIME= 3.0000

OUTPUT

AM= 0.

ALTP=

0.

T4= 1425.46

ETAR= 1.0000

THREE SPOOL ENGINE  
THE OUTPUT IS IN SI UNITS

PCNF	CNF	ZF	PRF	WAF	WAF
C.993348E+02	0.993348E+00	0.831783E+00	0.139483E+01	0.278014E+03	0.278014E+03
PCNI	CNI	ZI	PRI	MACI	MACI
C.993467E+02	0.994119E+00	0.823817E+00	0.155895E+01	0.140106E+03	0.140106E+03
PCNC	CNC	ZC	PRC	MACC	MACC
C.999798E+02	0.100166E+01	0.817143E+00	0.731696E+01	0.483671E+02	0.900970E+02
T2	P2	T22	P22	T21	P21
0.305349E+03	0.101325E+06	0.339910E+03	0.141331E+06	0.392605E+03	0.220328E+06
T3	P3	PCBLF	BLF	PCBLC	8LC
0.727519E+03	0.161213E+07	0.	0.	0.	0.
PCBLHP	BLHP	PCBLIP	BLIP	PCBLLP	BLLP
0.	0.	0.	0.	0.	0.
WA3	WFB	WG4	FAR4	T4	P4
C.900970E+02	0.185800E+01	0.919527E+02	0.206205E-01	0.142546E+C4	0.153167E+07
TFFHP	CNHP	DHTCHP	DHTC	T50	P50
0.500064E+02	0.199732E+01	0.240593E+03	0.342951E+06	0.114680E+04	0.536552E+06
TFFIP	CNIP	DHTCIP	DHTI	T5	P5
C.120149E+03	0.218324E+01	0.926810E+02	0.106226E+06	0.105833E+04	0.368763E+06
TFFLP	CNLP	DHTCLP	DHTF	T55	P55
C.130179E+03	0.228204E+01	0.975721E+02	0.103256E+06	0.971061E+03	0.248309E+06
ETAB	PCBLDU	ETAD	DPDUC	T24	P24
C.983000E+00	0.	0.	0.497929E-01	0.339909E+03	0.134294E+06
WAD	WFD	WG24	FAR24	T25	P25
0.901418E+02	0.	0.901408E+02	0.	0.339909E+03	0.134294E+06
ETAF	ETAI	ETAC	ETATHP	ETATIP	ETATLP
C.881090E+00	0.869682E+00	0.859149E+00	0.899713E+00	0.898809E+00	0.900556E+00
T6	P6	PS6	AM6	V6	WG6
C.971061E+03	0.248309E+06	0.239550E+06	0.238310E+00	0.144211E+03	0.919510E+02
T7	WFA	WG7	FAR7	ETAA	DPAFT
C.971061E+03	0.	0.919489E+02	0.206205E-01	0.	0.
PS8	AM8	V8	PS9	AM9	V9
0.135091E+06	0.100000E+01	0.565458E+03	0.135091E+06	0.100000E+01	0.565458E+03
PS28	AM28	V28	PS29	AM29	V29
0.101325E+06	0.646694E+00	0.229624E+03	0.101325E+06	0.646694E+00	0.229624E+03
BPRINT	DPCOM	DPWING	PS38	AM38	V38
C.996946E+00	0.499101E-01	0.100001E+00	0.104996E+06	0.100000E+01	0.362716E+03
BYPASS	HPEXT	WFT	MG7	VA	FRD
0.500987E+00	0.	0.185800E+01	0.271928E+03	0.	0.
PCBLI	WG37	VJW	PS39	AM39	V39
0.499235E+00	0.898230E+02	0.357275E+03	0.104996E+06	0.100000E+01	0.362716E+03
CVDWNG	FGMWNG	FGPWNG	FNWING	FNMAIN	P28
0.985000E+00	0.320915E+05	0.813497E+03	0.329050E+05	0.813259E+C5	0.134294E+06
FEDVFN	FWDVFN	FCOVFN	FMNDVFN	FNDVFD	P38
0.178481E+00	0.288057E+00	0.533462E+00	0.711943E+00	0.987906E+00	0.198295E+06
CVMNOZ	VJM	CVDNOZ	VJD	FGM	FGP
C.985000E+00	0.556976E+03	0.985000E+00	0.226180E+03	0.103693E+06	0.105380E+05

SFC= 0.05856

FN=114230.88

FG=114230.88

MAIN SONIC CONVERGENT NOZZLE  
DUCT SUBSONIC CONVERG. NOZZLE

CONVERGED AFTER 11 LOOPS

ORIGINAL PAGE IS  
OF POOR QUALITY

TIME= 0.8000

ETAR= 1.0000

AM= 0.0

T4= 1456.01

0.0

ALTP=

OUTPUT

THREE SPOOL ENGINE  
THE OUTPUT IS IN SI UNITS

PCNF	0.961356E+02	CNF	0.961356E+00	ZF	0.828203E+00	PRF	0.137193E+01	MAFC	0.267475E+03	WAF	0.259831E+03
PCNI	0.964459E+02	CNI	0.964459E+00	ZI	0.815482E+00	PRI	0.152896E+01	MACI	0.135967E+03	WAI	0.172262E+03
PCNC	0.977814E+02	CNC	0.985785E+00	ZC	0.828857E+00	PRC	0.721365E+01	MACC	0.470218E+02	WAC	0.849944E+02
T2	0.305349E+03	P2	0.101325E+06	T22	0.337872E+03	P22	0.139011E+06	T21	0.138772E+03	P21	0.212543E+06
T3	0.718761E+03	P3	0.153321E+07	PCBLF	0.0	BLF	0.0	PCBLC	0.0	BLC	0.0
PCBLHP	0.0	BLHP	0.0	PCBLIP	0.0	BLIP	0.0	PCBLLP	0.0	BLLP	0.0
WA3	0.849944E+02	WFB	0.0	WG4	0.0	FAR4	0.0	T4	0.0	P4	0.0
TFFHP	0.501150E+02	CNHP	0.193281E+01	DHTCHP	0.868354E+02	DHTC	0.218603E-01	T50	0.145601E+04	P50	0.145777E+07
TFFIP	0.120903E+03	CNIP	0.209501E+01	DHTCIP	0.240341E+03	DHTI	0.349312E+06	T5	0.117375E+04	P5	3.510085E+06
TFFLP	0.131033E+03	CNLP	0.218139E+01	DHTCLP	0.922404E+02	DHTF	0.107411E+06	T55	0.108484E+04	P55	0.351355E+06
ETAB	0.983000E+00	PCBLDU	0.0	ETAD	0.957237E+02	DPDUC	0.103252E+06	T24	0.998159E+03	P24	0.239277E+06
WAD	0.875686E+02	WFD	0.0	WG24	0.0	FAR24	0.490312E-01	T25	0.337871E+03	P25	0.132195E+06
ETAF	0.887608E+00	ETAI	0.0	ETAC	0.875652E+02	ETATHP	0.0	ETATIP	0.337871E+03	P28	0.132195E+06
T6	0.998159E+03	P6	0.873850E+00	PS6	0.851256E+00	AM6	0.895719E+00	V6	0.892874E+00	MG6	0.902817E+00
T7	0.998159E+03	WFA	0.239277E+06	WG7	0.230950E+06	FAR7	0.236940E+00	ETAA	0.145220E+03	DPAFT	0.868292E+02
PS8	0.129571E+06	AM8	0.0	V8	0.868233E+02	PS9	0.218603E-01	AM9	0.0	V9	0.0
PS28	0.101325E+06	AM28	0.100000E+01	V28	0.573005E+03	PS29	0.129571E+06	AM29	0.100000E+01	V29	0.573005E+03
BPRINT	0.102587E+01	DPCOM	0.627738E+00	DPWING	0.222727E+03	PS38	0.101325E+06	AM38	0.627738E+00	V38	0.222727E+03
BYPASS	0.508346E+00	HPEXT	0.492080E-01	WFT	0.100040E+00	WGT	0.101325E+06	VA	0.999940E+00	FRD	0.360465E+03
PCBLI	0.506385E+00	WG37	0.0	VJM	0.185800E+01	PS39	0.261689E+03	AM39	0.0	V39	0.0
CVDWNG	0.985000E+00	FGMNG	0.872236E+02	FGP WNG	0.355058E+03	FNMING	0.101325E+06	FNMA IN	0.999940E+00	P28	0.360465E+03
FFOVFN	0.179005E+00	FMOVFN	0.309695E+05	FCOVFN	0.0	FMOVFN	0.309695E+05	FNOVFD	0.763495E+05	P38	0.132195E+06
CVMNDZ	0.985000E+00	VJM	0.288574E+00	CVDNDZ	0.532421E+00	VJD	0.711426E+00	FGH	0.928129E+00	FGP	0.191280E+06
			0.564410E+03		0.985000E+00		0.219386E+03		0.991840E+05		0.813493E+04

MAIN SONIC CONVERGENT NOZZLE  
DUCT SUBSONIC CONVERG. NOZZLE

FG=107318.94

FN=107318.94

SFC= 0.06233

CONVERGED AFTER 11 LOOPS

TIME= 0.9000

OUTPUT

AM= 0.0 ALTP= 0.0 T4= 1453.27

ETAR= 1.0000

THREE SPOOL ENGINE

THE OUTPUT IS IN SI UNITS

PCNF	0.963847E+02	CNF	0.828064E+00	ZF	0.137352E+01	PRF	0.2603657E+03	MAF	0.172908E+03
PCNI	0.966556E+02	CNI	0.813661E+00	ZI	0.152955E+01	PRI	0.172908E+03	WAI	0.854219E+02
PCNC	0.980289E+02	CNC	0.828139E+00	ZC	0.723438E+01	PRC	0.387978E+03	WAC	0.212870E+06
T2	0.305349E+03	P2	0.101325E+06	T22	0.139172E+06	BLF	0.0	P21	0.0
T3	0.719482E+03	P3	0.153998E+07	PC8LF	0.0	BLIP	0.0	BLC	0.0
PC8LHP	0.0	BLHP	0.0	PC8LIP	0.0	BLIP	0.0	BLLP	0.0
WA3	0.854219E+02	WFB	0.185800E+01	WG4	0.872644E+02	FAR4	0.146412E+07	P4	0.512116E+06
TFFHP	0.501042E+02	CNHP	0.193952E+01	DHTCHP	0.240424E+03	DHTC	0.117121E+04	P50	0.352640E+06
TFFIP	0.120849E+03	CNIP	0.210185E+01	DHTCIP	0.923002E+02	DHTI	0.108233E+04	P5	0.995592E+03
TFFLP	0.130975E+03	CNLP	0.218958E+01	DHTCLP	0.958748E+02	DHTF	0.995592E+03	P55	0.239913E+06
ETAB	0.983000E+00	PC8LDU	0.0	ETAD	0.0	DPDUC	0.338016E+03	P24	0.132341E+06
WAD	0.877498E+02	WFD	0.0	WG24	0.877468E+02	FAR24	0.338016E+03	P25	0.132341E+06
ETAF	0.887061E+00	ETAI	0.0	ETAC	0.852108E+00	ETATHP	0.896105E+00	ETATLP	0.902739E+00
T6	0.995592E+03	P6	0.239913E+06	PS6	0.231547E+06	AM6	0.145186E+03	WG6	0.872594E+02
T7	0.995592E+03	WFA	0.0	WG7	0.872548E+02	FAR7	0.0	DPAPT	0.0
PS8	0.130025E+06	AM8	0.100000E+01	V8	0.572295E+03	PS9	0.100000E+01	V9	0.572295E+03
PS28	0.101325E+06	AM28	0.629076E+00	V28	0.223214E+03	PS29	0.629076E+00	V29	0.223214E+03
BPRINT	0.102337E+01	DPCOM	0.492627E-01	DPMING	0.100173E+00	PS38	0.100000E+01	V38	0.360573E+03
BYPASS	0.507496E+00	HPEXT	0.0	WFT	0.185800E+01	HGT	0.262515E+03	FRD	0.0
PCBLI	0.505775E+00	WG37	0.874475E+02	VJM	0.355165E+03	PS39	0.100000E+01	V39	0.360573E+03
CVDWNG	0.985000E+00	FGMWNG	0.310583E+05	FGPWHG	0.617632E+02	FNMING	0.767447E+05	P28	0.132341E+06
FFOVFN	0.178859E+00	FMOVFN	0.288510E+00	FCOVFN	0.532632E+00	FNDVFN	0.932849E+00	P38	0.191546E+06
CVMNOZ	0.985000E+00	VJM	0.563710E+03	CVDNOZ	0.985000E+00	VJD	0.219866E+03	FGP	0.832746E+04

SFC= 0.06201

FN=107864.72

FG=107864.72

MAIN SONIC CONVERGENT NOZZLE  
DUCT SUBSONIC CONVERG. NOZZLE

CONVERGED AFTER 11 LOOPS





TIME= 1.1000

OUTPUT AM= 0.0 ALTP= 0.0 T= 1448.02 ETAR= 1.0000

THREE SPOOL ENGINE  
THE OUTPUT IS IN SI UNITS

PCNF	0.968443E+02	CNF	0.968443E+00	ZF	0.828809E+00	PRF	0.137690E+01	WAF	0.262103E+03
PCNI	0.970481E+02	CNI	0.973399E+00	ZI	0.814576E+00	PRI	0.136908E+03	WAI	0.173967E+03
PCNC	0.984504E+02	CNC	0.991317E+00	ZC	0.826128E+00	PRC	0.725961E+01	WAC	0.862799E+02
T2	0.305349E+03	P2	0.101325E+06	T22	0.338319E+03	P22	0.139515E+06	P21	0.213932E+06
T3	0.721070E+03	P3	0.155307E+07	PCBLF	0.0	BLF	0.0	BLC	0.0
PCBLHP	0.0	BLHP	0.0	PCBLIP	0.0	BLIP	0.0	BLLP	0.0
MA3	0.862799E+02	MFB	0.185800E+01	WG4	0.881236E+02	FAR4	0.215346E-01	T4	0.144763E+07
TFFHP	0.500839E+02	CNHP	0.195139E+01	DHTCHP	0.240430E+03	DHTC	0.347786E+06	P50	0.516574E+06
TFFIP	0.120742E+03	CNIP	0.211455E+01	DHTCIP	0.923740E+02	DHTI	0.107081E+06	P5	0.355587E+06
TFFLP	0.130867E+03	CNLP	0.220462E+01	DHTCLP	0.961481E+02	DHTF	0.103185E+06	P55	0.241554E+06
ETAB	0.983000E+00	PCBLDU	0.0	ETAD	0.0	DPDUC	0.492030E-01	P24	0.132650E+06
MAD	0.881357E+02	MFD	0.0	WG24	0.881327E+02	FAR24	0.0	P25	0.132650E+06
ETAF	0.886071E+00	ETAI	0.872538E+00	ETAC	0.853707E+00	ETATHP	0.0	ETATIP	0.902592E+00
T6	0.991038E+03	P6	0.241554E+06	PS6	0.233119E+06	AM6	0.237292E+00	WG6	0.881176E+02
T7	0.991038E+03	MFA	0.0	WG7	0.881118E+02	FAR7	0.215346E-01	DPAFT	0.0
PS8	0.130960E+06	AM8	0.100000E+01	V8	0.571032E+03	PS9	0.130960E+06	V9	0.571032E+03
PS28	0.101325E+06	AM28	0.631914E+00	V28	0.224246E+03	PS29	0.101325E+06	V29	0.224246E+03
8PRINT	0.101559E+01	DPCDM	0.493928E-01	DPMING	0.999980E-01	PS38	0.101931E+06	V38	0.360896E+03
8YPASS	0.506623E+00	HPEXT	0.0	MFT	0.185800E+01	WGT	0.0	FRD	0.0
PCBLI	0.503869E+00	WG37	0.876491E+02	VJM	0.355482E+03	PS39	0.101931E+06	V39	0.360896E+03
CVDWNG	0.985000E+00	FGPWN	0.134224E+05	FGPWN	0.134224E+05	FNMING	0.775619E+05	P28	0.132650E+06
FFOVFN	0.178836E+00	FMOVFN	0.287467E+00	FCOVFN	0.533697E+00	FMOVFN	0.941403E+00	P38	0.192540E+06
CVMNOZ	0.985000E+00	VJM	0.562467E+03	CVDNOZ	0.985000E+00	VJD	0.220883E+03	FGP	0.866914E+04

SFC= 0.06145

FN=108853.78

FG=108853.78

MAIN SONIC CONVERGENT NOZZLE  
DUCT SUBSONIC CONVERG. NOZZLE

CONVERGED AFTER 11 LOOPS

ORIGINAL PAGE IS  
OF POOR QUALITY

TIME= 1.2000

ETAR= 1.0000

OUTPUT

AM= 0.

ALTP=

0.

T4= 1445.76

THREE SPOOL ENGINE  
THE OUTPUT IS IN SI UNITS

PCNF	CNF	ZF	PRF	WAF	MAF
0.970571E+02	0.970571E+00	0.829998E+00	0.137840E+01	0.270516E+03	0.262785E+03
PCNI	CNI	ZI	PI	WAI	MAI
0.975065E+02	0.975065E+00	0.814551E+00	0.153493E+01	0.137189E+03	0.174480E+03
PCNC	CNC	ZC	PRC	WAC	MAC
0.986314E+02	0.992756E+00	0.825366E+00	0.727111E+01	0.475961E+02	0.866455E+02
T2	P2	T22	P22	T21	P21
0.305349E+03	0.101325E+06	0.338453E+03	0.139667E+06	0.388972E+03	0.214379E+06
T3	P3	PCBLF	BLF	PCBLC	BLC
0.721676E+03	0.155877E+07	0. PCBLP	0.	0.	0.
PCBLHP	BLHP	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.
WA3	WF3	WG4	FAR4	T4	P4
0.866455E+02	0.185800E+01	0.884904E+02	0.214437E-01	0.144576E+04	0.148171E+07
YFFHP	CNHP	DHTCHP	DHTC	T50	P50
0.500753E+02	0.195650E+01	0.240462E+03	0.347353E+06	0.116456E+04	0.518432E+06
TFIP	CNIP	DHTCIP	DHTI	T5	P5
0.120695E+03	0.212043E+01	0.924205E+02	0.107009E+06	0.107580E+04	0.356772E+06
YFFLP	CNLP	DHTCLP	DHTF	T55	P55
0.130816E+03	0.221153E+01	0.962779E+02	0.103178E+06	0.988991E+03	0.242168E+06
ETAB	PCBLDU	ETAD	DRDUC	T24	P24
0.983000E+00	0.	0.	0.492539E-01	0.338452E+03	0.132787E+06
WAD	WFD	WG24	FAR24	T25	P25
0.883054E+02	0.	0.883026E+02	0.	0.338452E+03	0.132787E+06
ETAF	ETAI	ETAC	ETATHP	ETATIP	ETATLP
0.885617E+00	0.872178E+00	0.854368E+00	0.897165E+00	0.894497E+00	0.902489E+00
T6	P6	PS6	AM6	V6	MG6
0.988991E+03	0.242168E+06	0.233700E+06	0.237423E+00	0.144896E+03	0.884857E+02
T7	WFA	MG7	FAR7	ETAA	DPAPT
0.988991E+03	0.	0.884814E+02	0.214437E-01	0.	0.
PS8	AM8	V8	PS9	AM9	V9
0.131355E+06	0.100000E+01	0.570464E+03	0.131355E+06	0.100000E+01	0.570464E+03
PS28	AM28	V28	PS29	AM29	V29
0.101325E+06	0.633164E+00	0.224701E+03	0.101325E+06	0.633164E+00	0.224701E+03
8PRINT	DPCOM	DPMING	PS38	AM38	V38
0.101307E+01	0.494413E-01	0.999989E-01	0.102145E+06	0.100000E+01	0.361035E+03
8YPASS	HPEXT	WFT	WGT	VA	FRD
0.506106E+00	0.	0.185800E+01	0.264643E+03	0.	0.
PCBLI	MG37	VJM	PS39	AM39	V39
0.503247E+00	0.877991E+02	0.355619E+03	0.102145E+06	0.100000E+01	0.361035E+03
CVDWNG	FGMNG	FGPMNG	FNWING	FNMAIN	P28
0.985000E+00	0.312231E+05	0.181784E+03	0.314048E+05	0.779110E+05	0.132787E+06
FEQVFN	FQOVFN	FCOVFN	FHNDFN	FNOVFD	P38
0.178785E+00	0.278285E+00	0.533929E+00	0.712715E+00	0.945399E+00	0.192941E+06
CVMNOZ	VJM	CVDNOZ	VJD	FGM	FGP
0.985000E+00	0.561907E+03	0.985000E+00	0.221331E+03	0.100485E+06	0.883045E+04

SFC= 0.06119

FN=109315.86

FG=109315.86

MAIN SONIC CONVERGENT NOZZLE  
DUCT SUBSONIC CONVERG. NOZZLE

CONVERGED AFTER 11 LOOPS

TIME= 1.3000

AM= 0. ALTP= 0. T4= 1443.67

ETAR= 1 0000

OUTPUT

THREE SPOOL ENGINE  
THE OUTPUT IS IN SI UNITS

0.972583E+02	PCNF	0.829181E+00	ZF	0.137982E+01	PRF	0.271181E+03	WAF	0.263431E+03	WAF
0.974110E+02	PCNI	0.814657E+00	ZI	0.153649E+01	PRI	0.174965E+03	WAI	0.174965E+03	WAI
0.987962E+02	PCNC	0.994042E+00	ZC	0.728084E+01	PRC	0.477023E+02	WACC	0.869860E+02	WACC
0.305349E+03	T2	0.824618E+00	T22	0.338580E+03	P22	0.389264E+03	T21	0.214817E+06	P21
0.722233E+03	T3	0.101325E+06	PCBLF	0.156405E+07	BLF	0.389264E+03	PCBLC	0.389264E+03	BLC
0.869860E+02	PCBLHP	0.156405E+07	PCBLIP	0.156405E+07	BLIP	0.389264E+03	PCBLLP	0.389264E+03	BLIP
0.500676E+02	WA3	0.196119E+01	MG4	0.212602E+01	FAR4	0.116269E+04	T4	0.148665E+07	P4
0.120649E+03	TFFHP	0.88319E+02	DHTCHP	0.240503E+03	DHTC	0.116269E+04	T50	0.520138E+06	P50
0.130770E+03	TFFIP	0.196119E+01	DHTCIP	0.346955E+06	DHTI	0.116269E+04	T5	0.520138E+06	P5
0.987101E+03	TFFLP	0.212602E+01	DHTCLP	0.106941E+06	DHTF	0.107395E+04	T55	0.357863E+06	P55
0.983000E+00	ETAB	0.221803E+01	ETAD	0.103168E+06	DPDUC	0.987102E+03	T24	0.242729E+06	P24
0.884659E+02	WAD	0.964160E+02	MG24	0.493020E-01	FAR24	0.338579E+03	T25	0.132917E+06	P25
0.885191E+00	ETAF	0.884632E+02	ETAC	0.884632E+02	ETATHP	0.338579E+03	T25	0.132917E+06	P25
0.987101E+03	T6	0.871856E+00	PS6	0.854982E+00	AM6	0.894853E+00	ETATIP	0.902338E+00	ETATIP
0.987101E+03	T7	0.242729E+06	MG7	0.234231E+06	FAR7	0.144846E+03	V6	0.888276E+02	WG6
0.131720E+06	PS8	0.100000E+01	V8	0.131720E+06	PS9	0.100000E+01	AM9	0.569938E+03	V9
0.101325E+06	BPRINT	0.634347E+00	DPCOM	0.101325E+06	PS29	0.634347E+00	AM29	0.225132E+03	V29
0.101082E+01	BYPASS	0.494873E-01	HPEXT	0.999993E-01	PS38	0.100000E+01	AM38	0.361170E+03	V38
0.505620E+00	PCBLI	0.879461E+02	MG37	0.879461E+02	MG37	0.879461E+02	AM39	0.361170E+03	V39
0.502690E+00	CVDWNG	0.312870E+05	FGMNG	0.312870E+05	FGMNG	0.312870E+05	FMHAIN	0.132917E+06	P28
0.985000E+00	FFOVFN	0.287154E+00	FVDFN	0.287154E+00	FVDFN	0.287154E+00	FNOVFD	0.193336E+06	P38
0.985000E+00	CVMNOZ	0.985000E+00	VJM	0.985000E+00	VJM	0.985000E+00	FGM	0.898210E+04	FGP
0.985000E+00	CVMNOZ	0.985000E+00	CVDNOZ	0.985000E+00	VJD	0.221755E+03	FGM	0.898210E+04	FGP
0.985000E+00	CVMNOZ	0.985000E+00	CVDNOZ	0.985000E+00	VJD	0.221755E+03	FGM	0.898210E+04	FGP
0.985000E+00	CVMNOZ	0.985000E+00	CVDNOZ	0.985000E+00	VJD	0.221755E+03	FGM	0.898210E+04	FGP

MAIN SONIC CONVERGENT NOZZLE  
DUCT SUBSONIC CONVERG. NOZZLE

CONVERGED AFTER 11 LOOPS

TIME= 1.4000

OUTPUT

AM= 0.

ALTP=

0.

T4= 1441.74

ETAR= 1.0000

THREE SPOOL ENGINE  
THE OUTPUT IS IN SI UNITS

PCNF	0.974485E+02	CNF	0.974485E+00	ZF	0.829362E+00	PRF	0.138116E+01	WAF	0.264041E+03
PCNI	0.975806E+02	CNI	0.978190E+00	ZI	0.814871E+00	PKI	0.153805E+01	WAI	0.175424E+03
PCNC	0.989457E+02	CNC	0.995186E+00	ZC	0.823907E+00	PRC	0.728911E+01	WAC	0.477969E+02
T2	0.305349E+03	P2	0.101325E+06	T22	0.338700E+03	P22	0.139947E+06	T21	0.215245E+06
T3	0.722752E+03	P3	0.156895E+07	PCBLF	0.	BLF	0.	PCBLC	0.
PCBLHP	0.	BLHP	0.	PCBLIP	0.	BLIP	0.	PCBLLP	0.
WA3	0.873025E+02	WFB	0.185800E+01	MG4	0.891492E+02	FAR4	0.212823E-01	T4	0.149124E+07
TFHP	0.500605E+02	CNHP	0.196547E+01	DHTCHP	0.240525E+03	DHTC	0.346571E+06	T50	0.521757E+06
TFFIP	0.120605E+03	CNIP	0.213130E+01	DHTCIP	0.924960E+02	DHTI	0.106875E+06	T5	0.358906E+06
TFFLP	0.130724E+03	CNLP	0.222412E+01	DHTCLP	0.965408E+02	DHTF	0.103160E+06	T55	0.985376E+03
ETAB	0.983000E+00	PCBLDU	0.	ETAD	0.	DPOUC	0.493470E-01	T24	0.338699E+03
WAD	0.886172E+02	WFD	0.	MG24	0.886146E+02	FAR24	0.	T25	0.133041E+06
ETAF	0.884792E+00	ETAI	0.	ETAC	0.855545E+00	ETATHP	0.	ETATIP	0.902190E+00
T6	0.985376E+03	P6	0.243269E+06	PS6	0.234744E+06	AM6	0.237654E+00	V6	0.144791E+03
T7	0.985376E+03	WFA	0.	MG7	0.891412E+02	FAR7	0.212823E-01	ETAA	0.
PS8	0.132060E+06	AM8	0.100000E+01	V8	0.569458E+03	PS9	0.132060E+06	AM9	0.569458E+03
PS28	0.101325E+06	AM28	0.635461E+00	V28	0.22537E+03	PS29	0.101325E+06	AM29	0.225537E+03
8PRAINT	0.100883E+01	DpCOM	0.495300E-01	DPHING	0.100000E+00	PS38	0.102561E+06	AM38	0.361301E+03
BYPASS	0.505161E+00	HPEXT	0.	MFT	0.185800E+01	WGT	0.265899E+03	VA	0.
PCBLI	0.502197E+00	MG37	0.	VJM	0.355881E+03	PS39	0.102561E+06	AM39	0.361301E+03
CVDWNG	0.985000E+00	FGMNG	0.313497E+05	FGPWS	0.273932E+03	FNMING	0.785385E+05	FNMAIN	0.133041E+06
FFOVFN	0.178701E+00	FMOVFN	0.287065E+00	FCOVFN	0.534234E+00	FNOVFN	0.952718E+00	FNOVFD	0.193721E+06
CVMNDZ	0.985000E+00	VJM	0.560916E+03	CVDNDZ	0.985000E+00	VJD	0.222154E+03	FGM	0.912554E+04

MAIN SONIC CONVERGENT NOZZLE  
DUCT SUBSONIC CONVERG. NOZZLE

CONVERGED AFTER 11 LOOPS

FN=110162.15

FG=110162.15

SFC= 0.06072

TIME= 1.5000

OUTPUT

AM= 0.0

ALTP= 0.0

T4= 1439.97

ETAR= 1.0000

THREE SPOOL ENGINE  
THE OUTPUT IS IN SI UNITS

PCNF	CNF	ZF	PRF	WFC	WAF
0.976296E+02	0.829559E+00	0.829559E+00	0.138246E+01	0.272405E+03	0.264620E+03
PCNI	CNI	ZI	PRI	WACI	WAI
0.977413E+02	0.979633E+00	0.815174E+00	0.153960E+01	0.137939E+03	0.175856E+03
PCNC	CNC	ZC	PRC	WACC	MAC
C.990811E+02	0.996198E+00	0.823255E+00	0.729624E+01	0.478807E+02	0.875961E+02
T2	P2	T22	P22	T21	P21
0.305349E+03	0.101325E+06	0.338815E+03	0.140078E+06	0.389820E+03	0.215663E+06
T3	P3	PCBLF	BLF	PCBLC	BLC
0.723243E+03	0.157353E+07	0.0	0.0	0.0	0.0
PCBLHP	BLHP	PCBLIP	BLIP	PCBLLP	BLLP
0.0	0.0	0.0	0.0	0.0	0.0
WAB	WFB	WG4	FAR4	T4	P4
0.875961E+02	0.185800E+01	0.894436E+02	0.212110E-01	0.143997E+04	0.149553E+07
TFFHP	CNHP	DHTCHP	DHTC	T50	P50
0.500540E+02	0.196937E+01	0.240551E+03	0.346216E+06	0.115940E+04	0.523274E+06
TFFIP	CNIP	DHTCIP	DHTI	T5	P5
0.120557E+03	0.213625E+01	0.924856E+02	0.106774E+06	0.107073E+04	0.359951E+06
TFFLP	CNLP	DHTCLP	DHTF	T55	P55
0.130653E+03	0.222984E+01	0.966260E+02	0.103196E+06	0.983795E+03	0.243780E+06
ETAB	PCBLDU	ETAD	DPDUC	T24	P24
0.983000E+00	0.0	0.0	0.493911E-01	0.338814E+03	0.133159E+06
WAD	WFD	WG24	FAR24	T25	P25
0.887644E+02	0.0	0.887619E+02	0.0	0.338814E+03	0.133159E+06
ETAF	ETAI	ETAC	ETATHP	ETATIP	ETATLP
0.884417E+00	0.871131E+00	0.856052E+00	0.897941E+00	0.895580E+00	0.902016E+00
T6	P6	PS6	AM6	V6	MG6
0.983795E+03	0.243780E+06	0.235230E+06	0.237739E+00	0.1444735E+03	0.894396E+02
T7	WFA	WG7	FAR7	ETAA	DPAFT
0.983795E+03	0.0	0.894360E+02	0.212110E-01	0.0	0.0
PS8	AM8	V8	PS9	AM9	V9
0.132376E+06	0.100000E+01	0.569018E+03	0.132376E+06	0.100000E+01	0.569018E+03
PS28	AM28	V28	PS29	AM29	V29
0.101325E+06	0.636544E+00	0.225931E+03	0.101325E+06	0.636544E+00	0.225931E+03
BPRINT	DPCDM	DPWING	PS38	AM38	V38
0.100706E+01	0.495687E-01	0.100000E+00	0.102761E+06	0.100000E+01	0.361428E+03
BYPASS	HPEXT	WFT	WGT	VA	FRD
0.504757E+00	0.0	0.185800E+01	0.266478E+03	0.0	0.0
PCBLI	MG37	VJM	PS39	AM39	V39
0.501759E+00	0.882305E+02	0.356006E+03	0.102761E+06	0.100000E+01	0.361428E+03
CVDWNG	FGWNG	FGPWNG	FNMING	FNMAIN	P28
0.985000E+00	0.314106E+05	0.318224E+03	0.317288E+05	0.788231E+05	0.133159E+06
FDOVFN	FDOVFN	FCOVFN	FMNOFN	FNDVFD	P38
0.178679E+00	0.287004E+00	0.534318E+00	0.712996E+00	0.956089E+00	0.194097E+06
CVMNOZ	VJM	CVDNOZ	VJD	FGN	FGP
C.985000E+00	0.560483E+03	0.985000E+00	0.222542E+03	0.101291E+06	0.926079E+04

FG=110551.95

FN=110551.95

SFC= 0.04050

MAIN SONIC CONVERGENT NOZZLE  
DUCT SUBSONIC CONVERG. NOZZLE

CONVERGED AFTER 11 LOOPS

ORIGINAL PAGE IS  
OF POOR QUALITY

TIME= 1.6000

OUTPUT

AM= 0.

ALTP=

0.

T4= 1438.22

ETAR= 1.0000

THREE SPOOL ENGINE  
THE OUTPUT IS IN SI UNITS

PCNF	0.978002E+02	CNF	0.978002E+00	ZF	0.829767E+00	PRF	0.138369E+01	WAF	0.265165E+03
PCNI	0.978937E+02	CNI	0.981003E+00	ZI	0.815550E+00	PRI	0.154112E+01	WAI	0.176263E+03
PCNC	0.992034E+02	CNC	0.997090E+00	ZC	0.822261E+00	PRC	0.730201E+01	WAC	0.479548E+02
T2	0.305349E+03	P2	0.101325E+06	T22	0.338925E+03	P22	0.149202E+06	T21	0.216068E+06
T3	0.723692E+03	P3	0.157773E+07	PCBLF	0.	BLF	0.	PCBLC	0.
PCBLHP	0.	BLHP	0.	PCBLIP	0.	BLIP	0.	PCBLLP	0.
W3	0.878688E+02	WFB	0.185800E+01	WG4	0.897171E+02	FAR4	0.211452E-01	T4	0.149947E+07
TFFHP	0.	CNHP	0.197300E+01	DHTCHP	0.240578E+03	DHTC	0.345867E+06	T50	0.524650E+06
TFFIP	0.500480E+02	CNIP	0.214101E+01	DHTCIP	0.925047E+02	DHTI	0.106706E+06	T5	0.360848E+06
TFFLP	0.120515E+03	CNLP	0.223533E+01	DHTCLP	0.967258E+02	DHTF	0.103195E+06	T55	0.244227E+06
ETAB	0.130601E+03	PCBLDU	0.	ETAD	0.	DPDUC	0.338923E+03	T24	0.133272E+06
WAD	0.89018E+02	WFD	0.	WG24	0.888995E+02	FAR24	0.338923E+03	T25	0.133272E+06
ETAF	0.884068E+00	ETAI	0.871086E+00	ETAC	0.856521E+00	ETATHP	0.898160E+00	ETATIP	0.901867E+00
T6	0.982236E+03	P6	0.244227E+06	PS6	0.235654E+06	AM6	0.231833E+00	V6	0.144685E+03
T7	0.982236E+03	WFA	0.	WG7	0.897104E+02	FAR7	0.211452E-01	ETA	0.
PS8	0.132662E+06	AM8	0.100000E+01	V8	0.568583E+03	PS9	0.132662E+06	AM9	0.568583E+03
PS28	0.101325E+06	AM28	0.637557E+00	V28	0.226300E+03	PS29	0.101325E+06	AM29	0.226300E+03
BRINT	0.100551E+01	OPCOM	0.496059E-01	DPWING	0.100000E+00	PS38	0.102955E+06	AM38	0.361550E+03
BYPASS	0.504371E+00	HPEXT	0.	WFT	0.185800E+01	WGT	0.267023E+03	VA	0.
PCBLI	0.501373E+00	WG37	0.883669E+02	VJM	0.356126E+03	PS39	0.102955E+06	AM39	0.361550E+03
CVDWNG	0.985000E+00	FGMNG	0.314698E+05	FCOVFN	0.361275E+03	FNWING	0.318311E+05	FNMAIN	0.790840E+05
FDOVFN	0.178661E+00	FMOVFN	0.286986E+00	FNOVFN	0.534354E+00	FNOVFN	0.713014E+00	FNOVFD	0.194461E+06
CVMNOZ	0.985000E+00	VJM	0.560054E+03	CVDNOZ	0.985000E+00	VJD	0.222905E+03	FGM	0.938646E+04

MAIN SONIC CONVERGENT NOZZLE  
DUCT SUBSONIC CONVERG. NOZZLE

FN=110915.06

SFC= 0.06031

CONVERGED AFTER 11 LOOPS

TIME= 1.7030                      AM= 0.                      ALTP= 0.                      T4= 1436.76                      ETAR= 1.0000  
 OUTPUT

PCNF	CNF	ZF	PRF	WAF	MAF
0.979616E+02	0.979616E+00	0.829968E+00	0.138485E+01	0.273495E+03	0.265680E+03
0.980387E+02	0.982306E+00	0.815992E+00	0.154263E+01	0.138363E+03	0.176646E+03
0.993145E+02	0.997882E+00	0.822095E+00	0.730749E+01	0.480203E+02	0.881211E+02
0.305349E+03	0.101325E+06	0.339028E+03	0.140320E+06	0.390337E+03	0.216462E+06
0.724140E+03	0.158179E+07	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.881211E+02	0.185800E+01	0.899698E+02	0.210846E-01	0.143676E+04	0.150328E+07
0.500429E+02	0.197621E+01	0.240631E+03	0.345622E+06	0.115651E+04	0.525895E+06
0.120479E+03	0.214543E+01	0.925332E+02	0.106688E+06	0.106787E+04	0.361633E+06
0.130559E+03	0.224042E+01	0.968245E+02	0.103216E+06	0.980851E+03	0.244596E+06
0.983000E+00	0.0	0.0	0.494706E-01	0.339027E+03	0.133378E+06
0.890331E+02	0.0	0.890309E+02	0.0	0.339027E+03	0.133378E+06
0.883741E+00	0.870884E+00	0.856923E+00	0.898340E+00	0.896196E+00	0.901736E+00
0.980851E+03	0.244596E+06	0.235999E+06	0.237972E+00	0.144675E+03	0.899667E+02
0.980851E+03	0.0	0.899640E+02	0.210846E-01	0.0	0.0
0.132931E+06	0.100000E+01	0.568196E+03	0.132931E+06	0.100000E+01	0.568196E+03
0.101325E+06	0.638524E+00	0.226651E+03	0.101325E+06	0.638524E+00	0.226651E+03
0.100414E+01	0.496361E-01	0.100000E+00	0.103144E+06	0.100000E+01	0.361667E+03
0.504019E+00	0.0	0.185800E+01	0.267538E+03	0.0	0.0
0.501032E+00	0.884991E+02	0.356242E+03	0.103144E+06	0.100000E+01	0.361667E+03
0.985000E+00	0.315271E+05	0.402998E+03	0.19301E+05	0.793293E+05	0.133378E+06
0.178648E+00	0.286988E+00	0.534364E+00	0.713012E+00	0.962228E+00	0.194815E+06
0.985000E+00	0.559673E+03	0.985000E+00	0.223252E+03	0.101754E+06	0.950553E+04

MAIN SONIC CONVERGENT NOZZLE                      FN=111259.40                      SFC= 0.06012  
 DUCT SUBSONIC CONVERG. NOZZLE  
 CONVERGED AFTER 11 LOOPS

**ORIGINAL PAGE IS  
 OF POOR QUALITY**

TIME= 1.8000

OUTPUT AM= 0.0 ALTP= 0.0 T4= 1435.38 ETAR= 1.0000

THREE SPOOL ENGINE  
THE OUTPUT IS IN SI UNITS

PCNF	CNF	ZF	PRF	MAFC	MAF
0.981133E+02	0.981133E+00	0.830173E+00	0.138595E+01	0.273993E+03	0.266163E+03
PCNI	CNI	ZI	PRI	MACI	WAI
0.981759E+02	0.816473E+00	0.816473E+00	0.154410E+01	0.138555E+03	0.177007E+03
PCNC	CNC	ZC	PRC	WACC	WAC
0.994147E+02	0.998579E+00	0.821532E+00	0.731149E+01	0.480783E+02	0.883566E+02
T2	P2	T22	P22	T21	P21
0.305349E+03	0.101325E+06	0.339126E+03	0.140432E+06	0.390580E+03	0.216840E+06
T3	P3	PCBLF	BLF	PC8LC	BLC
0.724532E+03	0.158542E+07	0.0	0.0	0.0	0.0
PCBLHP	BLHP	PCBLIP	BLIP	PC8LLP	8LLP
0.0	0.0	0.0	0.0	0.0	0.0
WA3	WF8	WG4	FAR4	T4	P4
0.883566E+02	0.185800E+01	0.90202E+02	0.210284E-01	0.143538E+04	0.150668E+07
TFFHP	CNHP	DHTCHP	DHTC	T50	P50
0.500380E+02	0.197916E+01	0.240649E+03	0.345333E+06	0.115529E+04	0.527113E+06
TFFIP	CNIP	DHTCIP	DHTI	T5	P5
0.120443E+03	0.214956E+01	0.92510E+02	0.106614E+06	0.106667E+04	0.362435E+06
TFFLP	CNLP	DHTCLP	DHTF	T55	P55
0.130517E+03	0.224514E+01	0.969136E+02	0.103219E+06	0.979625E+03	0.245008E+06
ETAB	PCBLDU	ETAD	DPDUC	T24	P24
0.983000E+00	0.0	0.0	0.495064E-01	0.133479E+06	0.133479E+06
WAD	WFD	WG24	FAR24	T25	P25
0.891556E+02	0.0	0.891535E+02	0.0	0.339125E+03	0.133479E+06
ETAF	ETAI	ETAC	ETATHP	ETATIP	ETATLP
0.883438E+00	0.870703E+00	0.857311E+00	0.898520E+00	0.896478E+00	0.901610E+00
T6	P6	PS6	AM6	V6	MG6
0.979625E+03	0.245008E+06	0.236390E+06	0.238040E+00	0.144632E+03	0.902030E+02
T7	WFA	WG7	FAR7	ETAA	DPAPT
0.979625E+03	0.0	0.902001E+02	0.210284E-01	0.0	0.0
PS8	AM8	V8	PS9	AM9	V9
0.133185E+06	0.100000E+01	0.567854E+03	0.133185E+06	0.100000E+01	0.567854E+03
PS28	AM28	V28	PS29	AM29	V29
0.101325E+06	0.639427E+00	0.226980E+03	0.101325E+06	0.639427E+00	0.226980E+03
BPRINT	DPCOM	DPWING	PS38	AM38	V38
0.100293E+01	0.496681E-01	0.100001E+00	0.103325E+06	0.100000E+01	0.361780E+03
BYPASS	HPEXT	HFT	WGT	VA	FRD
0.503683E+00	0.0	0.185800E+01	0.268021E+03	0.0	0.0
PCBLI	MG37	VJM	PS39	AM39	V39
0.500731E+00	0.886269E+02	0.356353E+03	0.103325E+06	0.100000E+01	0.361780E+03
CVDWNG	FGWNG	FGPMNG	FMWING	FMWAIN	P28
0.985000E+00	0.315825E+05	0.443263E+03	0.320257E+05	0.795604E+05	0.133479E+06
FFOVFN	FMOVFN	FCOVFN	FMNOFN	FNOVFD	P38
0.178629E+00	0.287004E+00	0.534366E+00	0.712996E+00	0.965034E+00	0.195156E+06
CVMNOZ	VJM	CVDNOZ	VJD	FGH	FGP
0.985000E+00	0.559336E+03	0.985000E+00	0.223575E+03	0.101967E+06	0.961898E+04

MAIN SONIC CONVERGENT NOZZLE  
DUCT SUBSONIC CONVERG. NOZZLE  
CONVERGED AFTER 11 LOOPS  
SFC= 0.05994  
FN=111586.17  
FG=111586.17



TIME= 1.9000

OUTPUT

AM= 0.

ALTP=

0.

T4= 1434.12

ETAR= 1.0000

THREE SPOOL ENGINE

THE OUTPUT IS IN SI UNITS

PCNF	CNF	ZF	PRF	MAFC	MAF
0.982558E+02	0.982558E+00	0.830367E+00	0.138699E+01	0.274460E+03	0.266617E+03
PCNI	CNI	ZI	PRI	MACI	MAI
0.983054E+02	0.984702E+00	0.816998E+00	0.154553E+01	0.138735E+03	0.177345E+03
PCNC	CNC	ZC	PRC	MACC	MAC
0.995046E+02	0.999185E+00	0.821000E+00	0.773146E+01	0.481290E+02	0.885733E+02
T2	P2	T22	P22	T21	P21
0.305349E+03	0.101325E+06	0.339218E+03	0.140537E+06	0.390812E+03	0.217204E+06
T3	P3	PCBLF	BLF	PCBLC	BLC
0.724894E+03	0.158877E+07	0.	0.	0.	0.
PCBLHP	BLHP	PCBLIP	BLIP	PCBLLP	BLLP
0.	0.	0.	0.	0.	0.
WA3	WFB	WG4	FAR4	T4	P4
0.885733E+02	0.185800E+01	0.904236E+02	0.209770E-01	0.143412E+04	0.150981E+07
TFFHP	CNHP	DHTCHP	DHTC	T50	P50
0.500334E+02	0.198182E+01	0.240652E+03	0.345051E+06	0.115419E+04	0.528270E+06
TFFIP	CNIP	DHTCIP	DHTI	T5	P5
0.120409E+03	0.215342E+01	0.925647E+02	0.106564E+06	0.106559E+04	0.363203E+06
TFFLP	CNLP	DHTCLP	DHTF	T55	P55
0.130477E+03	0.224954E+01	0.969941E+02	0.103225E+06	0.978518E+03	0.245404E+06
ETAB	PCBLDU	ETAD	DPDUC	T24	P24
0.983000E+00	0.	0.	0.495407E-01	0.339217E+03	0.133574E+06
WAD	WFD	WG24	FAR24	T25	P25
0.892721E+02	0.	0.892701E+02	0.	0.339217E+03	0.133574E+06
ETAF	ETAI	ETAC	ETATHP	ETATIP	ETATLP
0.883155E+00	0.870545E+00	0.857663E+00	0.898688E+00	0.896746E+00	0.901490E+00
T6	P6	PS6	AM6	V6	WG6
0.978518E+03	0.245404E+06	0.236768E+06	0.238086E+00	0.144585E+03	0.904205E+02
T7	WFA	WG7	FAR7	ETAA	DPAPT
0.978518E+03	0.	0.904177E+02	0.209770E-01	0.	0.
PS8	AM8	V8	PS9	AM9	V9
0.133421E+06	0.100000E+01	0.567545E+03	0.133421E+06	0.100000E+01	0.567545E+03
PS28	AM28	V28	PS29	AM29	V29
0.101325E+06	0.640285E+00	0.227292E+03	0.101325E+06	0.640285E+00	0.227292E+03
BPRINT	DPCOM	DPMING	PS38	AM38	V38
0.100187E+01	0.496975E-01	0.100001E+00	0.103500E+06	0.100000E+01	0.361887E+03
BYPASS	HPEXT	WFT	WGT	VA	FRD
0.503380E+00	0.	0.185800E+01	0.268475E+03	0.	0.
PCBLI	WG37	VJM	PS39	AM39	V39
0.500468E+00	0.887497E+02	0.356459E+03	0.103500E+06	0.100000E+01	0.361887E+03
CVDWNG	FGMNG	FGPHNG	FNWING	FNMAIN	P28
0.985000E+00	0.316356E+05	0.481924E+03	0.321175E+05	0.797759E+05	0.133574E+06
FFDVFN	FWDVFN	FCOVFN	FNMOFN	FNNOVFD	P38
0.178617E+00	0.287037E+00	0.534347E+00	0.712963E+00	0.967691E+00	0.195484E+06
CVHNOZ	VJM	CVDNOZ	VJD	FGM	FGP
0.985000E+00	0.559032E+03	0.985000E+00	0.223883E+03	0.102168E+06	0.972545E+04

SFC= 0.05978

FN=111893.44

FG=111893.44

MAIN SJNIC CONVERGENT NOZZLE  
DUCT SUBSONIC CONVERG. NOZZLE

CONVERGED AFTER 11 LOOPS

ORIGINAL PAGE IS  
OF POOR QUALITY

TIME= 2.0000

ETAR= 1.0000

T4= 1432.96

0.

ALTP=

AM= 0.

OUTPUT

THREE SPOOL ENGINE  
THE OUTPUT IS IN SI UNITS

C.983894E+02	PCNF	CNF	ZF	PRF	MAFC	MAF
0.983894E+02	CNI	0.983894E+00	0.830559E+00	0.138797E+01	0.274898E+03	0.267043E+03
0.984274E+02	PCNI	CNI	ZI	PRI	MACI	MAI
0.984274E+02	PCNC	CNC	ZC	PRC	MACC	MAC
0.995853E+02	T2	P2	T22	P22	T21	0.887731E+02
0.305349E+03	T3	P3	PCBLF	BLF	PCBLC	0.217553E+06
0.725228E+03	PCBLHP	BLHP	PCBLIP	BLIP	PCBLLP	0.
0.	MA3	0.	0.	0.	0.	0.
0.887731E+02	TFFHP	WFB	WG4	FAR4	T4	P4
0.500294E+02	TFFIP	CNHP	DHTCHP	DHTC	T50	P50
0.120377E+03	TFFLP	CNIP	DHTCIP	DHTI	T5	P5
0.130441E+03	ETAB	CNLP	DHTCLP	DHTF	T55	P55
0.983000E+00	WAD	PCBLDU	ETAD	DPDUC	T24	P24
0.893813E+02	ETAF	0.	0.	0.495727E-01	0.339303E+03	0.133664E+06
0.882894E+00	T6	P6	PS6	FAR24	T25	P25
0.977501E+03	T7	WFA	WG7	ETATMP	ETATIP	0.133664E+06
0.977501E+03	PS8	AM8	V8	AM6	V6	0.901378E+00
0.133638E+06	PS28	AM28	V28	FAR7	ETAA	0.906213E+02
0.101325E+06	BPRINT	DPCOM	DPWING	PS9	AM9	V9
0.100096E+01	BYPASS	HPEXT	MFT	PS29	AM29	V29
0.503098E+00	PCBLI	WG37	VJM	PS38	AM38	V38
0.500240E+00	CVDWNG	FGMNG	FGPNG	WGT	VA	FRD
0.985000E+00	FFOVFN	FMOVFN	FNOVFN	PS39	AM39	V39
0.178606E+00	CVMNDZ	VJM	CVDNDZ	PS39	AM39	V39
0.985000E+00	0.985000E+00	0.558752E+03	0.985000E+00	0.103668E+06	0.100000E+01	0.567260E+03
				0.103668E+06	0.641089E+00	0.227585E+03
				0.103668E+06	0.100000E+00	0.361990E+03
				0.268901E+03	0.	0.
				0.103668E+06	0.100000E+01	0.361990E+03
				0.322058E+05	0.799758E+05	0.133664E+06
				0.712914E+00	0.970182E+00	0.195798E+06
				0.224171E+03	0.102356E+06	0.982525E+04

MAIN SONIC CONVERGENT NOZZLE  
DUCT SUBSONIC CONVERG. NOZZLE

FN=112181.53

SFC= 0.05962

CONVERGED AFTER 11 LOOPS

TIME= 2.1000

ETAR= 1.0000

T4= 1431.89

0.

ALTP=

AM= 0.

OUTPUT

THREE SPOOL ENGINE  
THE OUTPUT IS IN SI UNITS

PCNF	0.985145E+02	CNF	0.985145E+00	ZF	0.830753E+00	PRF	0.138889E+01	WAF	0.275307E+03	WAF	0.267440E+03
PCNI	0.985421E+02	CNI	0.985421E+00	ZI	0.818136E+00	PRI	0.154828E+01	MACI	0.139057E+03	WAI	0.177957E+03
PCNC	0.996571E+02	CNC	0.100016E+01	ZC	0.820022E+00	PRC	0.731902E+01	WACC	0.882135E+02	WAC	0.889614E+02
T2	0.305349E+03	P2	0.101325E+06	T22	0.339385E+03	P22	0.140729E+06	T21	0.391245E+03	P21	0.217888E+06
T3	0.725561E+03	P3	0.159473E+07	PCBLF	0.0.	BLF	0.0.	PC8LC	0.0.	BLC	0.0.
PCBLHP	0.0.	BLHP	0.0.	PCBLIP	0.0.	BLIP	0.0.	PCBLLP	0.0.	BLLP	0.0.
WA3	0.889614E+02	WFB	0.0.	MG4	0.0.	FAR4	0.0.	T4	0.0.	P4	0.0.
TFFHP	0.500256E+02	CNHP	0.185800E+01	DHTCHP	0.908127E+02	DHTC	0.208855E-01	T50	0.143189E+04	P50	0.151599E+07
TFFIP	0.120347E+03	CNIP	0.198640E+01	DHTCIP	0.240654E+03	DHTI	0.344567E+06	T5	0.115225E+04	P5	0.530300E+06
TFFLP	0.130406E+03	CNLP	0.216043E+01	DHTCLP	0.925879E+02	DHTF	0.106471E+06	T55	0.106368E+04	P55	0.364558E+06
ETAB	0.983000E+00	PCBLDU	0.225749E+01	ETAD	0.971403E+02	OPDUC	0.103228E+06	T24	0.976562E+03	P24	0.246107E+06
WAD	0.894836E+02	WFD	0.0.	MG24	0.0.	FAR24	0.496024E-01	T25	0.339384E+03	P25	0.133749E+06
ETAF	0.882653E+00	ETAI	0.0.	ETAC	0.894818E+02	ETATHP	0.0.	ETATIP	0.339384E+03	ETATLP	0.133749E+06
T6	0.976562E+03	P6	0.870285E+00	PS6	0.858226E+00	AM6	0.898781E+00	V6	0.897237E+00	MG6	0.901273E+00
T7	0.976562E+03	WFA	0.246107E+06	MG7	0.237439E+06	FAR7	0.238178E+00	ETAA	0.144506E+03	DPAF	0.908102E+02
PS8	0.133844E+06	AMB	0.0.	V8	0.908077E+02	PS9	0.208855E-01	AM9	0.0.	V9	0.0.
PS28	0.101325E+06	AM28	0.100000E+01	V28	0.566998E+03	PS29	0.133844E+06	AM29	0.100000E+01	V29	0.566998E+03
BPRINT	0.100007E+01	DPCDM	0.641843E+00	DPWING	0.227859E+03	PS38	0.1013225E+06	AM38	0.641843E+00	V38	0.227859E+03
BYPASS	0.502839E+00	HPEXT	0.497516E-01	MFT	0.999956E-01	WGT	0.103822E+06	VA	0.100000E+01	FRD	0.362087E+03
PCBLI	0.500016E+00	MG37	0.0.	VJM	0.185800E+01	PS39	0.269298E+03	AM39	0.0.	V39	0.0.
CVDWNG	0.985000E+00	FGWNG	0.889758E+02	FGPWNG	0.356656E+03	FNMING	0.103822E+06	FNMAIN	0.100000E+01	P28	0.362087E+03
FDOVFN	0.178596E+00	FMOVFN	0.317338E+05	FCOVFN	0.317338E+03	FMNOFN	0.222871E+05	FNOVFD	0.801643E+05	P38	0.133749E+06
CVMNOZ	0.985000E+00	VJM	0.287120E+00	CVDNOZ	0.534283E+00	VJD	0.712880E+00	FGM	0.972516E+00	FGP	0.196100E+06
			0.558493E+03		0.985000E+00		0.224441E+03		0.102533E+06		0.991872E+04

SFC= 0.05948

FN=112451.34

FG=112451.34

MAIN SONIC CONVERGENT NOZZLE  
DUCT SUBSONIC CONVERG. NOZZLE

CONVERGED AFTER 11 LOOPS

TIME= 2.2000

ETAR= 1.0000

OUTPUT

AM= 0.

ALTP=

0.

T4= 1430.47

THREE SPOOL ENGINE  
THE OUTPUT IS IN SI UNITS

PCNF	CNF	ZF	PRF	MAFC	MAF
0.986316E+02	0.986316E+00	0.830912E+00	0.138974E+01	0.275693E+03	0.275693E+03
PCNF	CNF	ZI	PRF	MACI	MAI
0.986501E+02	0.987801E+00	0.818621E+00	0.154951E+01	0.139205E+03	0.178236E+03
PCNC	CNC	ZC	PRC	MACC	MAC
0.997189E+02	0.100072E+01	0.819621E+00	0.732337E+01	0.482677E+02	0.891796E+02
T2	P2	T22	P22	Y21	P21
0.305349E+03	0.101325E+06	0.339461E+03	0.140816E+06	0.391297E+03	0.218196E+06
T3	P3	PCBLF	BLF	PCBLC	BLC
0.725723E+03	0.159793E+07	0.	0.	0.	0.
PCBLHP	BLHP	PCBLIP	BLIP	PCBLLP	BLLP
0.	0.	0.	0.	0.	0.
WA3	WF8	WG4	FAR4	T4	P4
0.891796E+02	0.185800E+01	0.910302E+02	0.208344E-01	0.143047E+04	0.151838E+07
TFFHP	CNHP	DHTCHP	DHTC	T50	P50
0.500223E+02	0.198862E+01	0.240719E+03	0.344280E+06	0.115099E+04	0.531304E+06
TFFLP	CNIP	DHTCIP	DHTI	T5	P5
0.120319E+03	0.216398E+01	0.926175E+02	0.106101E+06	0.110627E+04	0.365623E+06
TFFLP	CNLP	DHTCLP	DHTF	T55	P55
0.130373E+03	0.226121E+01	0.972083E+02	0.103183E+06	0.975604E+03	0.246765E+06
ETAB	PCBLDU	ETAD	DPDUC	T24	P24
0.983000E+00	0.	0.	0.496298E-01	0.339460E+03	0.133827E+06
WAD	WFD	WG24	FAR24	T25	P25
0.895779E+02	0.	0.895763E+02	0.	0.339460E+03	0.133827E+06
ETAF	ETAI	ETAC	ETATHP	ETATIP	ETATLP
0.882426E+00	0.870160E+00	0.858372E+00	0.899090E+00	0.897459E+00	0.901170E+00
T6	P6	PS6	AM6	V6	WG6
0.975604E+03	0.246765E+06	0.238088E+06	0.237968E+00	0.144315E+03	0.910266E+02
T7	WFA	WG7	FAR7	ETAA	DPAFT
0.975604E+03	0.	0.910218E+02	0.208344E-01	0.	0.
PS8	AM8	V8	PS9	AM9	V9
0.134084E+06	0.100000E+01	0.566730E+03	0.134084E+06	0.100000E+01	0.566730E+03
PS28	AM28	V28	PS29	AM29	V29
0.101325E+06	0.642538E+00	0.228112E+03	0.101325E+06	0.642538E+00	0.228112E+03
BPRINT	DPCOM	DPMING	PS38	AM38	V38
0.998275E+00	0.497794E-01	0.999288E-01	0.103899E+06	0.100000E+01	0.362112E+03
BYPASS	HPEXT	WFT	HGT	VA	FRD
0.502579E+00	0.	0.185800E+01	0.269672E+03	0.	0.
PCBLI	WG37	VJM	PS39	AM39	V39
0.499568E+00	0.890361E+02	0.356680E+03	0.103899E+06	0.100000E+01	0.362112E+03
CYDWMG	FGMNG	FGPMNG	FWMING	FNMAIN	P28
0.985000E+00	0.317574E+05	0.570490E+03	0.323279E+05	0.803726E+05	0.133827E+06
FFOVFN	FNOVFN	FCOVFN	FNDVFN	FNOVFD	P38
0.178588E+00	0.286848E+00	0.534564E+00	0.713152E+00	0.974670E+00	0.196392E+06
CVMNOZ	VJM	CVDNOZ	VJD	FGM	FGP
0.985000E+00	0.558229E+03	0.985000E+00	0.224691E+03	0.102695E+06	0.100051E+05

SFC= 0.05935

FN=112700.48

FG=112700.48

MAIN SONIC CONVERGENT NOZZLE  
DUCT SUBSONIC CONVERG. NOZZLE

CONVERGED AFTER 11 LOOPS



TIME= 2.4000

OUTPUT

AM= 0.0 ETAR= 1.0000

ALTP= 0.0 T4= 1428.92

THREE SPOOL ENGINE  
THE OUTPUT IS IN SI UNITS

PCNF	CNCF	ZF	PRF	WAF	WAF
0.988456E+02	0.988456E+00	0.830983E+00	0.139120E+01	0.276412E+03	0.268513E+03
PCNI	CNI	ZI	PRI	WACI	WAI
0.988620E+02	0.988620E+00	0.819438E+00	0.155187E+01	0.139505E+03	0.178773E+03
PCNC	CNC	ZC	PRC	WACC	WAC
0.998156E+02	0.100123E+01	0.818966E+00	0.732523E+01	0.483192E+02	0.894678E+02
T2	P2	T22	P22	T21	P21
0.305349E+03	0.101325E+06	0.339591E+03	0.140963E+06	0.391654E+03	0.218756E+06
T3	P3	PCBLF	BLF	PCBLC	BLC
0.726313E+03	0.160244E+07	0.0	0.0	0.0	0.0
PCBLHP	BLHP	PCBLIP	BLIP	PCBLLP	BLLP
0.0	0.0	0.0	0.0	0.0	0.0
WA3	WFB	MG4	FAR4	T4	P4
0.894678E+02	0.185800E+01	0.913205E+02	0.207672E-01	0.142892E+04	0.152261E+07
TFFHP	CNHP	DHTCHP	DHTC	T50	P50
0.500166E+02	0.199163E+01	0.240644E+03	0.343832E+06	0.114972E+04	0.533062E+06
TFFIP	CNIP	DHTCIP	DHTI	T5	P5
0.120266E+03	0.216982E+01	0.926295E+02	0.106335E+06	0.106122E+04	0.366424E+06
TFFLP	CNLP	DHTCLP	DHTF	T55	P55
0.130310E+03	0.226770E+01	0.973205E+02	0.103223E+06	0.974049E+03	0.247098E+06
ETAB	PCBLDU	ETAD	DPDUC	T24	P24
0.983000E+00	0.0	0.0	0.496771E-01	0.339590E+03	0.133960E+06
WAD	WFD	MG24	FAR24	T25	P25
0.897401E+02	0.0	0.897387E+02	0.0	0.339590E+03	0.133960E+06
ETAF	ETAI	ETAC	ETATHP	ETATIP	ETATLP
0.881991E+00	0.869885E+00	0.858597E+00	0.897879E+00	0.900979E+00	0.900979E+00
T6	P6	PS6	AM6	V6	MG6
0.974049E+03	0.247098E+06	0.238391E+06	0.238221E+00	0.144361E+03	0.913186E+02
T7	MFA	MG7	FAR7	ETAA	DPAFT
0.974049E+03	0.0	0.913170E+02	0.207672E-01	0.0	0.0
PS8	AMB	V8	PS9	AM9	V9
0.134397E+06	0.100000E+01	0.566295E+03	0.134397E+06	0.100000E+01	0.566295E+03
PS28	AM28	V28	PS29	AM29	V29
0.101325E+06	0.643735E+00	0.228548E+03	0.101325E+06	0.643735E+00	0.228548E+03
8PRINT	DPCOM	DPWING	PS38	AM38	V38
0.997935E+00	0.498198E-01	0.100001E+00	0.104243E+06	0.100000E+01	0.362277E+03
BYPASS	HPEXT	WFT	WGT	VA	FRD
0.501978E+00	0.0	0.185800E+01	0.270371E+03	0.0	0.0
PCBLI	MG37	VJM	PS39	AM39	V39
0.499483E+00	0.892892E+02	0.356843E+03	0.104243E+06	0.100000E+01	0.362277E+03
CVDWNG	FGWNG	FGPNG	FNWING	FNMA IN	P28
0.985000E+00	0.318622E+05	0.646672E+03	0.325088E+05	0.806634E+05	0.133960E+06
FFOVFN	FMOVFN	FCOVFN	FNDVFN	FNOVFD	P38
0.178506E+00	0.287251E+00	0.534243E+00	0.712749E+00	0.978750E+00	0.196881E+06
CVMNDZ	VJM	CVDNDZ	VJD	FGM	FGP
0.985000E+00	0.357800E+03	0.985000E+00	0.225120E+03	0.103001E+06	0.101715E+05

MAIN SONIC CONVERGENT NOZZLE  
DUCT SUBSONIC CONVERG. NOZZLE

FN=113172.22

SFC= 0.05910

CONVERGED AFTER 11 LOOPS



TIME= 2.6000

OUTPUT

ETAR= 1.0000

T4= 1427.55

0.

ALTP=

AM= 0.

THREE SPOOL ENGINE  
THE OUTPUT IS IN SI UNITS

PCNF	CNF	ZF	PRF	WAF	MAF	WAF
C.990318E+02	0.990318E+00	0.831245E+00	0.139256E+01	0.277024E+03	0.277024E+03	0.269108E+03
PCNI	CNI	ZI	PRI	WACI	WACI	WAI
0.990467E+02	0.990467E+00	0.820945E+00	0.155445E+01	0.139739E+03	0.139739E+03	0.179217E+03
PCNC	CNC	ZC	PRC	WACC	WACC	WAC
0.998872E+02	0.100150E+01	0.818277E+00	0.732349E+01	0.483472E+02	0.483472E+02	0.897183E+02
T2	P2	T22	P22	T21	T21	P21
0.305349E+03	0.101325E+06	0.339711E+03	0.141101E+06	0.392007E+03	0.392007E+03	0.219335E+06
T3	P3	PCBLF	BLF	PCBLC	PCBLC	BLC
0.726794E+03	0.160630E+07	0.160630E+07	0.160630E+07	0.160630E+07	0.160630E+07	0.160630E+07
PCBLHP	BLHP	PCBLIP	BLIP	PCBLLP	PCBLLP	BLLP
0.	0.	0.	0.	0.	0.	0.
WA3	WFB	WG4	FAR4	T4	T4	P4
0.897183E+02	0.185800E+01	0.915721E+02	0.207093E-01	0.142755E+04	0.142755E+04	0.152622E+07
TFFHP	CNHP	DHTCHP	DHTC	T50	T50	P50
0.500123E+02	0.199401E+01	0.240627E+03	0.343495E+06	0.114856E+04	0.114856E+04	0.534436E+06
TFFIP	CNIP	DHTCIP	DHTI	T5	T5	P5
0.120221E+03	0.217497E+01	0.926480E+02	0.106290E+06	0.106007E+04	0.106007E+04	0.367339E+06
TFFLP	CNLP	DHTCLP	DHTF	T55	T55	P55
0.130259E+03	0.227321E+01	0.974170E+02	0.103231E+06	0.972869E+03	0.972869E+03	0.247577E+06
ETAB	PCBLDU	ETAD	DPDUC	T24	T24	P24
0.983000E+00	0.	0.	0.497207E-01	0.339710E+03	0.339710E+03	0.134085E+06
WAD	WFD	WG24	FAR24	T25	T25	P25
0.898908E+02	0.	0.898895E+02	0.	0.339710E+03	0.339710E+03	0.134085E+06
ETAF	ETAI	ETAC	ETATHP	ETATIP	ETATIP	ETATLP
0.881639E+00	0.869781E+00	0.858818E+00	0.899483E+00	0.898238E+00	0.898238E+00	0.900817E+00
T6	P6	PS6	AM6	V6	V6	WG6
0.972869E+03	0.247577E+06	0.238848E+06	0.238262E+00	0.144305E+03	0.144305E+03	0.915704E+02
T7	WFA	WG7	FAR7	ETAA	ETAA	DPAFT
C.972869E+03	0.	0.915688E+02	0.207093E-01	0.	0.	0.
PS8	AMB	V8	PS9	AM9	AM9	V9
0.134675E+06	0.100000E+01	0.565964E+03	0.134675E+06	0.100000E+01	0.100000E+01	0.565964E+03
PS28	AM28	V28	PS29	AM29	AM29	V29
0.101325E+06	0.644845E+00	0.228952E+03	0.101325E+06	0.644845E+00	0.644845E+00	0.228952E+03
BPRINT	DPCOM	DPWING	PS38	AM38	AM38	V38
0.997357E+00	0.498558E-01	0.100001E+00	0.104521E+06	0.100000E+01	0.100000E+01	0.362440E+03
BYPASS	HPEXT	WFT	WGT	VA	VA	FRD
0.501574E+00	0.	0.185800E+01	0.270966E+03	0.	0.	0.
PCBLI	MG37	VJM	PS39	AM39	AM39	V39
0.499338E+00	0.894855E+02	0.357003E+03	0.104521E+06	0.100000E+01	0.100000E+01	0.362440E+03
CVDWNG	FGMNG	FGPNG	FNWING	FMNAIN	FMNAIN	P28
0.985000E+00	0.319466E+05	0.708105E+03	0.329547E+05	0.803408E+06	0.803408E+06	0.134085E+06
FDOVFN	FDOVFN	FDOVFN	FMNOFN	FNOVFD	FNOVFD	P38
0.178482E+00	0.234010E+00	0.234010E+00	0.712492E+00	0.982264E+00	0.982264E+00	0.197401E+06
CVMNOZ	VJM	CVDNOZ	VJD	FGH	FGH	FGP
0.985000E+00	0.557475E+03	0.985000E+00	0.225518E+03	0.103266E+06	0.103266E+06	0.103129E+05

SFC= 0.05889

FN=113578.48

FG=113578.48

MAIN SONIC CONVERGENT NOZZLE  
DUCT SUBSONIC CONVERG. NOZZLE

CONVERGED AFTER 11 LOOPS



TIME= 2.7000

ETAR= 1.0000

T4= 1427.02

ALTP= 0.

AM= 0.

OUTPUT

THREE SPOOL ENGINE  
THE OUTPUT IS IN SI UNITS

PCNF	AM	ALTP	0.	T4	0.	WAF	ETAR
0.991186E+02	0.991186E+00	0.991186E+00	0.831382E+00	0.139320E+01	0.277309E+03	0.269385E+03	
0.991321E+02	0.992179E+00	0.992179E+00	0.821674E+00	0.155567E+01	0.139847E+03	0.179423E+03	
0.999191E+02	0.100160E+01	0.100160E+01	0.818301E+00	0.732513E+01	0.483574E+02	0.898274E+02	
0.305349E+03	0.101325E+06	0.101325E+06	0.339768E+03	0.141166E+06	0.392173E+03	0.219608E+06	
0.727130E+03	0.160866E+07	0.160866E+07	0.339768E+03	0.141166E+06	0.392173E+03	0.219608E+06	
0.898274E+02	0.185800E+01	0.185800E+01	0.916799E+02	0.206824E-01	0.142702E+04	0.152846E+07	
0.500121E+02	0.199502E+01	0.199502E+01	0.240809E+03	0.343657E+06	0.114786E+04	0.534655E+06	
0.120210E+03	0.217751E+01	0.217751E+01	0.927189E+02	0.106374E+06	0.105929E+04	0.367301E+06	
0.130245E+03	0.227604E+01	0.227604E+01	0.974800E+02	0.103320E+06	0.971992E+03	0.247377E+06	
0.983000E+00	0.983000E+00	0.983000E+00	0.983000E+00	0.983000E+00	0.983000E+00	0.983000E+00	
0.899619E+02	0.899619E+02	0.899619E+02	0.899619E+02	0.899619E+02	0.899619E+02	0.899619E+02	
0.881478E+00	0.881478E+00	0.881478E+00	0.881478E+00	0.881478E+00	0.881478E+00	0.881478E+00	
0.971992E+03	0.247377E+06	0.247377E+06	0.238627E+06	0.238649E+00	0.144477E+03	0.916799E+02	
0.971992E+03	0.247377E+06	0.247377E+06	0.916814E+02	0.206824E-01	0.206824E-01	0.916799E+02	
0.134772E+06	0.100000E+01	0.100000E+01	0.565718E+03	0.134772E+06	0.100000E+01	0.565718E+03	
0.101325E+06	0.645369E+00	0.645369E+00	0.229143E+03	0.101325E+06	0.645369E+00	0.229143E+03	
0.997160E+00	0.498548E-01	0.498548E-01	0.100003E+00	0.104653E+06	0.100000E+01	0.362516E+03	
0.501397E+00	0.501397E+00	0.501397E+00	0.185800E+01	0.271243E+03	0.271243E+03	0.185800E+01	
0.499289E+00	0.895794E+02	0.895794E+02	0.357079E+03	0.104653E+06	0.100000E+01	0.362516E+03	
0.985000E+00	0.319869E+05	0.319869E+05	0.737400E+03	0.327243E+05	0.810252E+05	0.134144E+06	
0.178503E+00	0.287687E+00	0.287687E+00	0.533809E+00	0.712313E+00	0.983742E+00	0.197647E+06	
0.985000E+00	0.557232E+03	0.557232E+03	0.985000E+00	0.225706E+03	0.103379E+06	0.103702E+05	

FN=113749.44

FG=113749.44

MAIN SONIC CONVERGENT NOZZLE  
DUCT SUBSONIC CONVERG. NOZZLE

CONVERGED AFTER 11 LOOPS

SFC= 0.05880

ORIGINAL PAGE IS  
OF POOR QUALITY

TIME= 2.8000

OUTPUT

AM= 0.

ALTP=

0.

T4= 1426.43

ETAR= 1.0000

THREE SPOOL ENGINE  
THE OUTPUT IS IN SI UNITS

PCNF	CNF	ZF	PRF	MAFC	MAF
0.991968E+02	0.991968E+00	0.831520E+00	0.139379E+01	0.277564E+03	0.269633E+03
PCNI	CNI	ZI	PRI	WACI	WAI
0.992095E+02	0.992095E+00	0.822408E+00	0.159683E+01	0.139941E+03	0.179608E+03
PCNC	CNC	ZC	PRC	WACC	WAC
0.999433E+02	0.100165E+01	0.817775E+00	0.732170E+01	0.483638E+02	0.899321E+02
T2	P2	T22	P22	T21	P21
0.305349E+03	0.101325E+06	0.339819E+03	0.141225E+06	0.392327E+03	0.219863E+06
T3	P3	PCBLF	BLF	PCBLC	BLC
0.727241E+03	0.160977E+07	0.	0.	0.	0.
PCBLHP	BLHP	PCBLIP	BLIP	PCBLLP	BLLP
0.	0.	0.	0.	0.	0.
WA3	WFB	WG4	FAR4	T4	P4
0.899321E+02	0.185800E+01	0.917876E+02	0.206600E-01	0.142643E+04	0.152947E+07
TFHP	CNHP	DHTCHP	DHTC	T50	P50
0.500093E+02	0.199592E+01	0.240655E+03	0.343275E+06	0.114756E+04	0.535543E+06
TFIP	CNIP	DHTCIP	DHTI	T5	P5
0.120185E+03	0.217950E+01	0.926825E+02	0.106279E+06	0.105906E+04	0.368034E+06
YFFLP	CNLP	DHTCLP	DHTF	T55	P55
0.130221E+03	0.227809E+01	0.975100E+02	0.103266E+06	0.971799E+03	0.247894E+06
ETAB	PCBLDU	ETAD	DPDUC	T24	P24
0.983000E+00	0.	0.	0.497597E-01	0.339818E+03	0.134198E+06
WAD	WFD	WG24	FAR24	T25	P25
0.900264E+02	0.	0.900253E+02	0.	0.339818E+03	0.134198E+06
ETAF	ETAI	ETAC	ETATHP	ETATIP	ETATLP
0.881336E+00	0.869712E+00	0.858967E+00	0.898591E+00	0.898527E+00	0.900681E+00
T6	P6	PS6	AM6	V6	WG6
0.971799E+03	0.247894E+06	0.239145E+06	0.238380E+00	0.144303E+03	0.917847E+02
T7	WFA	WG7	FAR7	ETAA	DPAFT
0.971799E+03	0.	0.917810E+02	0.206600E-01	0.	0.
PS8	AMB	V8	PS9	AM9	V9
0.134902E+06	0.100000E+01	0.565664E+03	0.134902E+06	0.100000E+01	0.565664E+03
PS28	AM28	V28	PS29	AM29	V29
0.101325E+06	0.645844E+00	0.229316E+03	0.101325E+06	0.645844E+00	0.229316E+03
BPRINT	DPCDM	DPWING	PS38	AM38	V38
0.997012E+00	0.498821E-01	0.100001E+00	0.104773E+06	0.100000E+01	0.362587E+03
BYPASS	HPEXT	WFT	WGT	VA	FRD
0.501243E+00	0.	0.185800E+01	0.271491E+03	0.	0.
PCBLI	WG37	VJM	PS39	AM39	V39
0.499252E+00	0.896647E+02	0.357149E+03	0.104773E+06	0.100000E+01	0.362587E+03
CVDWNG	FGWNG	FGPWNG	FNMING	FNMAIN	P28
0.985000E+00	0.320236E+05	0.764116E+03	0.327877E+05	0.811433E+05	0.134198E+06
FFOVFN	FMOVFN	FCOVFN	FMDVFN	FNDVFD	P38
0.178481E+00	0.287786E+00	0.533733E+00	0.712214E+00	0.985313E+00	0.197877E+06
CVMNOZ	VJM	CVDNOZ	VJD	FGM	FGP
0.985000E+00	0.557179E+03	0.985000E+00	0.225876E+03	0.103497E+06	0.104344E+05

MAIN SONIC CONVERGENT NOZZLE  
DUCT SUBSONIC CONVERG. NOZZLE

FN=113931.04

SFC= 0.05871

CONVERGED AFTER 11 LOOPS

TIME= 2.9000

OUTPUT

THREE SPOOL ENGINE

THE OUTPUT IS IN SI UNITS

ETAR= 1.0000

T4= 1425.92

0.

ALTP=

AM= 0.

PCNF	CNF	ZF	PRF	WAF	WAF
0.992691E+02	0.992691E+00	0.831651E+00	0.139433E+01	0.277800E+03	0.269862E+03
PCNI	CNI	ZI	PRI	WACI	WAI
0.992812E+02	0.993527E+00	0.823114E+00	0.155791E+01	0.140029E+03	0.179776E+03
PCNC	CNC	ZC	PRC	WACC	WAC
0.999639E+02	0.100167E+01	0.817506E+00	0.731992E+01	0.483669E+02	0.900182E+02
T2	P2	T22	P22	T21	P21
0.305349E+03	0.101325E+06	0.339867E+03	0.141280E+06	0.392471E+03	0.220103E+06
T3	P3	PCBLF	BLF	PCBLC	BLC
0.727411E+03	0.161113E+07	0.	0.	0.	0.
PCBLHP	BLHP	PCBLIP	BLIP	PCBLLP	BLLP
0.	0.	0.	0.	0.	0.
WA3	WFB	WG4	FAR4	T4	P4
0.900182E+02	0.185800E+01	0.918730E+02	0.206385E-01	0.142592E+04	0.153075E+07
TFFHP	CNHP	DHTCHP	DHTC	T50	P50
0.500080E+02	0.199669E+01	0.240664E+03	0.343169E+06	0.114710E+04	0.535982E+06
TFFIP	CNIP	DHTCIP	DHTI	T5	P5
0.120168E+03	0.218151E+01	0.926292E+02	0.106272E+06	0.105860E+04	0.368324E+06
TFFLP	CNLP	DHTCLP	DHTF	T55	P55
0.130199E+03	0.228024E+01	0.975448E+02	0.103276E+06	0.971323E+03	0.248027E+06
ETAB	PCBLDU	ETAD	DPDUC	T24	P24
0.983000E+00	0.	0.	0.497771E-01	0.339865E+03	0.134248E+06
WAD	WFD	WG24	FAR24	T25	P25
0.900866E+02	0.	0.900856E+02	0.	0.339865E+03	0.134248E+06
ETAF	ETAI	ETAC	ETATHP	ETATIP	ETATLP
0.881206E+00	0.869691E+00	0.859045E+00	0.899636E+00	0.898663E+00	0.900614E+00
T6	P6	PS6	AM6	V6	WG6
0.971323E+03	0.248027E+06	0.239270E+06	0.238418E+00	0.144293E+03	0.918719E+02
T7	MFA	WG7	FAR7	ETAA	DPAFT
0.971323E+03	0.	0.918709E+02	0.206385E-01	0.	0.
PS8	AM8	V8	PS9	AM9	V9
0.134997E+06	0.100000E+01	0.565531E+03	0.134997E+06	0.100000E+01	0.565531E+03
PS28	AM28	V28	PS29	AM29	V29
0.101325E+06	0.646287E+00	0.229477E+03	0.101325E+06	0.646287E+00	0.229477E+03
BPRINT	DPCOM	DPWING	PS38	AM38	V38
0.996958E+00	0.498935E-01	0.100002E+00	0.104889E+06	0.100000E+01	0.362654E+03
BYPASS	HPEXT	WFT	WGT	VA	FRD
0.501105E+00	0.	0.185800E+01	0.271720E+03	0.	0.
PCBLI	WG37	VJM	PS39	AM39	V39
0.499238E+00	0.897471E+02	0.357214E+03	0.104889E+06	0.100000E+01	0.362654E+03
CVDWNG	FGWNG	FGPNG	FNWING	FNMAIN	P28
0.985000E+00	0.320589E+05	0.789797E+03	0.328487E+05	0.812365E+05	0.134248E+06
FFOVFN	FHOVFN	FDOVFN	FMNOFN	FNOVFD	P38
0.178485E+00	0.287931E+00	0.533584E+00	0.712069E+00	0.986646E+00	0.198092E+06
CVMNOZ	VJM	CVDNOZ	VJD	FCM	FGP
0.985000E+00	0.557048E+03	0.985000E+00	0.226035E+03	0.103398E+06	0.104874E+05
MAIN SONIC CONVERGENT NOZZLE	FG=114085.21	FN=114085.21	SFC= 0.05863		
DUCT SUBSONIC CONVERG. NOZZLE					
CONVERGED AFTER 11 LOOPS					

ORIGINAL PAGE IS OF POOR QUALITY

TIME= 3.0000

OUTPUT

ETAR= 1.0000

T4= 1425.46

0.

ALTP=

AM= 0.

THREE SPOOL ENGINE  
THE OUTPUT IS IN SI UNITS

PCNF	C.993348E+02	CNF	0.993348E+00	ZF	0.831783E+00	PRF	0.139483E+01	WAF	0.270070E+03
PCNI	C.993467E+02	CNI	0.993467E+00	ZI	0.823817E+00	PR1	0.155895E+01	WAI	0.140106E+03
PCNC	C.999798E+02	CNC	0.999798E+00	ZC	0.817143E+00	PRC	0.731696E+01	WAC	0.900970E+02
T2	0.305349E+03	P2	0.101325E+06	T22	0.339910E+03	P22	0.141331E+06	P21	0.220328E+06
T3	C.727519E+03	P3	0.161213E+07	PC8LF	0.	BLF	0.	BLC	0.
PCBLHP	0.	BLHP	0.	PC8LIP	0.	BLIP	0.	BLLP	0.
WA3	C.900970E+02	WFB	0.185800E+01	WG4	0.919527E+02	FAR4	0.206205E-01	P4	0.153167E+07
TFFHP	0.500064E+02	CNHP	0.199732E+01	DHTCHP	0.240593E+03	DHTC	0.342951E+06	P50	0.536552E+06
TFFIP	C.120149E+03	CNIP	0.218324E+01	DHTCIP	0.926810E+02	DHTI	0.105822E+06	P5	0.368763E+06
TFFLP	C.130179E+03	CNLP	0.228204E+01	DHTCLP	0.975721E+02	DHTF	0.103256E+06	P55	0.248309E+06
ETAB	C.983000E+00	PCBLDU	0.	ETAD	0.	DPDUC	0.497929E-01	P24	0.134294E+06
WAD	0.901418E+02	WFD	0.	WG24	0.901408E+02	FAP24	0.	P25	0.134294E+06
ETAF	C.881090E+00	ETAI	0.869682E+00	ETAC	0.859149E+00	ETATHP	0.	ETATLP	0.900556E+00
T6	C.971061E+03	P6	0.248309E+06	PS6	0.239550E+06	AM6	0.238310E+00	WG6	0.919510E+02
T7	C.971061E+03	WFA	0.	WG7	0.919489E+02	FAR7	0.206205E-01	DPAFT	0.
PS8	0.135091E+06	AMB	0.100000E+01	V8	0.565458E+03	PS9	0.135091E+06	V9	0.565458E+03
PS28	0.101325E+06	AM28	0.646694E+00	V28	0.229624E+03	PS29	0.101325E+06	V29	0.229624E+03
BPRINT	C.996946E+00	DPCOM	0.499101E-01	DPWING	0.100001E+00	PS38	0.646694E+00	V38	0.362716E+03
BYPASS	C.500987E+00	HPEXT	0.	WFT	0.185800E+01	WGT	0.271928E+03	FRD	0.
PC8LI	C.499235E+00	WG37	0.898230E+02	VJM	0.357275E+03	PS39	0.100000E+01	V39	0.362716E+03
CVDWNG	0.985000E+00	FGWNG	0.320915E+05	FGPHNG	0.813497E+03	FNWING	0.8134259E+05	P28	0.134294E+06
FFOVFN	0.178481E+00	FDOVFN	0.288057E+00	FCUVFN	0.533462E+00	FMNOFN	0.711943E+00	P38	0.198295E+06
CVMNDZ	C.985000E+00	VJM	0.556976E+03	CVDNDZ	0.985000E+00	VJD	0.226180E+03	FGP	0.105380E+05

MAIN SONIC CONVERGENT NOZZLE  
DUCT SUBSONIC CONVERG. NOZZLE

FG=114230.88

FN=114230.88

SFC= 0.05856

CONVERGED AFTER 11 LOOPS

As indicated earlier, the step in fuel flow for this case is up to the design- flow. A comparison of the results at 3 seconds and at the design point shows that the transient has not quite settled out. However, the results from both cases are close. Time histories of the fan speed, middle spool speed, core speed, and turbine inlet temperature are given in figure 17.

## APPENDIX C

### CONTROL SYSTEM SIMULATION

A set of subroutines has been written to allow the DYNGEN user to simulate such common control functions as integrations, first-order lags, and hysteresis. These subroutines are discussed in this appendix, and examples are shown to illustrate their use. Most of the subroutines (ALFLAG, ALINTR, etc.) are linear transfer functions. They are solved by assuming that the input is a ramp from the past value to the current value; the output is then the exact solution assuming the ramp input. The accuracy of this method is consistent with the accuracy of the modified Euler method used by DYNGEN itself.

All general-purpose control subroutines are listed in this appendix, except for AFQUIR and DERIV, which are part of the main program and are listed in appendix B.

All subroutines, including AFQUIR and DERIV, are discussed in the following section. Subroutines DISTRB, FCNTRL, and NOZCTR for the two-spool turbofan and one-spool turbojet example cases are also listed.

#### General-Purpose Subroutines

SUBROUTINE AFQUIR(X, AIND, DEPEND, ANS, AJ, TOL, DIR, ANEW, ICON)  
solves implicit loops.

X(I)	storage array for previous values
AIND	independent variable
DEPEND	dependent variable
ANS	desired value of dependent variable
AJ	maximum number of iterations
TOL	percentage tolerance on answer
DIR	direction for first guess
ANEW	new guess for independent variable
ICON	control = 1, guess again = 2, answer reached = 3, exceeded maximum number of iterations

Given successive values of AIND and corresponding values of DEPEND, AFQUIR will calculate new values for ANEW in an attempt to make DEPEND equal to ANS (within tolerance TOL). An example of the use of AFQUIR is given in subroutine FCNTRL for the two-spool example.

FUNCTION ALFLAG(I, X, TAU, YMAX, YMIN) determines amplitude-limited first-order lag.

I integer constant used with all first-order functions to identify location of previous values of function input and output (For first use of ALFLAG (or any first-order function with I as an argument), value of I must be 24. (First 23 locations are used by the main program.) Subsequent first-order function calls should be numbered consecutively, e.g.,

X = ALFLAG (24, . . .)

Y = ALINTR (25, . . .)

Z = FIRLAG (26, . . .)

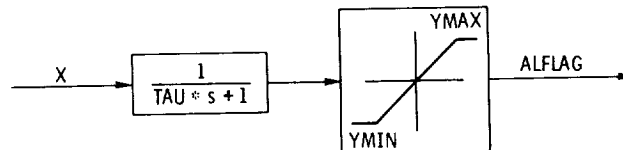
The maximum value for I is 50.)

X current input value

TAU time constant

YMAX maximum output value

YMIN minimum output value



```

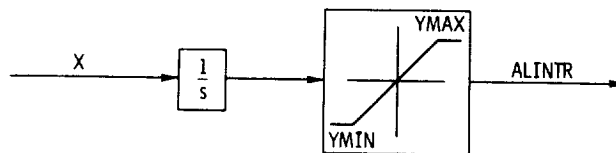
$IBFTC ALFLAG
  FUNCTION ALFLAG(I,X,TAU,YMAX,YMIN)
  COMMON /DYN/ ITRAN,TIME,DT,TF,JTRAN,NSTEP,TPRINT,DTPRNT
  COMMON /FOC/ FO(50,4)
  IF(JTRAN.EQ.1) GO TO 1
  ALFLAG=AMAX1(YMIN,AMIN1(YMAX,X))
  FO(I,1)= X
  FO(I,2)= X
  FO(I,3)=ALFLAG
  FO(I,4)=ALFLAG
  RETURN
1 X0=FO(I,2)
  Y0=FO(I,4)
  TEMP=-DT/TAU
  IF(ABS(TEMP)-75.)40,40,30
30 EX1=0.0
  GO TO 50
40 EX1=EXP(TEMP)
50 EX2=TAU/DT*(1.0-EX1)
  Y=Y0*EX1+X*(1.0-EX2)+X0*(EX2-EX1)
  ALTIMC=AMAX1(YMIN,AMIN1(YMAX,Y))
  FO(I,1) = X
  FO(I,3)=ALTIMC
  IF(ABS(ALTIMC-YMAX).LT.1.0E-5.OR.ABS(ALTIMC-YMIN).LT.1.0E-5)
1FO(I,1)=ALTIMC
  ALFLAG=ALTIMC
  RETURN
  END

```

FUNCTION ALINTR(I, X, YIC, YMAX, YMIN) performs amplitude-limited integra-  
tion.

- I integer constant used to identify storage location of previous function values  
(See ALFLAG for further discussion.)
- X current input value
- YIC initial condition
- YMAX maximum output value
- YMIN minimum output value

ALINTR





```

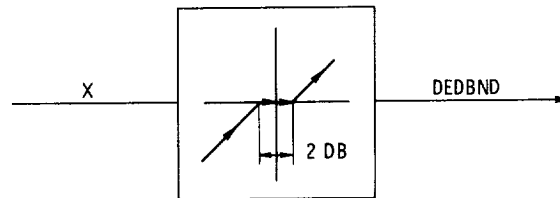
$IBFTC ALINTR
  FUNCTION ALINTR(I,X,YIC,YMAX,YMIN)
  COMMON /DYN/ ITRAN,TIME,DT,TF,JTRAN,NSTEP,TPRINT,DTPRNT
  COMMON /FOC/ FO(50,4)
  IF(JTRAN.EQ.1) GO TO 1
  ALINTR=YIC
  FO(I,1)= X
  FO(I,2)=X
  FO(I,3)=ALINTR
  FO(I,4)=ALINTR
  RETURN
1 XO=FO(I,2)
  YO=FO(I,4)
  ALINTR=YO+.5*DT*(X+XO)
  ALINTR=AMAX1(YMIN,AMIN1(YMAX,ALINTR))
  FO(I,1)= X
  FO(I,3)=ALINTR
  RETURN
  END

```

FUNCTION DEDBND(X, DB) determines the dead band.

X current input value

DB width of dead band



```

$IBFTC DEDBND
  FUNCTION DEDBND(X,DB)
  Y=0.
  IF(X.GT.DB)Y=X-DB
  IF(X.LT.-DB)Y=X+DB
  DEDBND=Y
  RETURN
  END

```

FUNCTION DELAY(IDLAY, X, TDELAY, TCLOCK) determines the time delay.

IDLAY integer constant, similar to I, used only with DELAY (Calls to DELAY should be numbered consecutively from IDLAY=1 to IDLAY=5.)

X current input value

TDELAY length of delay (TDELAY should not exceed  $49. \times DT$ , where DT is the solution time step specified by user.)

TCLOCK current time

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```

$IBFTC DELAY
  FUNCTION DELAY(IDLAY,X,TDELAY,TCLOCK)
  COMMON/CDELAY/PDATA(5,50),TIMEPT(50)
  COMMON /DYN/ ITRAN,TIME,DT,TF,JTRAN,NSTEP,TPRINT,DTPRNT
  IF(JTRAN.EQ.1) GO TO 20
  DO 10 I=1,50
  TIMEPT(I) = TCLOCK
10 PDATA(IDLAY,I) = X
  DELAY = X
  GO TO 50
20 PDATA(IDLAY,1) = X
  TIMEPT(1) = TCLOCK
  DO 30 I=1,50
  J = I
  IF ((TCLOCK-TIMEPT(I)).GE.TDELAY) GC TO 40
30 CONTINUE
40 DELTA = 0.0
  IF(ABS(TIMEPT(J-1)-TIMEPT(J)) .LT. 0.0001) GO TO 45
  IF (J.GT.1) DELTA = (PDATA(IDLAY,J-1)-PDATA(IDLAY,J))*(TCLOCK
1 -TIMEPT(J)-TDELAY)/(TIMEPT(J-1)-TIMEPT(J))
45 CONTINUE
  DELAY = PDATA(IDLAY,J) + DELTA
50 RETURN
  END

```

FUNCTION DERIV(I, X) calculates the time derivative.

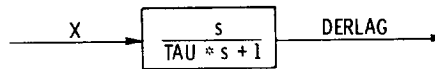
- I integer constant used to identify storage location of previous function values (See ALFLAG for further discussion.)
- X current input value



The listing for DERIV is given in appendix B.

FUNCTION DERLAG(I, X, TAU) calculates the derivative of first-order lag.

- I integer constant used to identify storage location of previous function values (See ALFLAG for further discussion.)
- X current input value
- TAU time constant



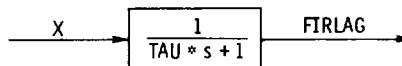
```

$IBFTC DERLAG
  FUNCTION DERLAG(I,X,TAU)
  COMMON /DYN/ ITRAN,TIME,DT,TF,JTRAN,NSTEP,TPRINT,DTPRNT
  COMMON /FOC/ FO(50,4)
  DERLAG=(1.0/TAU)*(X-FIRLAG(I,X,TAU))
  RETURN
  END

```

FUNCTION FIRLAG(I, X, TAU) determines the first-order lag.

- I integer constant used to identify storage location of previous function values (See ALFLAG for further discussion.)
- X current input value
- TAU time constant



```

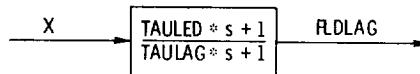
$IBFTC FIRLAG
  FUNCTION FIRLAG(I,X,TAU)
  COMMON /DYN/ ITRAN,TIME,DT,TF,JTRAN,NSTEP,TPRINT,DTPRNT
  COMMON /FOC/ FO(50,4)
  IF(JTRAN.EQ.1) GO TO 1
  FIRLAG=X
  FO(I,1)= X
  FO(I,2)= X
  FO(I,3)=FIRLAG
  FO(I,4)=FIRLAG
  RETURN
  1 X0=FO(I,2)
  Y0=FO(I,4)
  TEMP=-DT/TAU
  IF(ABS(TEMP)-75.)40,40,30
  30 EX1=0.
  GO TO 50
  40 EX1=EXP(TEMP)
  50 EX2=TAU/DT*(1.0-EX1)
  FIRLAG=Y0*EX1+X*(1.0-EX2)+X0*(EX2-EX1)
  FO(I,1) = X
  FO(I,3)=FIRLAG
  RETURN
  END

```

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FUNCTION FLDLAG(I, X, TAULED, TAULAG) determines the first-order lead-lag.

- I integer constant used to identify storage location of previous function values  
(See ALFLAG for further discussion.)
- TAULED lead-time constant
- TAULAG lag-time constant
- X current input value



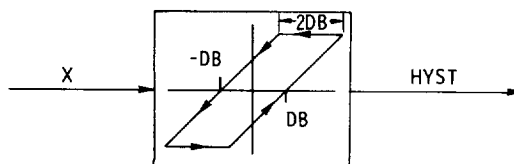
```

$IBFTC FLDLAG
FUNCTION FLDLAG(I,X,TAULED,TAULAG)
COMMON /DYN/ ITRAN,TIME,DT,TF,JTRAN,NSTEP,TPRINT,DTPRNT
COMMON /FOC/ FO(50,4)
Y=FIRLAG(I,X,TAULAG)
FLDLAG=(TAULED/TAULAG)*X+(1.0-TAULED/TAULAG)*Y
RETURN
END

```

FUNCTION HYST(I, X, DB) calculates the hysteresis.

- I integer constant used to identify storage location of previous function values (See ALFLAG for further discussion.)
- X current input value
- DB width of dead band



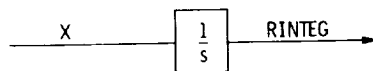
```

$IBFTC HYST
  FUNCTION HYST(I,X,DB)
  COMMON /DYN/ ITRAN,TIME,DT,TF,JTRAN,NSTEP,TPRINT,DTPRNT
  COMMON /FOC/ FO(50,4)
  IF(JTRAN.EQ.1) GO TO 1
  FO(I,1)=X
  FO(I,2)=X
  FO(I,3)=X
  FO(I,4)=X
  HYST=X
  RETURN
1 XO=FO(I,2)
  YO=FO(I,4)
  HYST=YO
  IF(X-DB.GT.YO.AND.X.GT.XO) HYST=X-DB
  IF(X+DB.LT.YO.AND.X.LT.XO) HYST=X+DB
  FO(I,1)=X
  FO(I,3)=HYST
  RETURN
END

```

FUNCTION RINTEG(I, X, YIC) performs integration.

- I integer constant used to identify storage location of previous function values (See ALFLAG for further discussion.)
- X current input value
- YIC initial condition



```

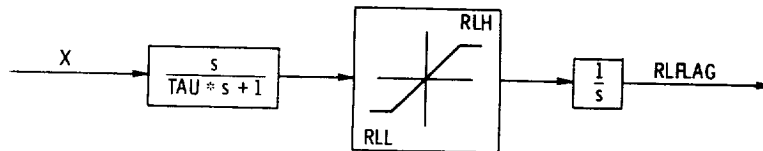
$IBFTC RINTEG
  FUNCTION RINTEG(I,X,YIC)
  COMMON /DYN/ ITRAN,TIME,DT,TF,JTRAN,NSTEP,TPRINT,DTPRNT
  COMMON /FOC/ FO(50,4)
  IF(JTRAN.EQ.1) GO TO 1
  RINTEG=YIC
  FO(I,1)= X
  FO(I,2)=X
  FO(I,3)=RINTEG
  FO(I,4)=RINTEG
  RETURN
1 XO=FO(I,2)
  YO=FO(I,4)
  RINTEG=YO+.5*DT*(X+XO)
  FO(I,1)= X
  FO(I,3)=RINTEG
  RETURN
END

```

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FUNCTION RFLAG(I, X, TAU, RLH, RLL) determines the rate-limited first-order lag.

- I integer constant used to identify storage location of previous function values (See ALFLAG for further discussion.)
- X current input value
- TAU time constant
- RLH upper rate limit
- RLL lower rate limit



```

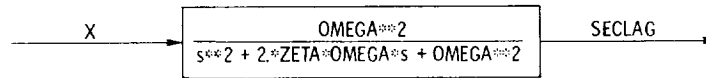
$IBFTC RFLAG
FUNCTION RFLAG(I,X,TAU,RLH,RLL)
COMMON /DYN/ ITRAN,TIME,DT,TF,JTRAN,NSTEP,TPRINT,DTPRINT
COMMON /FOC/ FO(50,4)
IF(JTRAN.EQ.1) GO TO 1
RFLAG=X
FO(I,1)= X
FO(I,2)= X
FO(I,3)=RFLAG
FO(I,4)=RFLAG
RETURN
1 X0=FO(I,2)
  Y0=FO(I,4)
  TEMP=-DT/TAU
  IF(ABS(TEMP)-75.)40,40,30
30 EX1=0.0
  GO TO 50
40 EX1=EXP(TEMP)
50 EX2=TAU/DT*(1.0-EX1)
  RFLAG=Y0*EX1+X*(1.0-EX2)+X0*(EX2-EX1)
  RFLAG=Y0+AMIN1(RLH,AMAX1(RLL,(RFLAG-Y0)/DT))*DT
  FO(I,1)= X
  FO(I,3)=RFLAG
RETURN
END

```

FUNCTION SECLAG(J, X, OMEGA, ZETA) determines the second-order lag.

- J integer constant, similar to I, used only with second-order functions SECLAG and SLDLAG (Calls to SECLAG and SLDLAG should be numbered consecutively from J=1 to J=10.)

X current input value  
 OMEGA natural frequency  
 ZETA damping ratio



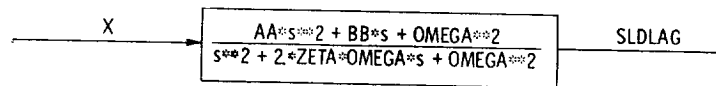
```

$IBFTC SECLAG
  FUNCTION SECLAG(J,X,OMEGA,ZETA)
  COMMON /DYN/ ITRAN,TIME,DT,TF,JTRAN,NSTEP,TPRINT,DTPRNT
  COMMON/SQC/SQ(10,6)
  IF(JTRAN.EQ.1) GO TO 1
  SQ(J,1)=X
  SQ(J,2)=X
  SQ(J,3)=X
  SQ(J,4)=X
  SQ(J,5)=X
  SQ(J,6)=X
  SECLAG=X
  RETURN
1 X0=SQ(J,2)
  X00=SQ(J,3)
  Y0=SQ(J,5)
  Y00=SQ(J,6)
  A=-ZETA*OMEGA
  CM1=OMEGA*SQRT(1.0-ZETA**2)
  YD=(Y0-Y00)/DT
  XD=(X-X00)/DT/2.0
  XDD=(X-2.0*X0+X00)/DT/DT
  A1=X0-XDD/OMEGA/OMEGA*(1.0-4.0*ZETA*ZETA)-2.0*ZETA*X0/OMEGA
  B1=X0-2.0*ZETA*XDD/OMEGA
  SECLAG=(YD-A1)*EXP(A*DT)*COS(CM1*DT)+A1+B1*DT+XDD*DT*DT/2.0
  1+(YD+ZETA*OMEGA*Y0-XD*(1.0-2.0*ZETA*ZETA)+ZETA*XDD/OMEGA*
  2(3.0-4.0*ZETA*ZETA)-ZETA*OMEGA*X0)*EXP(A*DT)/CM1*SIN(CM1*DT)
  SQ(J,1)=X
  SQ(J,4)=SECLAG
  RETURN
  END

```

FUNCTION SLDLAG(J, X, OMEGA, ZETA, AA, BB) determines the second-order lead-lag.

J integer constant, similar to I, used with second-order functions (See SECLAG for discussion.)  
 X current input value  
 OMEGA denominator natural frequency  
 ZETA denominator damping ratio  
 AA, BB numerator coefficients



```

$IBFTC SLDLAG
FUNCTION SLDLAG(J,X,OMEGA,ZETA,AA,BB)
COMMON /DYN/ ITRAN,TIME,DT,TF,JTRAN,NSTEP,TPRINT,DTPRNT
COMMON/SOC/SO(10,6)
IF(JTRAN.EQ.1) GO TO 1
SO(J,1)=X
SO(J,2)=X
SO(J,3)=X
SO(J,4)=X
SO(J,5)=X
SO(J,6)=X
SLDLAG=X
RETURN
1 X0=SO(J,2)
X00=SO(J,3)
Y0=SO(J,5)
Y00=SO(J,6)
A=-ZETA*OMEGA
OM1=OMEGA*SQRT(1.0-ZETA**2)
YD=(Y0-Y00)/DT
XD=(X-X00)/DT/2.0
XDD=(X-2.0*X0+X00)/DT/DT
X0TEMP=X0
X0=X0+(AA*XDD+BB*XD)/OMEGA/OMEGA
XD=XD+BB*XDD/OMEGA/OMEGA
A1=X0-XDD/OMEGA/OMEGA*(1.0-4.0*ZETA*ZETA)-2.0*ZETA*XD/OMEGA
B1=XD-2.0*ZETA*XDD/OMEGA
SECLAG=(Y0-A1)*EXP(A*DT)*COS(OM1*DT)+A1+B1*DT+XDD*DT*DT/2.0
1+(Y0+ZETA*OMEGA*Y0-XD*(1.0-2.0*ZETA*ZETA)+ZETA*XDD/OMEGA*
2(3.0-4.0*ZETA*ZETA)-ZETA*OMEGA*X0)*EXP(A*DT)/OM1*SIN(OM1*DT)
X0=X0TEMP
SO(J,1)=X
SLDLAG=SECLAG
SO(J,4)=SLDLAG
RETURN
END

```

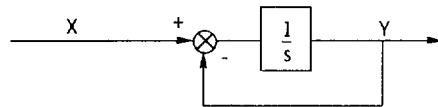
### Use of Control Subroutines

For any engine he wishes to simulate, the user must write three subroutines: FCNTRL, NOZCTR, and DISTRB. Subroutine FCNTRL is called by COCOMB and is used to calculate main fuel flow WFB. Subroutine NOZCTR is called by COMNOZ and is used to calculate nozzle area. Subroutine DISTRB is called by ENGBAL and supplies a time-varying transient input to the simulation. Listings of subroutines FCNTRL, NOZCTR, and DISTRB for the two-spool and one-spool example cases used in this report are given at the end of this appendix. If one of these subroutines is not needed for a particular engine, it should consist of a RETURN statement, as shown in the listings.



The fuel control system for the two-spool turbofan is given in figure 18, and the fuel and nozzle control systems for the afterburning turbojet are shown in figure 20.

The fuel control system for the two-spool turbofan (fig. 18) is used as an example to illustrate programming techniques. Certain problems arise from the fact that DYNGEN can use a large time step  $DT$  in obtaining solutions to differential equations. For example, consider a simple block diagram, as shown in the following sketch:



A programmer could use function RINTEG, with  $X-Y$  as input, to calculate the output of the integrator. For maximum accuracy, RINTEG requires that the current value of  $X-Y$  be used as input; however, only the past value of  $Y$  is available (unless iterative methods are used). Use of the past value of  $Y$  can lead to appreciable errors if the value of  $DT$  is large. Hence, to ensure maximum accuracy, the programmer must sometimes resort to iterative methods when writing control subroutines for DYNGEN. This technique is illustrated in subroutine FCNTRL for the control system of figure 18. In order to begin the iterative process, a value for integrator output  $YF$  is assumed. By using function DERIV, a value for integrator input  $YFDOT$  is then calculated. Also EXNL and EACL, the inputs to the MIN function, can be calculated by using the assumed value of  $YF$ . The lesser of these inputs is the output of the MIN function  $YFDOTX$ . For a consistent solution,  $YFDOT$  and  $YFDOTX$  should be equal. This fact is used to generate an error variable  $ERRW$ . Subroutine AFQUIR is then used to generate a new guess for  $YF$ , and the process continues until  $ERRW$  is less than a desired tolerance.

#### Example Case - Two-Spool Turbofan

An example of DISTRB, FCNTRL, and NOZCTR are given for the two-spool turbofan case. In this example a throttle step is accomplished by starting the transient at a specified low-pressure-rotor speed. DISTRB is called by DYNGEN and the demanded speed for the low-pressure rotor is set higher (at the design-point value). The difference between the actual speed and the demanded speed is used to generate a fuel flow (fig. 18).

Subroutine DISTRB is now shown. COMMON blocks DYN, RPMS, and CNTRL are shown. In DISTRB the demanded speed  $XNLDEM$  is set equal to the low-pressure-rotor design speed  $XNLPDS$  (table V), which is set in the NAMELIST input (not presented).

XNLDEM is transferred to the fuel control subroutine FCNTRL through COMMON block CNTRL.

```
$IBFTC DISTRB
SUBROUTINE DISTRB
COMMON /DYN/ ITRAN,TIME,DT,TF,JTRAN,NSTEP,TPRINT,DTPRNT
COMMON /RPMS/ XNHPDS,XNIPDS,XNLPDS,PMIHP,PMIIP,PMILP
COMMON /CNTRL/ XNHM,XNLM,T21M,P3M,YF,YFDT,YFB,EXNL,PHI,WFBACL,
1 YFACL,EACL,XNLDEM,XNHP,XNLP
XNLDEM=XNLPDS
RETURN
END
```

Subroutine FCNTRL is now presented. COMMON blocks ALL1 to ALL5 are used as previously described in the three-pool example. In this subroutine,

```
DATA AWORD/6HFCNTRL/
WORD=AWORD
```

is set so that the name FCNTRL is sent to subroutine ERROR if an error is found. The other commons are used to transmit data to and from FCNTRL as needed.

```
$IBFTC FCNTRL
SUBROUTINE FCNTRL
COMMON /WORDS/ WORD
COMMON /DESIGN/
1IDES ,JDES ,KDES ,MODE ,INIT ,IDUMP ,IAMTP ,IGASMX,
2IDBURN,IAFTBN,IDCD ,IMCD ,IDSHOC,IMSHOC,NOZFLT,ITRYS ,
3LOOPER,NOMAP ,NUMMAP,MAPEDG,TCLALL,ERR(9)
COMMON /ALL1/
1PCNFGU,PCNCGU,T4GU ,DUMD1 ,DUMD2 ,DELFG ,DELFN ,DELSFC,
2ZFDS ,PCNFDS,PRFDS ,ETAFDS,WAFDS ,PRFCF ,ETAFCF,WAFCF ,
3ZCDS ,PCNCDS,PRCDS ,ETACDS,WACDS ,PRCCF ,ETACCF,WACCF ,
4T4DS ,WFBDS ,DTCODS,ETABDS,WA3CDS,DPCODS,DTCOCF,ETABCF,
5TFHPDS,CNHPDS,ETHPDS,TFHPCF,CNHPCF,ETHPCF,DHHPCF,T2DS ,
6TFLPDS,CNLPDS,ETLPDS,TFLPCF,CNLPFC,ETLPCF,DHLPCF,T21DS ,
7T24DS ,WFDSD ,DTDUDS,ETADDS,WA23DS,CPDUDS,DTDUCF,ETADCF,
8T7DS ,WFAADS ,DTAFDS,ETAADS,WG6CDS,CPAFDS,DTAFCF,ETAACF,
9A55 ,A25 ,A6 ,A7 ,A8 ,A9 ,A28 ,A29 ,
$PS55 ,AM55 ,CVDNOZ,CVMNOZ,A8SAV ,A9SAV ,A28SAV,A29SAV
COMMON /ALL2/
1T1 ,P1 ,H1 ,S1 ,T2 ,P2 ,H2 ,S2 ,
2T21 ,P21 ,H21 ,S21 ,T3 ,P3 ,H3 ,S3 ,
3T4 ,P4 ,H4 ,S4 ,T5 ,P5 ,H5 ,S5 ,
4T55 ,P55 ,H55 ,S55 ,BLF ,BLC ,BLDU ,BLOB ,
5CNF ,PRF ,ETAF ,WAF ,WAF ,WA3 ,WG4 ,FAR4 ,
6CNC ,PRC ,ETAC ,WACC ,WAC ,ETAB ,DPCOM ,DUMP ,
```

```

7CNHP ,ETATHP,DHTCHP,DHTC ,BLHP ,WG5 ,FAR5 ,CS ,
8CNLP ,ETATLP,DHTCLP,DHTF ,BLLP ,WG55 ,FAR55 ,HPEXT ,
9AM ,ALTP ,ETAR ,ZF ,PCNF ,ZC ,PCNC ,WFB ,
$TFFHP ,TFFLP ,PCBLF ,PCBLC ,PCBLDU,PCBLOB,PCBLHP,PCBLLP

```

COMMON /ALL3/

```

1XP1 ,XWAF ,XWAC ,XBLF ,XBLDU ,XH3 ,DUMS1 ,DUMS2 ,
2XT21 ,XP21 ,XH21 ,XS21 ,T23 ,P23 ,H23 ,S23 ,
3T24 ,P24 ,H24 ,S24 ,T25 ,P25 ,H25 ,S25 ,
4T28 ,P28 ,H28 ,S28 ,T29 ,P29 ,H29 ,S29 ,
5WAD ,WFD ,WG24 ,FAR24 ,ETAD ,DPDUC ,BYPASS,DUMS3 ,
6TS28 ,PS28 ,V28 ,AM28 ,TS29 ,PS29 ,V29 ,AM29 ,
7XT55 ,XP55 ,XH55 ,XS55 ,XT25 ,XP25 ,XH25 ,XS25 ,
8XWFB ,XWG55 ,XFAR55,XWFD ,XWG24 ,XFAR24,XXP1 ,DUMB ,
9T6 ,P6 ,H6 ,S6 ,T7 ,P7 ,H7 ,S7 ,
$T8 ,P8 ,H8 ,S8 ,T9 ,P9 ,H9 ,S9

```

COMMON /ALL4/

```

1WG6 ,WFA ,WG7 ,FAR7 ,ETAA ,DPAFT ,V55 ,V25 ,
2PS6 ,V6 ,AM6 ,TS7 ,PS7 ,V7 ,AM7 ,AM25 ,
3TS8 ,PS8 ,V8 ,AM8 ,TS9 ,PS9 ,V9 ,AM9 ,
4VA ,FRD ,VJD ,FGMD ,VJM ,FGMM ,FGPD ,FGPM ,
5FGM ,FGP ,WFT ,WGT ,FART ,FG ,FN ,SFC ,
6WA32 ,DPWGDS,DPWING,WA32DS,A38 ,AM38 ,V38 ,T38 ,
7H38 ,P38 ,TS38 ,PS38 ,T39 ,H39 ,P39 ,TS39 ,
8V39 ,AM39 ,A39 ,BPRINT,WG37 ,CVDWNG,FGMWNG,FGPWNG,
9FNWING,FNMAIN,FWOVFN,PS39 ,FFOVFN,FCOVFN,FMNOFN,FNOVFD;
$VJW ,T22 ,P22 ,H22 ,S22 ,T50 ,P50 ,H50

```

COMMON /ALL5/

```

1S50 ,WA22 ,ZI ,PCNI ,CNI ,PRI ,ETAI ,WACI ,
2TFFIP ,CNIP ,ETATIP,DHTCIP,DHTI ,BLIP ,PCBLIP,PCNIGU,
3ZIDS ,PCNIDS,PRIDS ,ETAIDS,WAIDS ,PRICF ,ETAICF,WAICF ,
4TFIPDS,CNIPDS,ETIPDS,TFIPCF,CNIPCF,ETIPCF,DHIPCF,WAICDS,
5WAI ,PCBLI ,BLI ,T22DS ,WA21 ,WG50 ,FAR50 ,A24 ,
6AM23 ,DUMSPL,FXFN2M,FXM2CP,AFTFAN,PUNT ,PCBLID,P6DSAV,
7AM6DSV,ETAASV,FAR7SV,T4PBL ,T41 ,FAN ,ISPOOL

```

COMMON /DYN/ ITRAN,TIME,DT,TF,JTRAN,NSTEP,TPRINT,DTPRNT

COMMON /RMS/ XNHPDS,XNIPDS,XNLPDS,PMIHP,PMIIP,PMILP

COMMON /CNTRL/ XNHM,XNLM,T21M,P3M,YF,YFDOT,YFB,EXNL,PHI,WFBACL,

1 YFACL,EACL,XNLDEM,XNHP,XNLP

DIMENSION Q(9)

DATA AWORD /6HFCNTRL/

WORD=AWORD

XNHP=XNHPDS\*PCNC/100.

XNLP=XNLPDS\*PCNF/100.

IF (ITRAN.EQ.1.AND.JTRAN.EQ.0) XNLDEM=XNLP

XNHM=FIRLAG(24,XNHP,.01)

XNLM=FIRLAG(25,XNLP,.01)

T21M=FIRLAG(26,T21,.50)

P3M=FIRLAG(27,P3,.02)

YF=SQRT(WFB/4.653)-.0846

Q(2)=0.0

Q(3)=0.0

18

YFDOT=DERIV(28,YF)

YFB=14.978\*FIRLAG(29,YFDOT,.50)

EXNL=25.91\*(XNLDEM-XNLM)/XNLPDS-YFB

PHI=(-9.4+(33.\*XNHM/XNHPDS)\*SQRT(518.67/T21M))\*(.3124+.6895\*T21M

1 /518.67)

WFBACL=14.696\*PHI\*P3M/3600.

YFACL=SQRT(WFBACL/4.653)

EACL=33.\*(YFACL-YF)

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      YFDOTX=EXNL
      IF(EACL.LT.EXNL) YFDOTX=EACL
      ERRW=YFDOT-YFDOTX
      DIR=0.0
      IF(YFDOTX.NE.0.0) DIR=SQRT(ABS(YFDOT/YFDOTX))
      CALL AFQUIR(Q(1),YF,ERRW,C.,20.,1.E-4,DIR,YFT,IGO)
      GO TO (19,21,20),IGO
19    YF=YFT
      GO TO 18
20    CALL ERROR
21    CONTINUE
      WFB=4.653*(YF+.0846)**2
      RETURN
      END

```

There is no main nozzle control required for this case, and subroutine NOZCTR contains only a return.

```

$IBFTC NOZCTR
      SUBROUTINE NOZCTR
      RETURN
      END

```

#### Example Case - One-Spool Turbojet

For this example a throttle slam from idle (60 percent corrected speed) to full afterburning for a one-spool turbojet is simulated. Subroutine DISTRB sets the demanded speed at 60 percent at TIME=0.0. If TIME is greater than 0.1 second, the demanded speed (PCNFDM) is set equal to 101.5 percent. PCNFDM is transferred to subroutine FCNTRL through COMMON block XXPCNF. Also when the speed equals 100 percent, the fuel flow to the afterburner (WFA) is ramped. Note here that IAFTBN must now be set equal to 2 so that this can be accomplished (table III). The change in IAFTBN is transferred into DYNGEN through COMMON block DESIGN. WFA is transferred into DYNGEN through COMMON block ALL4.

```

$IBFTC DISTRB
      SUBROUTINE DISTRB
      COMMON /WORDS/ WORD
      COMMON /DESIGN/
      IIDES ,JOES ,KDES ,MODE ,INIT ,IDUMP ,IAMTP ,IGASM,
      2IDBURN,IAFTBN,IDCD ,IMCD ,IDSHDC,IMSHCC,NOZFLT,ITRYS ,
      3LOOPER,NOMAP ,NUMMAP,MAPEDG,TCLALL,ERR(9)
      COMMON /ALL1/
      1PCNFGU,PCNCGU,T4GU ,DUMD1 ,DUMD2 ,DELFG ,CELFN ,DELSFC,

```

```

2ZFDS ,PCNFDS,PRFDS ,ETAFDS,WAFDS ,PRFCF ,ETAFCF,WAFCF ,
3ZCDS ,PCNCDS,PRCDS ,ETACDS,WACDS ,PRCCF ,ETACCF,WACCF ,
4T4DS ,WFBDS ,DTCODS,ETABDS,WA3CDS,DPCODS,DTCCOF,ETABCF,
5TFHPDS,CNHPDS,ETHPDS,TFHPCF,CNHPCF,ETHPCF,DHHPCF,T2DS ,
6TFLPDS,CNLPDS,ETLPDS,TFLPCF,CNLPDF,ETLPCF,DHLPCF,T21DS ,
7T24DS ,WFDDDS ,DTODDS,ETADDS,WA23DS,DPDUDS,DTDUFC,ETADCF,
8T7DS ,WFAFDS ,DTAFDS,ETAADS,WG6CDS,DPAFDS,DTAFCF,ETAACF,
9A55 ,A25 ,A6 ,A7 ,A8 ,A9 ,A28 ,A29 ,
$PS55 ,AM55 ,CVDNOZ,CVMNOZ,A8SAV ,A9SAV ,A28SAV,A29SAV
COMMON /ALL2/
1T1 ,P1 ,H1 ,S1 ,T2 ,P2 ,H2 ,S2 ,
2T21 ,P21 ,H21 ,S21 ,T3 ,P3 ,H3 ,S3 ,
3T4 ,P4 ,H4 ,S4 ,T5 ,P5 ,H5 ,S5 ,
4T55 ,P55 ,H55 ,S55 ,BLF ,BLC ,BLDU ,BLOB ,
5CNF ,PRF ,ETAF ,WAF ,WAF ,WA3 ,WG4 ,FAR4 ,
6CNC ,PRC ,ETAC ,WACC ,WAC ,ETAB ,DPCOM ,DUMP ,
7CNHP ,ETATHP,DHTCHP,DHTC ,BLHP ,WG5 ,FAR5 ,CS ,
8CNLP ,ETATLP,DHTCLP,DHTF ,BLLP ,WG55 ,FAR55 ,HPEXT ,
9AM ,ALTP ,ETAR ,ZF ,PCNF ,ZC ,PCNC ,WFB ,
$TFFHP ,TFFLP ,PCBLF ,PCBLC ,PCBLDU,PCBLOB,PCBLHP,PCBLP
COMMON /ALL3/
1XP1 ,XWAF ,XWAC ,XBLF ,XBLDU ,XH3 ,DUMS1 ,DUMS2 ,
2XT21 ,XP21 ,XH21 ,XS21 ,T23 ,P23 ,H23 ,S23 ,
3T24 ,P24 ,H24 ,S24 ,T25 ,P25 ,H25 ,S25 ,
4T28 ,P28 ,H28 ,S28 ,T29 ,P29 ,H29 ,S29 ,
5WAD ,WFD ,WG24 ,FAR24 ,ETAD ,DPDUC ,BYPASS,DUMS3 ,
6TS28 ,PS28 ,V28 ,AM28 ,TS29 ,PS29 ,V29 ,AM29 ,
7XT55 ,XP55 ,XH55 ,XS55 ,XT25 ,XP25 ,XH25 ,XS25 ,
8XWF8 ,XWG55 ,XFAR55,XWFD ,XWG24 ,XFAR24,XXP1 ,DUMB ,
9T6 ,P6 ,H6 ,S6 ,T7 ,P7 ,H7 ,S7 ,
$T8 ,P8 ,H8 ,S8 ,T9 ,P9 ,H9 ,S9
COMMON /ALL4/
1WG6 ,WFA ,WG7 ,FAR7 ,ETAA ,DPAFT ,V55 ,V25 ,
2PS6 ,V6 ,AM6 ,TS7 ,PS7 ,V7 ,AM7 ,AM25 ,
3TS8 ,PS8 ,V8 ,AM8 ,TS9 ,PS9 ,V9 ,AM9 ,
4VA ,FRD ,VJD ,FGMD ,VJM ,FGMM ,FGPD ,FGPM ,
5FGM ,FGP ,WFT ,WGT ,FART ,FG ,FN ,SFC ,
6WA32 ,DPWGDs,DPWING,WA32DS,A38 ,AM38 ,V38 ,T38 ,
7H38 ,P38 ,TS38 ,PS38 ,T39 ,H39 ,P39 ,TS39 ,
8V39 ,AM39 ,A39 ,BPRINT,WG37 ,CVDWNG,FGMWNG,FGPWNG,
9FNWING,FNMAIN,FWOVFN,PS39 ,FFOVFN,FCOVFN,FMNOFN,FNOVFD,
$VJW ,T22 ,P22 ,H22 ,S22 ,T50 ,P50 ,H50
COMMON /ALL5/
1S50 ,WA22 ,ZI ,PCNI ,CNI ,PRI ,ETAI ,WACI ,
2TFFIP ,CNIP ,ETATIP,DHTCIP,DHTI ,BLIP ,PCBLIP,PCNIGU,
3ZIDS ,PCNIDS,PRIDS ,ETAIDS,WAIDS ,PRICF ,ETAICF,WAICF ,
4TFIPDS,CNIPDS,ETIPDS,TFIPCF,CNIPCF,ETIPCF,DHIPCF,WAICDS,
5WAI ,PCBLI ,BLI ,T22DS ,WA21 ,WG50 ,FAR50 ,A24 ,
6AM23 ,DUMSPL,FXFN2M,FXM2CP,AFTFAN,PUNT ,PCBLID,P6DSAV,
7AM6DSV,ETAASV,FAR7SV,T4PBL ,T41 ,FAN ,ISPOOL
COMMON /DYN/ ITRAN,TIME,DT,TF,JTRAN,NSTEP,TPRINT,DTPRNT
COMMON /RPMS/ XNHPDS,XNIPDS,XNLPDS,PMIHP,PMIIP,PMILP
COMMON/XXPCNF/PCNFDM
IF (ITIME .EQ. 1) GO TO 1
TIMEA=0.0
ITIME=0
1 CONTINUE
PCNFDM=60.0
IF (TIME .GE. .1) PCNFDM=101.5

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IF (PCNF .GE. 100.0) ITIME=1
IF (ITIME .EQ. 0) GO TO 3
IF (TIMEA .GT. 0.0) GO TO 2
IF (ITIME .EQ. 1) TIMEA=TIME
2 CONTINUE
IF (TIME .GT. TIMEA) IAFTBN=2
IF (TIME .GT. TIMEA) WFA=2.5/2.0*(TIME-TIMEA)
IF (WFA .GE. 2.5) WFA=2.5
3 CONTINUE
RETURN
END

```

Subroutine FCNTRL calculates main burner fuel flow from the speed error. The fuel flow (WFB) is transferred into DYNGEN through COMMON block ALL2.

```

$IBFTC FCNTRL
SUBROUTINE FCNTRL
COMMON /ALL1/
1PCNFGU,PCNCGU,T4GU ,DUMD1 ,DUMD2 ,DELFG ,DELFN ,DELSFC,
2ZFDS ,PCNFDS,PRFDS ,ETAFDS,WAFDS ,PRFCF ,ETAFCF,WAFCF ,
3ZCDS ,PCNCDS,PRCDS ,ETACDS,WACDS ,PRCCF ,ETACCF,WACCF ,
4T4DS ,WFBDS ,DTCODS,ETABDS,WA3CDS,CPCODS,DTCCOF,ETABCF,
5TFHPDS,CNHPDS,ETHPDS,TFHPCF,CNHPCF,ETHPCF,DHHPCF,T2DS ,
6TFLPDS,CNLPDS,ETLPDS,TFLPCF,CNLPFC,ETLPFC,DHLPFC,T21DS ,
7T24DS ,WFDSD ,DTDUDS,ETADDS,WA23DS,DPDUDS,DTDUFC,ETADCF,
8T7DS ,WFADS ,DTAFDS,ETAADS,WG6CDS,DPAFDS,DTAFCF,ETAACF,
9A55 ,A25 ,A6 ,A7 ,A8 ,A9 ,A28 ,A29 ,
$PS55 ,AM55 ,CVDNOZ,CVMNCZ,A8SAV ,A9SAV ,A28SAV,A29SAV
COMMON /ALL2/
1T1 ,P1 ,H1 ,S1 ,T2 ,P2 ,H2 ,S2 ,
2T21 ,P21 ,H21 ,S21 ,T3 ,P3 ,H3 ,S3 ,
3T4 ,P4 ,H4 ,S4 ,T5 ,P5 ,H5 ,S5 ,
4T55 ,P55 ,H55 ,S55 ,BLF ,BLC ,BLDU ,BLOB ,
5CNF ,PRF ,ETAF ,WAF ,WAF ,WA3 ,WG4 ,FAR4 ,
6CNC ,PRC ,ETAC ,WACC ,WAC ,ETAB ,DPCOM ,DUMP ,
7CNHP ,ETATHP,DHTCHP,DHTC ,BLHP ,WG5 ,FAR5 ,CS ,
8CNLP ,ETATLP,DHTCLP,DHTF ,BLLP ,WG55 ,FAR55 ,HPEXT ,
9AM ,ALTP ,ETAR ,ZF ,PCNF ,ZC ,PCNC ,WFB ,
$TFFHP ,TFFLP ,PCBLF ,PCBLC ,PCBLDU,PCBLOB,PCBLHP,PCBLLP
COMMON /ALL3/
1XP1 ,XWAF ,XWAC ,XBLF ,XBLOU ,XH3 ,DUMS1 ,DUMS2 ,
2XT21 ,XP21 ,XH21 ,XS21 ,T23 ,P23 ,H23 ,S23 ,
3T24 ,P24 ,H24 ,S24 ,T25 ,P25 ,H25 ,S25 ,
4T28 ,P28 ,H28 ,S28 ,T29 ,P29 ,H29 ,S29 ,
5WAD ,WFD ,WG24 ,FAR24 ,ETAD ,DPDUC ,BYPASS,DUMS3 ,
6TS28 ,PS28 ,V28 ,AM28 ,TS29 ,PS29 ,V29 ,AM29 ,
7XT55 ,XP55 ,XH55 ,XS55 ,XT25 ,XP25 ,XH25 ,XS25 ,
8XWFB ,XWG55 ,XFAR55,XWFD ,XWG24 ,XFAR24,XXP1 ,DUMB ,
9T6 ,P6 ,H6 ,S6 ,T7 ,P7 ,H7 ,S7 ,
$T8 ,P8 ,H8 ,S8 ,T9 ,P9 ,H9 ,S9
COMMON /ALL4/
1WG6 ,WFA ,WG7 ,FAR7 ,ETAA ,CPAFT ,V55 ,V25 ,

```

```

2PS6 ,V6 ,AM6 ,TS7 ,PS7 ,V7 ,AM7 ,AM25 ,
3TS8 ,PS8 ,V8 ,AM8 ,TS9 ,PS9 ,V9 ,AM9 ,
4VA ,FRD ,VJD ,FGMD ,VJM ,FGMM ,FGPD ,FGPM ,
5FGM ,FGP ,WFT ,WGT ,FART ,FG ,FN ,SFC ,
6WA32 ,DPWGDS,DPWING,WA32DS,A38 ,AM38 ,V38 ,T38 ,
7H38 ,P38 ,TS38 ,PS38 ,T39 ,H39 ,P39 ,TS39 ,
8V39 ,AM39 ,A39 ,BPRINT,WG37 ,CVDWNG,FGMWNG,FGPWNG,
9FNWING,FNMAIN,FWOVFN,PS39 ,FFOVFN,FCOVFN,FMNOFN,FNOVFD,
$VJW ,T22 ,P22 ,H22 ,S22 ,T50 ,P50 ,H50
COMMON /ALL5/
1S50 ,WA22 ,ZI ,PCNI ,CNI ,PRI ,ETAI ,WACI ,
2TFFIP ,CNIP ,ETATIP,DHTCIP,DHTI ,BLIP ,PCBLIP,PCNIGU,
3ZIDS ,PCNIDS,PRIDS ,ETAIDS,WAIDS ,PRICF ,ETAICF,WAICF ,
4TFIPDS,CNIPDS,ETIPDS,TFIPCF,CNIPCF,ETIPCF,DHIPCFC,WAICDS,
5WAI ,PCBLI ,BLI ,T22DS ,WA21 ,WG50 ,FAR50 ,A24 ,
6AM23 ,DUMSPL,FXFN2M,FXM2CP,AFTFAN,PUNT ,PCBLID,P6DSAV,
7AM6DSV,ETAASV,FAR7SV,T4PBL ,T41 ,FAN ,ISPOOL
COMMON /DYN/ ITRAN,TIME,DT,TF,JTRAN,NSTEP,TPRINT,DTPRNT
COMMON/XXPCNF/PCNFDM
XKP=.0006351
IF (ITRAN .EQ. 1 .AND. JTRAN .EQ. 0) PCNFDM=60.0
ERPCNF=PCNFDM-PCNF
ALIM=.005501
BLIM=.008806
WFOP3U=(ALIM-BLIM)*(PCNF-105.0)/(-45.0)+BLIM
WFOP3L=WFOP3U/3.
WFPB=.005833+XKP*ERPCNF
IF(WFPB.GT.WFOP3U) WFPB=WFOP3U
IF(WFPB.LT.WFOP3L) WFPB=WFOP3L
WFB=WFPB*P3*14.696
RETURN
END

```

Subroutine NOZCTR calculates the afterburner nozzle area (A8) as a function of pressure ratio error. Values needed for this error are P3 and P2 and are transferred to NOZCTR from DYNGEN through COMMON block ALL2. The nozzle area (A8) is transferred out of NOZCTR through COMMON block ALL1.

```

$IBFTC NOZCTR
SUBROUTINE NOZCTR
COMMON /ALL1/
1PCNFGU,PCNCGU,T4GU ,DUMD1 ,DUMD2 ,DELFG ,DELFN ,DELSFC,
2ZFDS ,PCNFDS,PRFDS ,ETAADS,WAADS ,PRFCF ,ETAFCF,WAFCF ,
3ZCDS ,PCNCDS,PRCDS ,ETACDS,WACDS ,PRCCF ,ETACCF,WACCF ,
4T4DS ,WFBDS ,DTCODS,ETABDS,WA3CDS,CPCODS,DTCCCF,ETABCF,
5TFHPDS,CNHPDS,ETHPDS,TFHPCF,CNHPCF,ETHPCF,DHHPCF,T2DS ,
6TFLPDS,CNLPDS,ETLPDS,TFLPCF,CNLPDF,ETLPCF,DHLPDF,T21DS ,
7T24DS ,WFADS ,DTDUDS,ETADDS,WA23DS,CPDUDS,DTDUCCF,ETADCF,
8T7DS ,WFADS ,DTAFDS,ETAADS,WG6CDS,CPAFDS,DTAFCF,ETAACF,
9A55 ,A25 ,A6 ,A7 ,A8 ,A9 ,A28 ,A29 ,
$PS55 ,AM55 ,CVDNOZ,CVMNOZ,A8SAV ,A9SAV ,A28SAV,A29SAV
COMMON /ALL2/

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1T1 ,P1 ,H1 ,S1 ,T2 ,P2 ,H2 ,S2 ,
2T21 ,P21 ,H21 ,S21 ,T3 ,P3 ,H3 ,S3 ,
3T4 ,P4 ,H4 ,S4 ,T5 ,P5 ,H5 ,S5 ,
4T55 ,P55 ,H55 ,S55 ,BLF ,BLC ,BLDU ,BLOB ,
5CNF ,PRF ,ETAF ,WAF ,WAF ,WA3 ,WG4 ,FAR4 ,
6CNC ,PRC ,ETAC ,WACC ,WAC ,ETAB ,DPCOM ,DUMP ,
7CNHP ,ETATHP,DHTCHP,DHTC ,BLHP ,WG5 ,FAR5 ,CS ,
8CNLP ,ETATLP,DHTCLP,DHTF ,BLLP ,WG55 ,FAR55 ,HPEXT ,
9AM ,ALTP ,ETAR ,ZF ,PCNF ,ZC ,PCNC ,WFB ,
$TFFHP ,TFFLP ,PCBLF ,PCBLC ,PCBLDU,PCBLOB,PCBLHP,PCBLLP
COMMON /ALL3/
1XP1 ,XWAF ,XWAC ,XBLF ,XBLDU ,XH3 ,DUMS1 ,DUMS2 ,
2XT21 ,XP21 ,XH21 ,XS21 ,T23 ,P23 ,H23 ,S23 ,
3T24 ,P24 ,H24 ,S24 ,T25 ,P25 ,H25 ,S25 ,
4T28 ,P28 ,H28 ,S28 ,T29 ,P29 ,H29 ,S29 ,
5WAD ,WFD ,WG24 ,FAR24 ,ETAD ,DPDUC ,BYPASS ,DUMS3 ,
6TS28 ,PS28 ,V28 ,AM28 ,TS29 ,PS29 ,V29 ,AM29 ,
7XT55 ,XP55 ,XH55 ,XS55 ,XT25 ,XP25 ,XH25 ,XS25 ,
8XWFB ,XWG55 ,XFAR55 ,XWFD ,XWG24 ,XFAR24 ,XXP1 ,DUMB ,
9T6 ,P6 ,H6 ,S6 ,T7 ,P7 ,H7 ,S7 ,
$T8 ,P8 ,H8 ,S8 ,T9 ,P9 ,H9 ,S9
COMMON /ALL4/
1WG6 ,WFA ,WG7 ,FAR7 ,ETAA ,DPAFT ,V55 ,V25 ,
2PS6 ,V6 ,AM6 ,TS7 ,PS7 ,V7 ,AM7 ,AM25 ,
3TS8 ,PS8 ,V8 ,AM8 ,TS9 ,PS9 ,V9 ,AM9 ,
4VA ,FRD ,VJD ,FGMD ,VJM ,FGMM ,FGPD ,FGPM ,
5FGM ,FGP ,WFT ,WGT ,FART ,FG ,FN ,SFC ,
6WA32 ,DPWGD ,DPWING ,WA32DS ,A38 ,AM38 ,V38 ,T38 ,
7H38 ,P38 ,TS38 ,PS38 ,T39 ,H39 ,P39 ,TS39 ,
8V39 ,AM39 ,A39 ,BPRINT ,WG37 ,CVDWNG ,FGMWNG ,FGPWNG ,
9FNWING ,FNMAIN ,FWOVFN ,PS39 ,FFOVFN ,FCOVFN ,FMNOFN ,FNQVFD ,
$VJW ,T22 ,P22 ,H22 ,S22 ,T50 ,P50 ,H50
COMMON /ALL5/
1S50 ,WA22 ,ZI ,PCNI ,CNI ,PRI ,ETAI ,WACI ,
2TFFIP ,CNIP ,ETATIP ,DHTCIP ,DHTI ,BLIP ,PCBLIP ,PCNIGU ,
3ZIDS ,PCNIDS ,PRIDS ,ETAIDS ,WAIDS ,PRICF ,ETAICF ,WAICF ,
4TFIPDS ,CNIPDS ,ETIPDS ,TFIPCF ,CNIPCF ,ETIPCF ,DHIPCF ,WAICDS ,
5WAI ,PCBLI ,BLI ,T22DS ,WA21 ,WG50 ,FAR50 ,A24 ,
6AM23 ,DUMSPL ,FXFN2M ,FXM2CP ,AFTFAN ,PUNT ,PCBLID ,P6DSAV ,
7AM6DSV ,ETAASV ,FAR7SV ,T4PBL ,T41 ,FAN ,ISPOOL
COMMON /DYN/ ITRAN ,TIME ,DT ,TF ,JTRAN ,NSTEP ,TPRINT ,DTPRINT
A8MIN=.790078
P3QP2D=14.07
XKI=1.0
XKP=.1
YICC=0.0
DERV=P3/P2-P3QP2D
IF (ABS(DERV) .LE. 1.0E-5) DERV=0.0
A8INT=ALINTR(24,DERV,YICC,10000.0,-10000.0)*XKI
A8PROP=XKP*DERV
2 A8=A8MIN+A8INT+A8PROP
IF (A8 .GE. A8MIN .AND. WFA .GT. 0.0) GO TO 3
XERV=0.0
A8INT=ALINTR(24,XERV,YICC,0.0,0.0)*XKI
A8=A8MIN
3 CONTINUE
IF (WFA .LE. 1.0E-3) WFA=0.0
RETURN
END

```



## APPENDIX D

### DEBUGGING PROCEDURES

This appendix is intended to give the DYNGEN user some hints for debugging problems which may occur in running the program. If the proper input variables are provided by the user, trouble will usually not occur in running the design point (IDES=1) case. However, problems will often arise in obtaining solutions for off-design cases. One frequent source of trouble is going out of range on the component maps, usually the turbine. If this occurs, an appropriate error message will be printed out, for example,

```
***** CNHP OFF MAP
```

which indicates that the high-pressure-turbine speed parameter is out of range for the map supplied. The most obvious, and effective, way of remedying this problem is to extend the range of the maps. However, the user should take note if the engine is operating beyond the performance limits of a component.

Occasionally, trouble will occur in COMIX, CODUCT, or COAFBN when the program tries to calculate Mach numbers less than zero or greater than 0.700. The error listing will contain COMMON blocks ALL1, ALL2, etc., and the user should check variables such as AM55, AM6, AM7, AM23, and AM24 to see if they are negative or equal to 0.700. If they are and if the problem was not initiated by a map-out-of-range, it may be possible to solve the problem by changing Mach numbers at the design point. For example, if AM55 goes negative for some off-design case, increasing AM55 at the design point will tend to raise the value of AM55 for all cases and help to avoid the problem.

The Newton-Raphson method of solving simultaneous equations (appendix A) requires a matrix of approximate partial derivatives  $\Delta E_i / \Delta V_j$ , where  $\Delta V_j$  is an incremental change in the  $j^{\text{th}}$  variable and  $\Delta E_i$  is the resulting change in the  $i^{\text{th}}$  error. The size of  $\Delta V_j$  can be changed by the DYNGEN user, and this often is effective in solving convergence problems. In order to change the size of  $\Delta V_j$ , the user should change variables VDELTA and DELSAV from their nominal values of 1.E-4. These values are set by DATA statements in subroutine ENGBAL.

The variable VRATIO, also found in ENGBAL, may sometimes help to solve convergence problems if it is set to some value less than its nominal value of 1.0. VRATIO controls the maximum step size in changing the iteration variables.

The basic version of DYNGEN uses slightly less than 32 000 words of computer storage. If the user has a computer with a maximum storage capacity of 32 000 words, he will exceed that limit when attempting to add control system subroutines. Certain subroutines in the basic program can be omitted to save space. For example, if the

engine to be simulated has only a converging exhaust nozzle, subroutine CONDIV can be eliminated. Similarly, if the engine has only a converging-diverging nozzle, subroutine CONVRG can be eliminated. In all cases, a dummy subroutine, consisting only of a RETURN statement, must replace the omitted subroutine. Also, storage space can be omitted by deleting component maps which are not used, along with their associated storage locations (table I).

A list of error messages in DYNGEN is given in the following table:

Error message	Subroutine found in
AN ERROR HAS BEEN FOUND IN (SUBROUTINE NAME)	ERROR
CHANGE TOO SMALL	ENGBAL
CNC OFF MAP	COCOMP
CNC WAS = _____, AND NOW = _____, CHECK PCNC INPUT	COCOMP
CNF OFF MAP	COFAN
CNF WAS = _____, AND NOW = _____, CHECK PCNF INPUT	COFAN
CNHP OFF MAP	COHPTB
CNI OFF MAP	COINTC
CNI WAS = _____, AND NOW = _____, CHECK PCNI INPUT	COINTC
CNIP OFF MAP	COIPTB
CNLP OFF MAP	COLPTB
COLUMN IS ZERO IN EMAT	ENGBAL
ERROR IN CONOUT INPUT	CONOUT
ERROR IN SYG	SYG
FAILED TO CONVERGE AFTER (NUMBER) LOOPS	ERROR
NO CONVERGENCE IN THERMO	THERMO
ROW IS ZERO IN EMAT	ENGBAL
TFFHP OFF MAP	COHPTB
TFFIP OFF MAP	COIPTB
TFFLP OFF MAP	COLPTB
THE ERROR IN (SUBROUTINE NAME) IS AT (NUMBER)	ERROR <sup>1</sup>
THE WORD _____ NOT FOUND IN COMMON ARRAY	CONOUT

<sup>1</sup>For subroutines COAFBN, COMIX, and CODUCT.

The list contains the error messages in alphabetical order and also the subroutine in which the error message is generated. Most messages are self-explanatory; thus, the determination of the actual cause for the error message printout is left to the user.

In the subroutines COAFBN, COMIX, and CODUCT, there are many implicit loops and as a result many calls to the ERROR routine. Therefore, as shown in the previous table, a special error message is given if an error occurs in one of these subroutines. The number given in this error message corresponds to a number which has been set into the subroutine in error. For example, before each call to ERROR in subroutine COAFBN, ICOAFB=1, 2, 3, . . . is set; then, if the error message in ERROR says, THE

ERROR IN COAFBN IS AT 2, the user need only look in subroutine COAFBN for the implicit loop at which ICOAFB=2 was set. The same procedure can be followed in subroutines COMIX and CODUCT, where the error indicators are ICOMIX and ICODUC, respectively.

## APPENDIX E

### COMPARISON WITH GENENG AND GENENG II

In addition to having transient capability, DYNGEN combines in one program the steady-state capabilities of GENENG and GENENG II. The following list summarizes the differences (apart from transient capability) between DYNGEN and those programs:

- (1) In order to conserve storage, DYNGEN uses NAMELIST input rather than Huff input. Only subroutine PUTIN needs to be modified to allow use of Huff input.
- (2) Subroutine MAPBAC, which changes the independent variable, has been deleted. Instead, subroutine SEARCH is used to extrapolate if values of CNHP, CNIP, or CNLP are out of range for the turbine maps. Error messages are still printed on UNIT08 if this occurs.
- (3) Additional error messages have been added to COAFBN, CODUCT, and COMIX (appendix D).
- (4) Calculations may be performed in SI units.
- (5) Unlike GENENG (but not GENENG II), IAFTBN=1 will not automatically result in IMCD=1. Similarly, IDBURN=1 will not automatically result in IDCD=1.
- (6) Unlike GENENG (but not GENENG II), subroutine FRATIO has been deleted. The user must supply his own values of CVMNOZ and CVDNOZ. These values are single-point inputs and not table lookups as in GENENG.

## APPENDIX F

### SYMBOLS

A	state matrix
$A_g$	main nozzle throat area, $m^2$ ( $ft^2$ )
a	coefficient
E	error variable
$\Delta E$	change in error variable
f( )	function
$(HP)_{ext}$	power extracted, W (Btu/sec)
h	enthalpy, J/kg (Btu/lbm)
$\Delta h$	change in enthalpy, J/kg (Btu/lbm)
I	polar moment of inertia, $kg \cdot m^2$ ( $Btu \cdot sec^2$ )
M	matrix of $\partial E_1 / \partial V_j$
N	rotor speed, rpm
$\Delta N$	change in rotor speed, rpm
P	pressure, $N/m^2$ (atm)
R	gas constant, J/kg-K ( $atm \cdot ft^3/lbm \cdot ^\circ R$ )
s	Laplace transform variable, 1/sec
T	temperature, K ( $^\circ R$ )
$\Delta T$	change in temperature, K ( $^\circ R$ )
t	time, sec
$\Delta t$	time step, sec
u	specific internal energy, J/kg (Btu/lbm)
V	independent variable in Newton-Raphson iteration
$\Delta V$	change in independent variable
$\tilde{V}$	component volume, $m^3$ ( $ft^3$ )
$\dot{w}$	mass flow rate, kg/sec (lbm/sec)
X	independent variable

Y	dependent variable
y	difference equation variable
$\epsilon$	parameter in difference equation
$\lambda$	eigenvalue of differential equation
$\mu$	eigenvalue of difference equation
$\Phi$	state matrix

Subscripts:

C	compressor
f	fuel flow
i	integer
in	into control volume
j	integer
max	maximum
min	minimum
n	integer
out	out of control volume
r	reference
T	turbine
0	base value

Superscripts:

'	denotes calculated quantity
*	denotes quantity modified by dynamic terms

General symbols internal to program: Variables in program are formed by combining these symbols.

Station numbers: See figures 1 to 11 for each type of engine.

Thermodynamic property symbols:

AM	Mach number
FAR	fuel-air ratio
H	enthalpy, J/kg (Btu/lbm)
P	total pressure, N/m <sup>2</sup> (atm)

PS	static pressure, $\text{N/m}^2$ (atm)
S	entropy, $\text{J/kg-K}$ ( $\text{Btu/lbm-}^\circ\text{R}$ )
T	total temperature, $\text{K}$ ( $^\circ\text{R}$ )
TS	static temperature, $\text{K}$ ( $^\circ\text{R}$ )
U	internal energy, $\text{J/kg}$ ( $\text{Btu/lbm}$ )
V	velocity, $\text{m/sec}$ ( $\text{ft/sec}$ )

Component symbols:

A, AFT	afterburner
B	burner
C	inner compressor
COM	combustor
D	fan duct
F	first or fan compressor
I	intermediate (middle) compressor
M	core nozzle
MAIN	all but wing
NOZ	nozzle
OB	overboard
T	total
THP	inner (high pressure) turbine
TIP	middle (intermediate pressure) turbine
TLP	outer (low pressure) turbine
WDUCT	wing (third stream) duct
WING, WNG	wing (third stream)

Engine symbols:

BL	bleed, $\text{kg/sec}$ ( $\text{lbm/sec}$ )
CN	ratio of corrected speed to design corrected speed
DHT	turbine delta enthalpy, $\text{J/kg}$ ( $\text{Btu/lbm}$ )
DHTC	turbine delta enthalpy (temperature corrected), $(H_{\text{in}} - H_{\text{out}})/T_{\text{in}}$ , $\text{J/kg-K}$ ( $\text{Btu/lbm-}^\circ\text{R}$ )

DP	pressure drop, $\Delta P/P$
ETA	efficiency
ETAR	ram recovery, $P_2/P_1$
HPEXT	power extracted, W (hp)
PCBL	fractional bleed
PCN	percent of design shaft speed
PR	pressure ratio
TFF	turbine flow function, $\text{kg} \cdot \sqrt{\text{K}} \cdot \text{m}^2 / \text{N} \cdot \text{sec}$ ( $\text{lbf} \cdot \sqrt{\text{R}} \cdot \text{in.}^2 / \text{lbf} \cdot \text{sec}$ )
WA	airflow, kg/sec (lbf/sec)
WF	fuel flow, kg/sec (lbf/sec)
WG	gas flow, kg/sec (lbf/sec)
Z	ratio of pressure ratios
Miscellaneous symbols:	
A	area, $\text{m}^2$ ( $\text{ft}^2$ )
ALTP	altitude, m (ft)
AM	Mach number of aircraft
BPRINT	bypass ratio (wing duct air/core air)
BYPASS	bypass ratio (fan duct air/air entering intermediate compressor)
C	when following component symbol, signifies "corrected"
CF	when following component symbol, signifies "correction factor"
CS	ambient speed of sound, m/sec (ft/sec)
CV	nozzle velocity coefficient
DEL	delta degradation coefficient
DOT	time derivative
DS	design value
DUM	dummy value
FCOVFN	ratio of core thrust to net thrust
FFOVFN	ratio of fan thrust to net thrust
FG	gross thrust, N (lbf)



FGM momentum thrust, N (lbf)  
 FGP pressure thrust, N (lbf)  
 FMOVFN ratio of fan plus core thrust to net thrust  
 FN net thrust, N (lbf)  
 FNOVFD ratio of net thrust to design-point net thrust  
 FRD ram drag, N (lbf)  
 GU initial or guessed values  
 ITRYS number of loops through engine before quitting  
 LOOP variable counter  
 LOOPER number of loops through engine counter  
 P1 standard pressure,  $N/m^2$  (atm)  
 SFC specific fuel consumption, kg/N-hr (lbm/lbf-hr)  
 TOLALL tolerance on convergence  
 T1 standard temperature, K ( $^{\circ}R$ )  
 VA velocity of aircraft, m/sec (ft/sec)  
 VJ jet velocity, m/sec (ft/sec)

Input symbols:

AFTFAN logical control for an aft-fan engine  
 ALTP altitude, m (ft)  
 AM Mach number of aircraft  
 AM6 design afterburner entrance Mach number  
 AM23 design ductburner entrance Mach number  
 AM55 design low-pressure-turbine exit Mach number  
 A6 area of afterburner entrance (calculated from AM6),  $m^2$  ( $ft^2$ )  
 A8 main nozzle throat area (can be changed at off design),  $m^2$  ( $ft^2$ )  
 A28 fan duct nozzle throat area (see A8),  $m^2$  ( $ft^2$ )  
 A38 wing duct nozzle throat area (see A8),  $m^2$  ( $ft^2$ )  
 CNHPDS design corrected speed - inner turbine  
 CNIPDS design corrected speed - middle turbine  
 CNLPDS design corrected speed - outer turbine

CVDNOZ nozzle thrust coefficient (duct)  
CVDWNG nozzle thrust coefficient (wing)  
CVMNOZ nozzle thrust coefficient (core)  
DELFG gross-thrust delta degradation multiplier  
DELFN net-thrust delta degradation multiplier  
DELSFC specific-fuel-consumption delta degradation multiplier  
DELTA1 correction to standard-day temperature, K ( $^{\circ}$ R)  
DPAFDS afterburner design pressure drop,  $\Delta P/P$   
DPCODS combustor design pressure drop,  $\Delta P/P$   
DPDUDS duct design pressure drop,  $\Delta P/P$   
DPWGDS wing duct design pressure drop,  $\Delta P/P$   
DT solution time step for transients, sec  
DTPRNT time step for output listings, sec  
DUMSPL logical control for spool which does not change temperature or pressure of  
air  
ETAA afterburner efficiency (not required)  
ETAADS afterburner efficiency at design  
ETABDS combustor efficiency at design  
ETACDS inner-compressor adiabatic efficiency at design  
ETAD ductburner combustor efficiency  
ETAFDS front (outer) compressor adiabatic efficiency at design  
ETAIDS intermediate (middle) compressor adiabatic efficiency at design  
ETAR inlet pressure recovery (ram recovery),  $P_2/P_1$   
ETHPDS high-pressure-(inner) turbine design adiabatic efficiency  
ETIPDS intermediate-pressure-(middle) turbine design adiabatic efficiency  
ETLPDS low-pressure-(outer) turbine design adiabatic efficiency  
FAN logical control which indicates fan or turbojet  
FXFN2M logical control for boosted fan  
FXM2CP logical control for supercharged compressor  
HPEXT power extraction, W (hp)

**IAFTBN** index on afterburning desired  
**IAMTP** index on ram or inlet operation desired  
**IDBURN** index on ductburning desired  
**IDCD** duct nozzle convergent-divergent when IDCD=1 (design or off design)  
**IDES** index for design point; must be set equal to 1 to design engine; zeroed automatically  
**IDUMP** index for dumping of error matrix  
**IGASMIX** index for mixed-flow or non-mixed-flow turbofans  
**IMCD** main nozzle convergent-divergent when IMCD=1 (design or off design)  
**INIT** index for initializing guesses  
**ISPOOL** number of engine rotors  
**ITRAN** index for initiating transients  
**ITRYS** index for maximum number of iterations  
**JTRAN** index which indicates a transient is in process  
**MODE** independent variable designator for engine operation  
**NOZFLT** index for floating main or duct nozzle  
**PCBLC** ratio of compressor bleed to turbines to compressor airflow  
**PCBLDU** ratio of compressor bleed leaked into fan duct to total compressor bleed flow  
**PCBLF** ratio of bleed from outer compressor to fan airflow dumped overboard (i. e., leakage)  
**PCBLHP** fraction of PCBLC used for high-pressure (inner) turbine (cooling)  
**PCBLID** ratio of design value of air into wing to air into core; zero for two-stream engine  
**PCBLIP** fraction of PCBLC used for intermediate-pressure turbine (cooling)  
**PCBLLP** fraction of PCBLC used for low-pressure (outer) turbine (cooling)  
**PCBLOB** inner-compressor bleed compressor airflow (overboard for customer use)  
**PCNC** inner-compressor shaft speed as a percent of design  
**PCNCDS** design inner-compressor corrected speed as a percent of design  
**PCNF** outer-compressor shaft speed as a percent of design  
**PCNFDS** design outer-compressor corrected speed as a percent of design

PCNI	intermediate-compressor shaft speed as a percent of design
PCNIDS	design intermediate-compressor corrected speed as a percent of design
PMIHP	high-pressure-rotor polar moment of inertia, $\text{kg}\cdot\text{m}^2$ (slug-ft <sup>2</sup> )
PMIIP	intermediate-pressure-rotor polar moment of inertia, $\text{kg}\cdot\text{m}^2$ (slug-ft <sup>2</sup> )
PMILP	low-pressure-rotor polar moment of inertia, $\text{kg}\cdot\text{m}^2$ (slug-ft <sup>2</sup> )
PRCDS	design inner-compressor pressure ratio
PRFDS	design outer-compressor pressure ratio
PS55	static pressure at low-pressure-turbine exit, $\text{N}/\text{m}^2$ (atm)
P2	fan inlet total pressure, $\text{N}/\text{m}^2$ (atm)
SI	logical control for SI or U.S. customary (English) units
TF	final time for transient, sec
TFHPDS	design inner-turbine flow function, $\text{kg}\cdot\sqrt{\text{K}}\cdot\text{m}^2/\text{N}\cdot\text{sec}$ ( $\text{lbm}\cdot\sqrt{\text{R}}\cdot\text{in.}^2/\text{lbf}\cdot\text{sec}$ )
TFIPDS	design intermediate-turbine flow function, $\text{kg}\cdot\sqrt{\text{K}}\cdot\text{m}^2/\text{N}\cdot\text{sec}$ ( $\text{lbm}\cdot\sqrt{\text{R}}\cdot\text{in.}^2/\text{lbf}\cdot\text{sec}$ )
TFLPDS	design outer-turbine flow function, $\text{kg}\cdot\sqrt{\text{K}}\cdot\text{m}^2/\text{N}\cdot\text{sec}$ ( $\text{lbm}\cdot\sqrt{\text{R}}\cdot\text{in.}^2/\text{lbf}\cdot\text{sec}$ )
TOLALL	tolerance on error matrix
T2	fan inlet total temperature, K ( <sup>o</sup> R)
T4	combustor exit temperature, K ( <sup>o</sup> R)
T7	afterburner exit temperature, K ( <sup>o</sup> R)
T24	ductburner exit temperature, K ( <sup>o</sup> R)
T4DS	design combustor exit temperature, K ( <sup>o</sup> R)
T7DS	design afterburner exit temperature, K ( <sup>o</sup> R)
VAFTBN	control volume associated with afterburner, $\text{m}^3$ (ft <sup>3</sup> )
VCOMB	control volume associated with combustor, $\text{m}^3$ (ft <sup>3</sup> )
VCOMP	control volume associated with high-pressure compressor, $\text{m}^3$ (ft <sup>3</sup> )
VFAN	control volume associated with fan, $\text{m}^3$ (ft <sup>3</sup> )
VFDUCT	control volume associated with fan duct, $\text{m}^3$ (ft <sup>3</sup> )
VHPTRB	control volume associated with high-pressure turbine, $\text{m}^3$ (ft <sup>3</sup> )
VINTC	control volume associated with intermediate compressor, $\text{m}^3$ (ft <sup>3</sup> )
VIPTRB	control volume associated with intermediate-pressure turbine, $\text{m}^3$ (ft <sup>3</sup> )

VLPTRB	control volume associated with low-pressure turbine, $m^3$ ( $ft^3$ )
VWDUCT	control volume associated with wing duct, $m^3$ ( $ft^3$ )
WACCDS	design inner-compressor corrected airflow, kg/sec (lbm/sec)
WAFCDs	design outer-compressor corrected airflow, kg/sec (lbm/sec)
WAICDS	design intermediate-compressor corrected airflow, kg/sec (lbm/sec)
WFA	fuel flow rate to afterburner (IAFTBN=2 only), kg/sec (lbm/sec)
WFB	fuel flow rate to main burner (MODE=2 only), kg/sec (lbm/sec)
WFBDS	design fuel flow rate to main burner (MODE=2 only), kg/sec (lbm/sec)
XNHPDS	high-pressure-rotor design speed, rpm
XNIPDS	intermediate-pressure-rotor design speed, rpm
XNLPDS	low-pressure-rotor design speed, rpm
ZCDS,	design ratio of inner-compressor, fan-compressor, and middle-compressor pressure ratios, respectively; equals pressure ratio at design point on design speed line minus value of pressure ratio at lowest point on speed line, divided by high (surge) value minus low value of pressure ratio on design speed line
ZFDS,	
ZIDS	

Output symbols:<sup>1</sup>

A	area, $m^2$ ( $ft^2$ )
ALTP	altitude, m (ft)
AM	Mach number
BLC	bleed flow out of compressor, kg/sec (lbm/sec)
BLDU	bleed flow into fan duct, kg/sec (lbm/sec)
BLF	bleed flow out of fan (dumped overboard), kg/sec (lbm/sec)
BLHP	bleed flow into high-pressure turbine, kg/sec (lbm/sec)
BLI	airflow into third stream, kg/sec (lbm/sec)
BLIP	bleed flow into intermediate-pressure turbine, kg/sec (lbm/sec)
BLLP	bleed flow into low-pressure turbine, kg/sec (lbm/sec)
BLOB	bleed flow lost overboard (customer bleed), kg/sec (lbm/sec)
BPRINT	ratio of airflow into wing duct to airflow into core

<sup>1</sup>Some symbols, such as T4, are followed by station numbers; see appropriate figure for each engine in order to determine station locations.

BYPASS	ratio of airflow into fan duct to airflow into intermediate compressor
CNC	corrected shaft speed - inner compressor
CNF	corrected shaft speed - fan
CNHP	corrected shaft speed - high-pressure turbine
CNHPCF	corrected speed - high-pressure-turbine correction factor
CNI	corrected shaft speed - intermediate compressor
CNIP	corrected shaft speed - intermediate-pressure turbine
CNIPCF	corrected speed - intermediate-pressure-turbine correction factor
CNLP	corrected speed - low-pressure turbine
CNLPCF	corrected speed - low-pressure-turbine correction factor
CVDNOZ	velocity coefficient of fan nozzle
CVDWNG	velocity coefficient of wing nozzle
CVMNOZ	velocity coefficient of core nozzle
DHHPCF	high-pressure-turbine delta enthalpy correction factor
DHPCF	intermediate-pressure-turbine delta enthalpy correction factor
DHLPCF	low-pressure-turbine delta enthalpy correction factor
DHTC	work done by high-pressure turbine, J/kg (Btu/lbm)
DHTCHP	enthalpy change temperature corrected - high-pressure turbine, J/kg-K (Btu/lbm- <sup>o</sup> R)
DHTCIP	enthalpy change temperature corrected - intermediate-pressure turbine, J/kg-K (Btu/lbm- <sup>o</sup> R)
DHTCLP	enthalpy change temperature corrected - low-pressure turbine, J/kg-K (Btu/lbm- <sup>o</sup> R)
DHTF	work done by low-pressure turbine, J/kg (Btu/lbm)
DHTI	work done by intermediate-pressure turbine, J/kg (Btu/lbm)
DPAFT	$(\Delta P/P)_{\text{afterburner}}$
DPCOM	$(\Delta P/P)_{\text{combustor}}$
DPDUC	$(\Delta P/P)_{\text{fan duct}}$
DPWING	$(\Delta P/P)_{\text{wing duct}}$
ETAA	afterburner efficiency

ETAB	combustor efficiency
ETABCF	combustor efficiency correction factor
ETAC	inner-compressor adiabatic efficiency
ETACCF	inner-compressor efficiency correction factor
ETAD	ductburner efficiency
ETAf	fan adiabatic efficiency
ETAFCF	fan efficiency correction factor
ETAI	intermediate-compressor adiabatic efficiency
ETAICF	intermediate-compressor efficiency correction factor
ETATHP	high-pressure-turbine adiabatic efficiency
ETATIP	intermediate-pressure-turbine adiabatic efficiency
ETATLP	low-pressure-turbine adiabatic efficiency
ETHPCF	high-pressure-turbine efficiency correction factor
ETIPCF	intermediate-pressure-turbine efficiency correction factor
ETLPCF	low-pressure-turbine efficiency correction factor
FAR	fuel-air ratio
FCOVFN	ratio of core thrust to net thrust
FFOVFN	ratio of fan thrust to net thrust
FG	gross thrust, N (lbf)
FGM	momentum thrust of all but wing, N (lbf)
FGMWNG	momentum thrust of wing, N (lbf)
FGP	pressure thrust of all but wing, N (lbf)
FGPWNG	pressure thrust of wing, N (lbf)
FMNOFN	ratio fan thrust plus core thrust to net thrust
FN	net thrust, N (lbf)
FNMAIN	net thrust of all but wing, N (lbf)
FNOVFD	ratio of net thrust to design-point net thrust
FNWING	net thrust of wing, N (lbf)
FRD	ram drag, N (lbf)
FWOVFN	ratio of net wing thrust to net thrust

HPEXT	power extracted, W (hp)
P	total pressure, $N/m^2$ (atm)
PCBLC	fraction of compressor exit air bled for cooling or lost to cycle
PCBLDU	fraction of bleed air out of compressor which leaks into fan duct
PCBLF	fraction of fan exit airflow lost overboard
PCBLHP	fraction of compressor bleed air put into high-pressure turbine
PCBLI	fraction of intermediate-compressor air which goes into third stream
PCBLIP	fraction of compressor bleed air put into intermediate-pressure turbine
PCBLLP	fraction of compressor bleed air put into low-pressure turbine
PCBLOB	fraction of bleed air out of compressor lost overboard
PCNC	inner-compressor shaft speed as percent of design
PCNF	fan-compressor shaft speed as percent of design
PCNI	intermediate-compressor shaft speed as percent of design
PRC	pressure ratio of inner compressor
PRCCF	pressure-ratio-of-inner-compressor correction factor
PRF	pressure ratio of fan
PRFCF	pressure-ratio-of-fan correction factor
PRI	pressure ratio of intermediate compressor
PRICF	pressure-ratio-of-intermediate-compressor correction factor
PS	static pressure, $N/m^2$ (atm)
SFC	specific fuel consumption, kg/N-hr (lbm/lbf-hr)
T	total temperature, K ( $^{\circ}R$ )
T3DS	design exit temperature of inner compressor, K ( $^{\circ}R$ )
T21DS	design exit temperature of intermediate compressor, K ( $^{\circ}R$ )
T22DS	design exit temperature of fan, K ( $^{\circ}R$ )
TFFHP	high-pressure-turbine flow function, $kg-\sqrt{K}-m^2/sec-N$ ( $lbm-\sqrt{^{\circ}R}-in.^2/sec-lbf$ )
TFFIP	intermediate-pressure-turbine flow function, $kg-\sqrt{K}-m^2/sec-N$ ( $lbm-\sqrt{^{\circ}R}-in.^2/sec-lbf$ )
TFFLP	low-pressure-turbine flow function, $kg-\sqrt{K}-m^2/sec-N$ ( $lbm-\sqrt{^{\circ}R}-in.^2/sec-lbf$ )



TFHPCF	high-pressure-turbine flow function correction factor
TFIPCF	intermediate-pressure-turbine flow function correction factor
TFLPCF	low-pressure-turbine flow function correction factor
TIME	time, sec
V	velocity, m/sec (ft/sec)
VA	velocity of aircraft, m/sec (ft/sec)
VJD	fan duct exhaust velocity, m/sec (ft/sec)
VJM	core exhaust velocity, m/sec (ft/sec)
VJW	wing duct exhaust velocity, m/sec (ft/sec)
WA	airflow, kg/sec (lbm/sec)
WAC	inner-compressor airflow, kg/sec (lbm/sec)
WACC	inner-compressor corrected airflow, kg/sec (lbm/sec)
WACCF	inner-compressor corrected airflow correction factor
WA3CDS	corrected airflow in combustor at design, kg/sec (lbm/sec)
WACI	intermediate-compressor corrected airflow, kg/sec (lbm/sec)
WAD	fan duct airflow, kg/sec (lbm/sec)
WAF	fan airflow, kg/sec (lbm/sec)
W AFC	fan corrected airflow, kg/sec (lbm/sec)
WAFCF	fan corrected airflow correction factor
WAI	intermediate-compressor airflow, kg/sec (lbm/sec)
WAICF	intermediate-compressor corrected airflow correction factor
WFA	fuel flow rate to afterburner, kg/sec (lbm/sec)
WFB	fuel flow rate to combustor, kg/sec (lbm/sec)
WFD	fuel flow rate to ductburner, kg/sec (lbm/sec)
WFT	total fuel flow rate, kg/sec (lbm/sec)
WG	gas flow rate, kg/sec (lbm/sec)
WGT	total gas flow rate, kg/sec (lbm/sec)
ZC	ratio of inner-compressor pressure ratios
ZF	ratio of fan pressure ratios
ZI	ratio of intermediate-compressor pressure ratios

Control system symbols (figs. 18 and 20):

A8MIN	minimum main nozzle throat area, $m^2$ ( $ft^2$ )
EACL	acceleration error
EXNL	speed error
MAX	function whose output is equal to largest input
MIN	function whose output is equal to smallest input
PCNFDM	commanded rotor speed, percent
PHI	output of acceleration schedule, $kg\text{-}m^2/N\text{-sec}$ ( $lbm\text{-}in.^2/lbf\text{-}sec$ )
P3M	sensed P3, $N/m^2$ (atm)
P3QP2D	commanded compressor pressure ratio
T21M	sensed T21, K ( $^{\circ}R$ )
WFBACL	acceleration fuel flow, $kg/sec$ ( $lbm/sec$ )
WFOP3L	lower limit on WFB/P3, $kg\text{-}m^2/N\text{-sec}$ ( $lbm\text{-}in.^2/lbf\text{-}sec$ )
WFOP3U	upper limit on WFB/P3, $kg\text{-}m^2/N\text{-sec}$ ( $lbm\text{-}in.^2/lbf\text{-}sec$ )
XNHM	sensed core speed, rpm
XNHP	core speed, rpm
XNLDEM	commanded fan speed, rpm
XNLM	sensed fan speed, rpm
XNLP	fan speed, rpm
YF	metering valve position
YFACL	metering valve position for accelerations
YFB	metering valve position feedback
YFDOT	time derivative of metering valve position

## REFERENCES

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TABLE I. - COMPONENT MAP SPECIFICATION

[DYNGEN is supplied with storage locations and dummy maps for all components. The user may supply maps for a particular engine and leave the maps for unused components in the simulation.]

Engine configuration	Component map <sup>1</sup>						
	BLKFAN	BLKINT	BLKCOMP	CMBDAT	HPTDAT	IPTDAT	LPTDAT
a	Yes	Yes	Yes	Yes	Yes	Yes	Yes
b	↓	↓	↓	↓	↓	No	↓
c <sup>2</sup>		No					
d		↓					
e		No					
f		Yes					
g <sup>2</sup>		Yes					
h		No					
i		Yes					
j		No					
k		No					

<sup>1</sup>A "Yes" entry means that component map must be specified. A "No" entry means that component map need not be specified and storage space may be deleted. However, if storage space is not deleted and BLOCK DATA are supplied for components which are not used, calculations are not affected.

<sup>2</sup>Engine configurations c and g (figs. 3 and 7) have intermediate and core compressors physically attached. Combination is driven by intermediate-pressure turbine. Calculation bypasses routine which calculates high-pressure-turbine performance but transfers turbine performance data from this routine into that of intermediate-pressure turbine to represent turbine performance. Since intermediate-pressure turbine speed is set by speed of intermediate compressor, which also sets speed of combined compressors, this procedure is necessary. In these cases, COIPTB uses COMMON/HTUR13/, which is high-pressure-turbine data.



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TABLE II. - INPUTS FOR DESIGN POINTS

Variable	Units or type	Definition	Default value	Engine configuration										
				a	b	c	d	e	f	g	h	i	j	k
Variables that specify engine configuration and should be input only when IDES=1														
PRFDS	kg sec (lbm sec)	Fan pressure ratio	0.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
WAFCD5	kg sec (lbm sec)	Fan corrected airflow	0.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
F-TAFDS		Fan efficiency	1.5	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ZFDS		Ratio of pressure ratios of fan	1.5	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
PCNFDS		Fan corrected speed	0.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
PRDS		Intermediate pressure ratio	1.0	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
WACDS	kg sec (lbm sec)	Fan corrected airflow	0.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ETAFDS		Intermediate efficiency	0.75	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ZDS		Ratio of pressure ratios of intermediate compressor	1.00	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
PCNFDS		Intermediate compressor corrected speed	0.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
PRCD5		Compressor pressure ratio	0.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
WACUD5	kg sec (lbm sec)	Compressor corrected airflow	0.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
PCBLD		Fraction of air into wing duct	0.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ETACDS		Compressor efficiency	0.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ZCDS		Ratio of pressure ratios of compressor	1.00	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
PCNCD5		Compressor corrected speed	0.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ETABDS		Compressor efficiency	0.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
DPCD5		Compressor pressure drop, ΔP P	0.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
TDS	K (°R)	Turbine inlet temperature		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
WFHDS	kg sec (lbm sec)	Compressor fuel flow		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
THPDS	kg √k m <sup>2</sup> /s-sec (lbm-√ <sup>h</sup> R-in. <sup>2</sup> /lb-sec)	High-pressure-turbine flow function		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CNHPS	percent/√k	High-pressure turbine corrected speed		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ETHPS	percent/√k	High-pressure turbine efficiency		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
TFHPS	kg-√k m <sup>2</sup> /s-sec (lbm-√ <sup>h</sup> R-in. <sup>2</sup> /lb-sec)	Intermediate-pressure-turbine flow function		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CNIFDS	percent/√k	Intermediate-pressure-turbine corrected speed		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ETIFDS	percent/√k	Intermediate-pressure-turbine efficiency		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
TFIFDS	kg-√k m <sup>2</sup> /s-sec (lbm-√ <sup>h</sup> R-in. <sup>2</sup> /lb-sec)	Low-pressure-turbine flow function		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CNLFDS	percent/√k	Low-pressure-turbine corrected speed		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ETLFDS	percent/√k	Low-pressure-turbine efficiency		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
DFDUD5		Fan duct pressure drop, ΔP P		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
DPWGD5		Wing duct pressure drop, ΔP P		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
DPAFDS		Afterburner pressure drop, ΔP P		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
T7DS	K (°R)	Afterburner exit temperature		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
F-TAADS		Afterburner efficiency		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
AM55	N m <sup>2</sup> (atm)	Low-pressure-turbine exit Mach number		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
PS55	N m <sup>2</sup> (atm)	Low-pressure-turbine exit static pressure		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
AM23		Duct burner entrance Mach number		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

TADS or WFBD5, but not both, should be specified by user for all engine types. If MODE=0, supply TADS, if MODE=2, supply WFBD5. MODE=1 and MODE=3 cannot be used when IDES=1.

TTDS and ETAADS must be supplied only if afterburning operation will be requested for some off-design case. Afterburning should not be requested when IDES=1.

AM55 or PS55, but not both, should be specified by the user for all engine types. Unless a particular value for AM55 is desired, 0.300 is a reasonable number to use.



TABLE III. - PROGRAM INDICES

Name	Value	Features <sup>1</sup>				Purpose
		1	2	3	4	
IDES	0	X				Off-design case
	1	X				Design-point case
MODE	0		X	X		Specify T4
	1			X		Specify PCNC
	2		X	X		Specify WFB
	3			X		Specify PCNF
INIT	0	X	X			Will call GUESS
	1	X	X			Will not call GUESS
IDUMP	0		X	X		Will not print stored messages
	1		X	X		Will print stored messages after errors
	2		X	X		Will print stored messages after every point
IAMTP	0		X	X		Input AM, ALTP; military-specification ETAR will be used
	1		X	X		Input AM, ALTP, ETAR
	2		X	X		Input AM, ALTP, DELT1; military-specification ETAR will be used
	3		X	X		Input AM, ALTP, P2
	4		X	X		Input P2, T2
	5		X	X		Input AM, ALTP; ETAR schedule stored in RAM2
IGASMX	-1			X		Separate flow, input AM6
	0			X		Separate flow, A6 = A55
	1			X		Mixed flow, A6 = A25 + A55
	2			X		Mixed flow, input AM6
IDBURN	0	X				No ductburning
	1	X			X	Ductburning, input T24
	2	X			X	Ductburning, input WFD
IAFTBN	0	X				No afterburning
	1	X			X	Afterburning, input T7
	2	X			X	Afterburning, input WFA
IDCD	0		X	X		Convergent duct nozzle
	1		X	X		Convergent-divergent duct nozzle
IMCD	0		X	X		Convergent main nozzle
	1		X	X		Convergent-divergent main nozzle
NOZFLT	0	X				A9 and A29 are held constant
	1	X			X	A9 will be set for fully expanded flow
	2	X			X	A29 will be set for fully expanded flow
	3	X			X	A9 and A29 will be set for fully expanded flow
ITRYS	N <sup>2</sup>			X		Number of iterations before calling ERROR
TOLALL	X <sup>3</sup>			X		Tolerance which errors must satisfy for convergence
SI	T			X		Input and output in SI units
	F			X		Input and output in English units
ITRAN	0		X	X		A steady-state point
	1			X		The initial condition for a transient

<sup>1</sup> - Automatically returns to zero after each point.

<sup>2</sup> - Can be used for design or off design.

<sup>3</sup> - Value remains as input unless changed by new input.

4 - A setup case must be run where all components are matched; then the identical case can be run using these options.

<sup>2</sup>User-specified value; default value is 0

<sup>3</sup>User-specified value; default value is 0.



TABLE IV. - INPUTS FOR OFF-DESIGN POINTS

Variable	Units or type	Definition	Variable	Units or type	Definition
ITRYS	-----	Index for maximum number of iterations	ETAD	-----	Ductburner efficiency <sup>4</sup>
TOLALL	-----	Tolerance on error vector	IAFTBN	-----	Index for afterburning <sup>5</sup>
INIT	-----	Index for initializing point	T7	K (°R)	Afterburner exit temperature <sup>5</sup>
MODE	-----	Independent variable designator <sup>1</sup>	WFA	kg/sec (lbm/sec)	Afterburner fuel flow <sup>5</sup>
T4	K (°R)	Turbine inlet temperature <sup>1</sup>	DELFG	-----	Correction factor on gross thrust
PCNC	-----	Compressor speed <sup>1</sup>	DELFN	-----	Correction factor on net thrust
WFB	kg/sec (lbm/sec)	Combustor fuel flow <sup>1</sup>	DELSFC	-----	Correction factor on specific fuel consumption
PCNF	-----	Fan speed <sup>1</sup>	CVDNOZ	-----	Duct nozzle thrust coefficient
IDUMP	-----	Index for dumping program messages	CVMNOZ	-----	Main nozzle thrust coefficient
IAMTP	-----	Index on ram or inlet operation <sup>2</sup>	CVDWNG	-----	Wing nozzle thrust coefficient
ALTP	m (ft)	Altitude <sup>2</sup>	A6	m <sup>2</sup> (ft <sup>2</sup> )	Afterburner entrance area
AM	-----	Mach number <sup>2</sup>	A38	m <sup>2</sup> (ft <sup>2</sup> )	Wing nozzle throat area
ETAR	-----	Inlet pressure recovery <sup>2</sup>	A8	m <sup>2</sup> (ft <sup>2</sup> )	Main nozzle throat area
DELT1	-----	Correction to standard-day temperature <sup>2</sup>	A28	m <sup>2</sup> (ft <sup>2</sup> )	Duct nozzle throat area
P2	N/m <sup>2</sup> (atm)	Fan inlet total pressure <sup>2</sup>	HPEXT	W (hp)	Power extracted from high-pressure turbine
T2	K (°R)	Fan inlet total temperature <sup>2</sup>	PCBLC	-----	Fraction of compressor airflow removed as bleed <sup>6</sup>
IDCD	-----	Index for converging-diverging duct nozzle <sup>3</sup>	PCBLDU	-----	Fraction of bleed going to fan duct <sup>6</sup>
IMCD	-----	Index for converging-diverging main nozzle <sup>3</sup>	PCBLOB	-----	Fraction of bleed lost overboard <sup>6</sup>
NOZFLT	-----	Index for floating nozzle exit area <sup>3</sup>	PCBLHP	-----	Fraction of bleed going to high-pressure turbine <sup>6</sup>
IDBURN	-----	Index for ductburning <sup>4</sup>	PCBLIP	-----	Fraction of bleed going to intermediate-pressure turbine <sup>6</sup>
T24	K (°R)	Ductburner exit temperature <sup>4</sup>	PCBLLP	-----	Fraction of bleed going to low-pressure turbine <sup>6</sup>
WFD	kg/sec (lbm/sec)	Ductburner fuel flow <sup>4</sup>	PCBLF	-----	Fraction of fan airflow lost to cycle <sup>6</sup>

<sup>1</sup>Four basic options are available for specifying off-design operating points: MODE=0, specify T4; MODE=1, specify PCNC; MODE=2, specify WFB; MODE=3, specify PCNF.

<sup>2</sup>IAMTP determines which inlet variables are to be specified. The following options are available: IAMTP=0 - User specifies ALTP and AM; standard-day T1 and P1 and military-specification ETAR will be calculated. IAMTP=1 - User specifies ALTP, AM, and ETAR; standard-day T1 and P1 will be calculated. IAMTP=2 - User specifies ALTP, AM, and DELT1; military-specification ETAR will be calculated; standard-day P1 will be used; DELT1 will be added to standard-day T1. IAMTP=3 - User specifies ALTP, AM, and P2; ETAR and standard-day T1 will be calculated. IAMTP=4 - User specifies T2 and P2. IAMTP=5 - User specifies ALTP and AM; ETAR is calculated from user-supplied table of ETAR as a function of AM located in subroutine RAM2; standard-day P1 and T1 are calculated.

<sup>3</sup>If IDCD=1 at design point, A29 will automatically be calculated to obtain fully expanded flow. However, to recalculate A29 for an off-design point, NOZFLT must be set equal to 2 or 3 in addition to specifying IDCD=1. Similarly, IMCD=1 at design point means A9 will be calculated to obtain fully expanded flow; but to recalculate A9 for an off-design case, NOZFLT must be set equal to 1 or 3 in addition to specifying IMCD=1. If NOZFLT=0, A9 and A29 will retain their previous values.

<sup>4</sup>The following options are available for ductburning: IDBURN=0, no ductburning; IDBURN=1, specify T24; IDBURN=2, specify WFD. If IDBURN=1 or IDBURN=2 is to be used, the user must also specify a value for ETAD. No parameters other than T24, WFD, and ETAD may be changed while running a ductburning case, unless program is in transient (ITRAN 1) mode. This restriction is necessary because, in steady-state mode, DYNGEN recalculates A28 to maintain operating point which was established in case immediately previous to ductburning case.

<sup>5</sup>The following options are available for afterburning: IAFTBN=0, no afterburning; IAFTBN=1, specify T7; IAFTBN=2, specify WFA. The user need not specify a value for ETAA since it is calculated automatically. No parameters other than T7 or WFA may be changed while running an afterburning case, unless program is in transient (ITRAN 1) mode. This restriction is necessary because, in steady-state mode, DYNGEN recalculates A8 to maintain operating point which was established in case immediately previous to afterburning case.

<sup>6</sup>Bleed distribution in engine is governed by following equations:

$$BLF = PCBLF \cdot WAF$$

where BLF is fan flow lost overboard.

$$BLC = PCBLC \cdot WAC$$

where BLC is compressor bleed flow, which is distributed as follows:

$$BLDU = PCBLDU \cdot BLC$$

$$BLOB = PCBLOB \cdot BLC$$

$$BLHP = PCBLHP \cdot BLC$$

$$BLIP = PCBLIP \cdot BLC$$

$$BLLP = PCBLLP \cdot BLC$$

PCBLDU + PCBLOB + PCBLHP + PCBLIP + PCBLLP must equal 1 to maintain conservation of flow.

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TABLE V. - TRANSIENT INPUTS

Variable <sup>1</sup>	Units or type	Definition	Default value	Engine configuration														
				a	b	c	d	e	f	g	h	i	j	k				
														Number of spools				
3	2	2	3	2	2	3	2	2	2	3	2	2	2	2	3	2	2	1
														Number of streams				
3	3	3	2	2	2	3	2	2	2	3	3	2	2	2	2	2	1	1
				Turbo-fan		Super-charged com-pressor		Turbofan		Aft fan		Super-charged com-pressor		Aft fan		Turbojet		
1	Yes	Index to begin transient <sup>2</sup>	0	1	Yes	1	1	1	1	1	1	1	1	1	1	1	1	1
DT	sec	Time step for modified Euler method	0.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
DTPRNT	sec	Time interval between printouts		→	→	→	→	→	→	→	→	→	→	→	→	→	→	→
TF	sec	Final time for transient		→	→	→	→	→	→	→	→	→	→	→	→	→	→	→
P MILP	kg-m <sup>2</sup> (slug-ft <sup>2</sup> )	Low-pressure-rotor polar moment of inertia		→	→	→	→	→	→	→	→	→	→	→	→	→	→	→
P MHP	kg-m <sup>2</sup> (slug-ft <sup>2</sup> )	Intermediate-pressure-rotor polar moment of inertia		→	→	→	→	→	→	→	→	→	→	→	→	→	→	→
P MHP	kg-m <sup>2</sup> (slug-ft <sup>2</sup> )	High-pressure-rotor polar moment of inertia		Yes	No	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No	Yes	No	No
XXLPDS	rpm	Low-pressure-rotor design speed <sup>3</sup>		Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
XXNPDS	rpm	Intermediate-pressure-rotor design speed <sup>3</sup>		No	No	Yes	No	No	Yes	No	Yes	No	Yes	No	No	Yes	No	No
XNHPDS	rpm	High-pressure-rotor design speed <sup>3</sup>		Yes	Yes	No	Yes	Yes	Yes	No	Yes	No	Yes	No	Yes	Yes	No	No
V FAN	m <sup>3</sup> (ft <sup>3</sup> )	Fan volume		Optional	Optional	Optional	Optional	Optional	Optional	Optional	Optional	Optional	Optional	Optional	Optional	Optional	Optional	Optional
V INTC		Intermediate-pressure-compressor volume		→	→	→	→	→	→	→	→	→	→	→	→	→	→	→
V COMP		High-pressure-compressor volume		→	→	→	→	→	→	→	→	→	→	→	→	→	→	→
V COMB		Compressor volume		→	→	→	→	→	→	→	→	→	→	→	→	→	→	→
V HPTRB		High-pressure-turbine volume		→	→	→	→	→	→	→	→	→	→	→	→	→	→	→
V IPTRB		Intermediate-pressure-turbine volume		→	→	→	→	→	→	→	→	→	→	→	→	→	→	→
V LPTRB		Low-pressure-turbine volume		→	→	→	→	→	→	→	→	→	→	→	→	→	→	→
V AFTBN		Afterburner volume		→	→	→	→	→	→	→	→	→	→	→	→	→	→	→
V FDUCT		Fan duct volume		→	→	→	→	→	→	→	→	→	→	→	→	→	→	→
V WDUCT		Wing duct volume		→	→	→	→	→	→	→	→	→	→	→	→	→	→	→

<sup>1</sup> A "Yes" entry in the columns on the right means that the user must supply a value for the variable in question; the default value should not be used. A "No" entry means the user must not supply a value; the default value should be used. "Optional" means that the user may supply a value, but the default value can be used if desired.

<sup>2</sup> Setting UTRAN equal to 1 has the following effects: (1) The next point calculated will be for TIME = 0.0. For each succeeding time point, subroutine DISTRB will be called by ENGBAL to obtain transient input. (2) If MODE = 2, subroutine FCNTRL will be called by COCOMB to obtain a controlled value of WFB. (3) If IAFBN = 1 or 2, A8 will not be automatically recalculated. If the user wants controlled A8, he should write subroutine NOZCTR, which is called by COMNOZ. (4) If IDBURN = 1 or 2, A28 will not be automatically recalculated. The user can easily add a subroutine similar to NOZCTR to be called by CODUCT if he wishes to have controlled A28.

<sup>3</sup> Rotor design speed is defined as the rpm corresponding to 100 percent PCNF, PCNI, or PCNC. DYNGEN assumes that rotor mechanical speed (in percent) is equal to corrected speed (in percent) at the design point. For example, if PCNCDS = 80.0 and the user wants high-pressure-rotor speed to be 10 000 rpm at the design point, he should input ANHPDS 10 000 0 80 12 500.

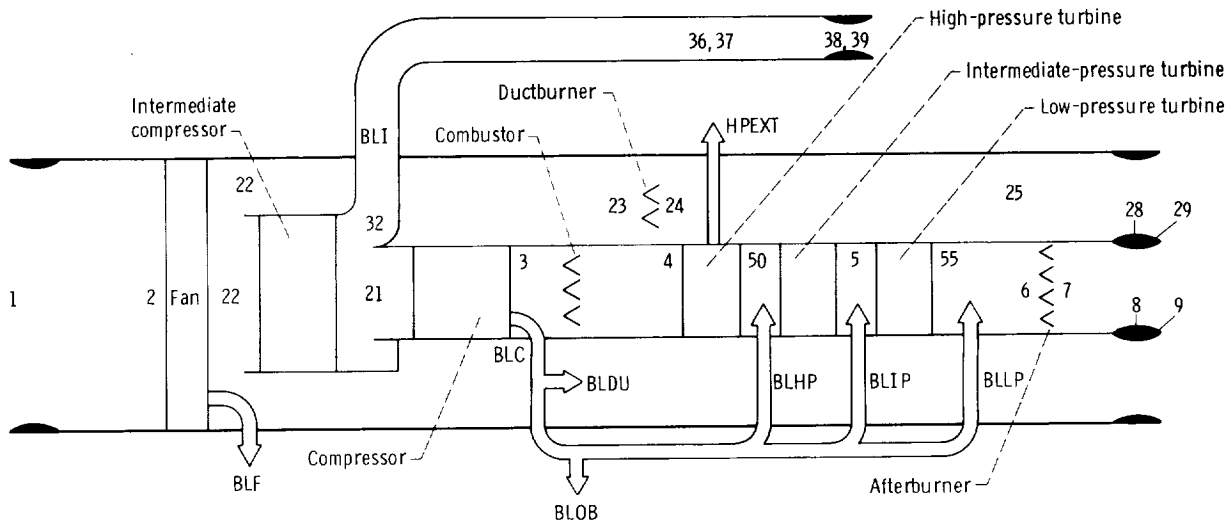


Figure 1. - Three-spool, three-stream turbofan engine (type a).

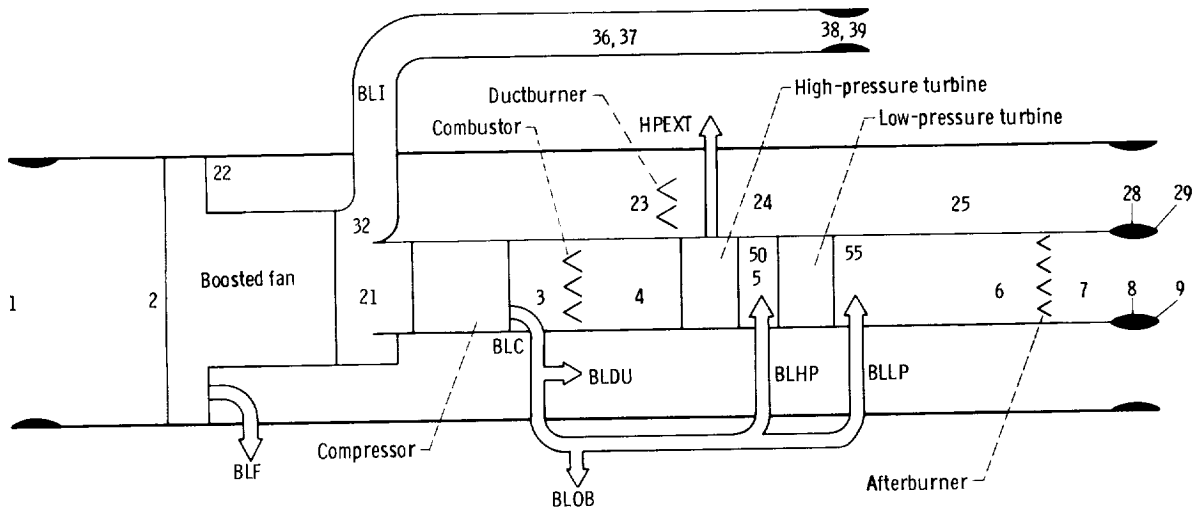


Figure 2. - Two-spool, three-stream boosted-fan engine (type b).

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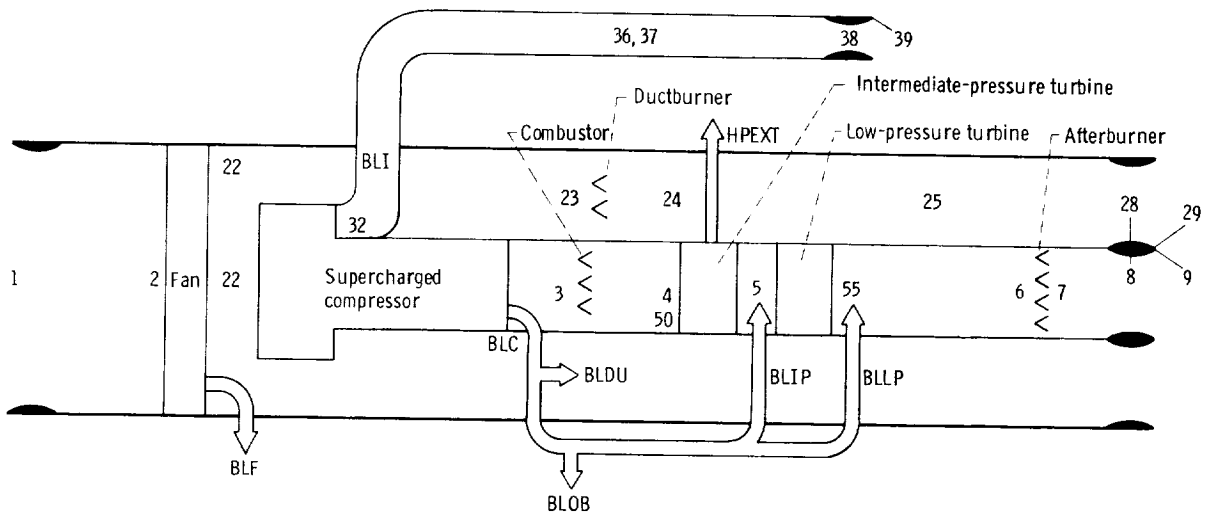


Figure 3. - Two-spool, three-stream, supercharged-compressor engine (type c).

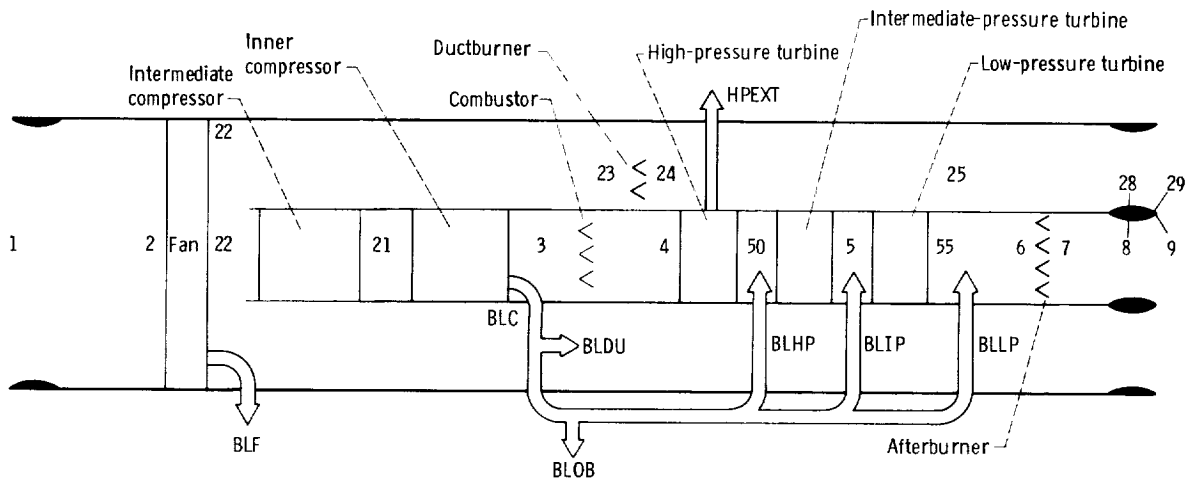


Figure 4. - Three-spool, two-stream engine (type d).

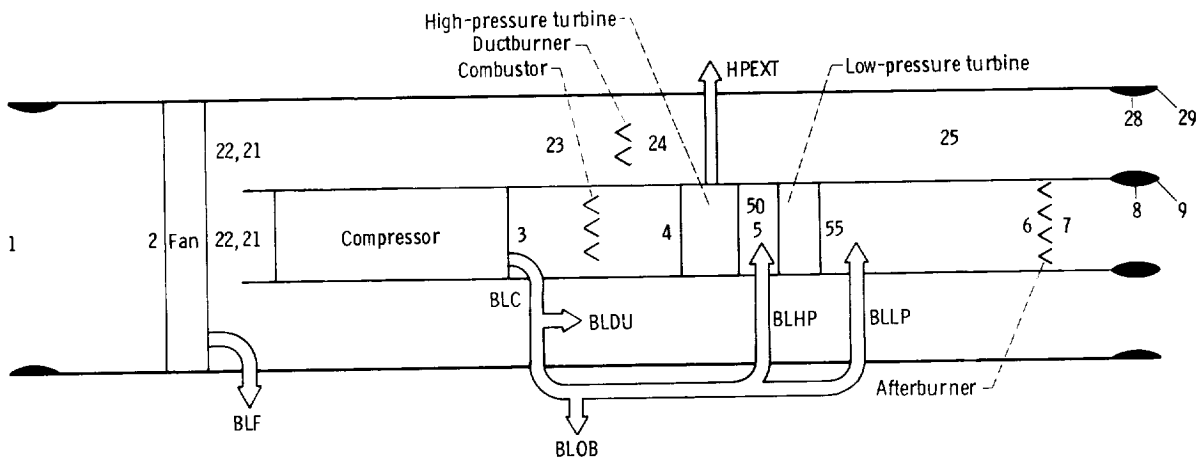


Figure 5. - Two-spool, two-stream turbofan engine (type e).

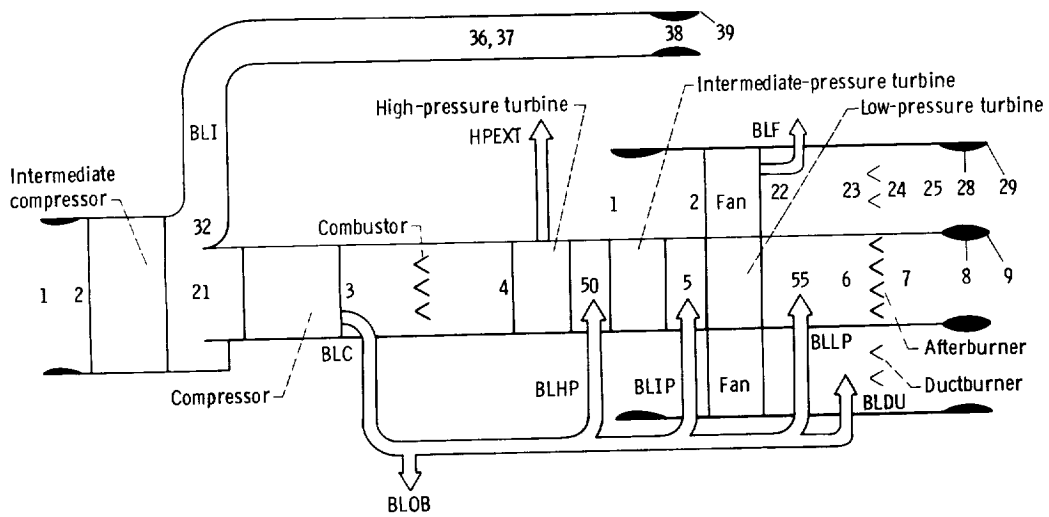


Figure 6. - Three-spool, three-stream, aft-fan engine (type f).

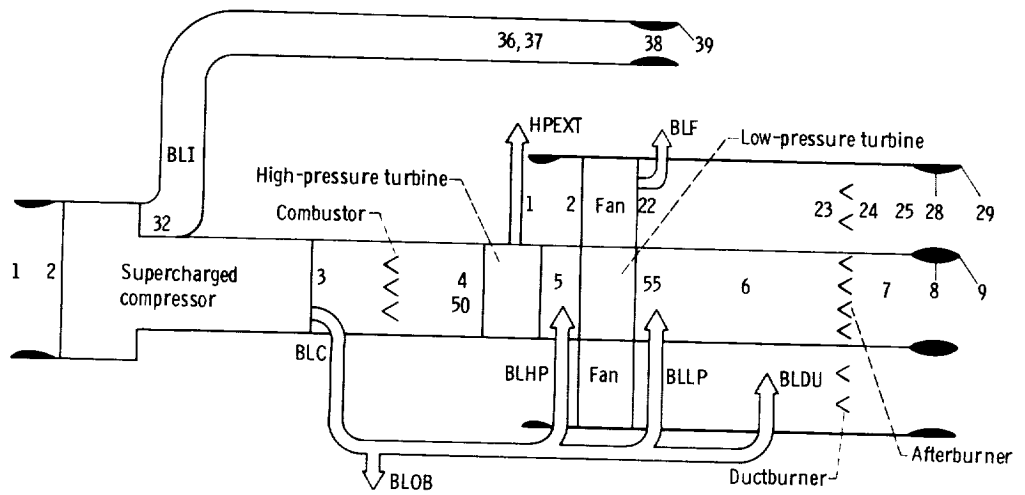


Figure 7. - Two-spool, three-stream, aft-fan engine (type g).

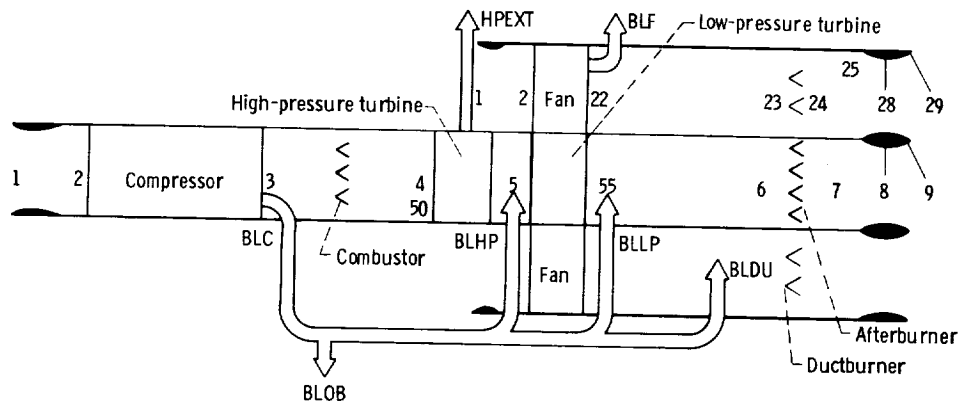


Figure 8. - Two-spool, two-stream aft-fan engine (type h).

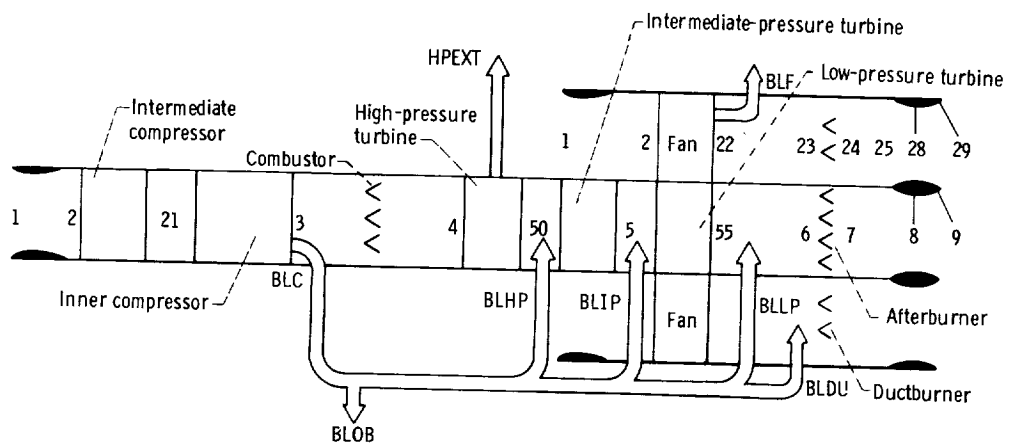


Figure 9. - Three-spool, two-stream aft-fan engine (type i).

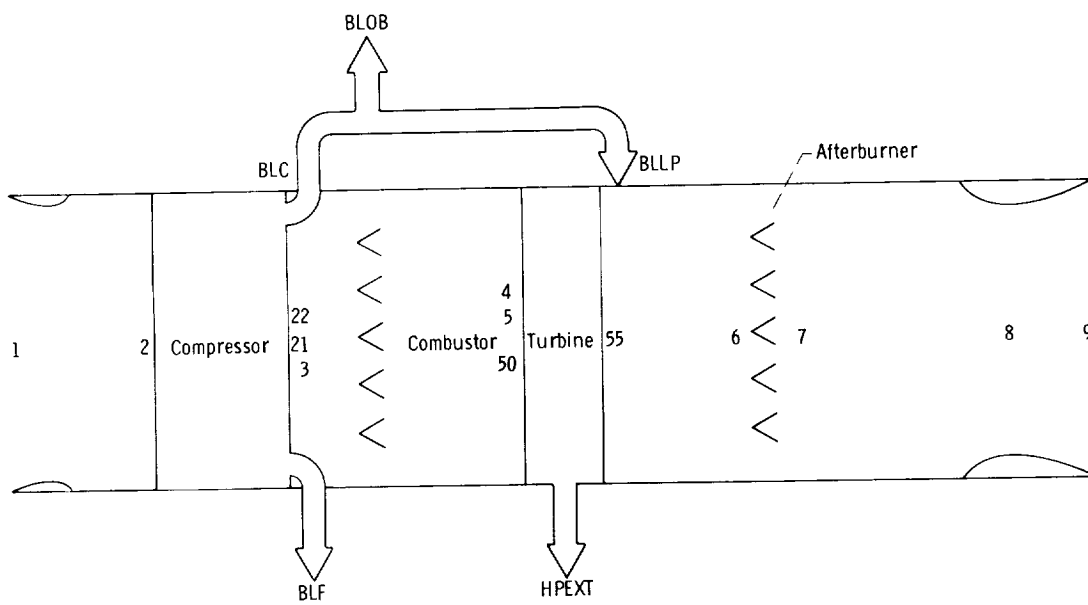
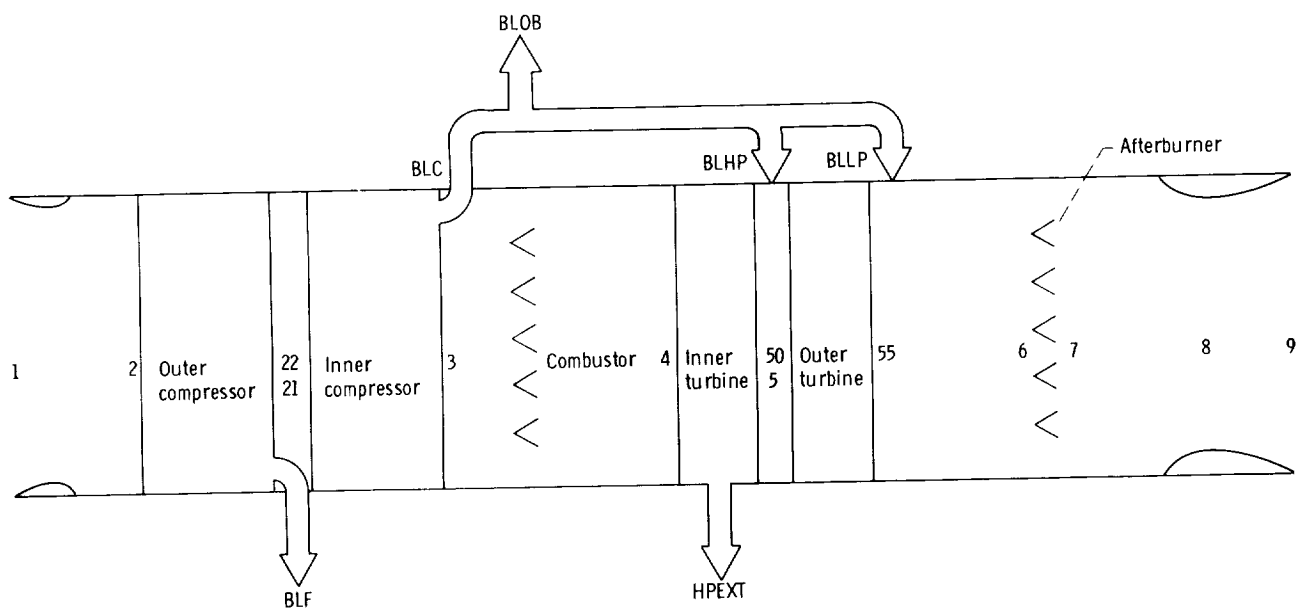


Figure 11. - One-spool turbojet (type k).

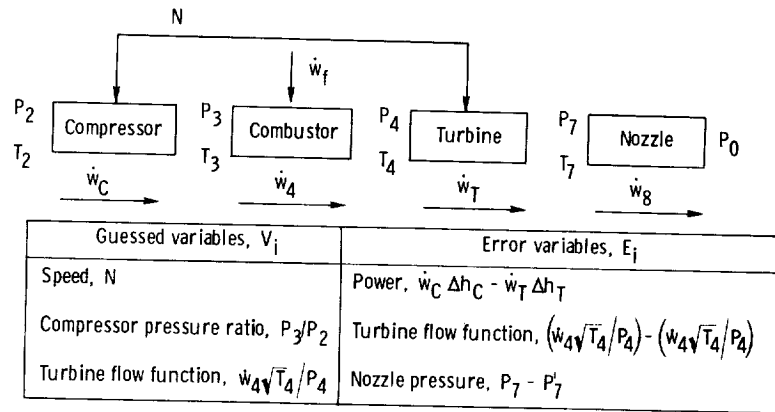


Figure 12. - Steady-state engine calculations for a turbojet.

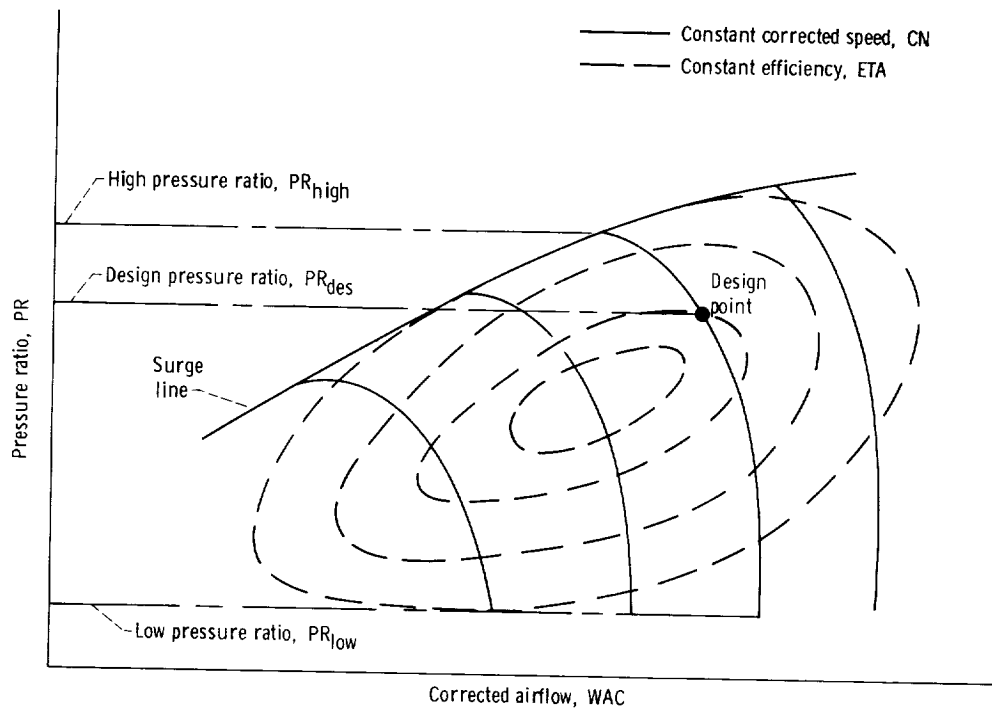


Figure 13. Example of specific fan-compressor map.  $Z = (PR_x - PR_{low}) / (PR_{high} - PR_{low})$ .



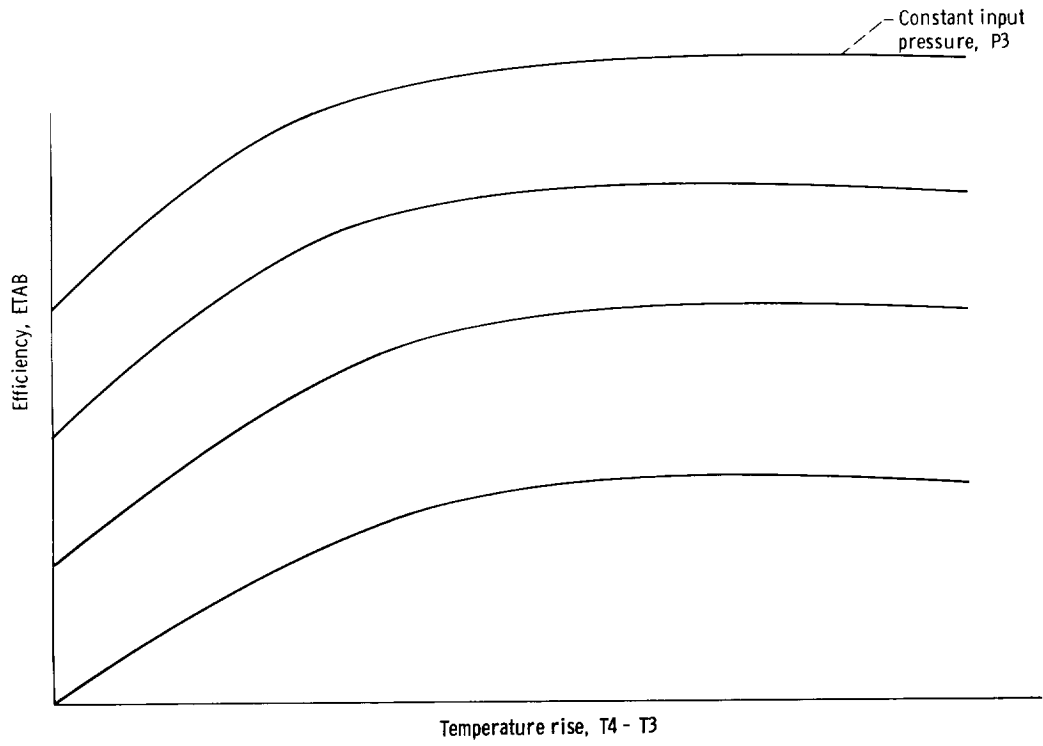


Figure 14. - Example of combustor map.

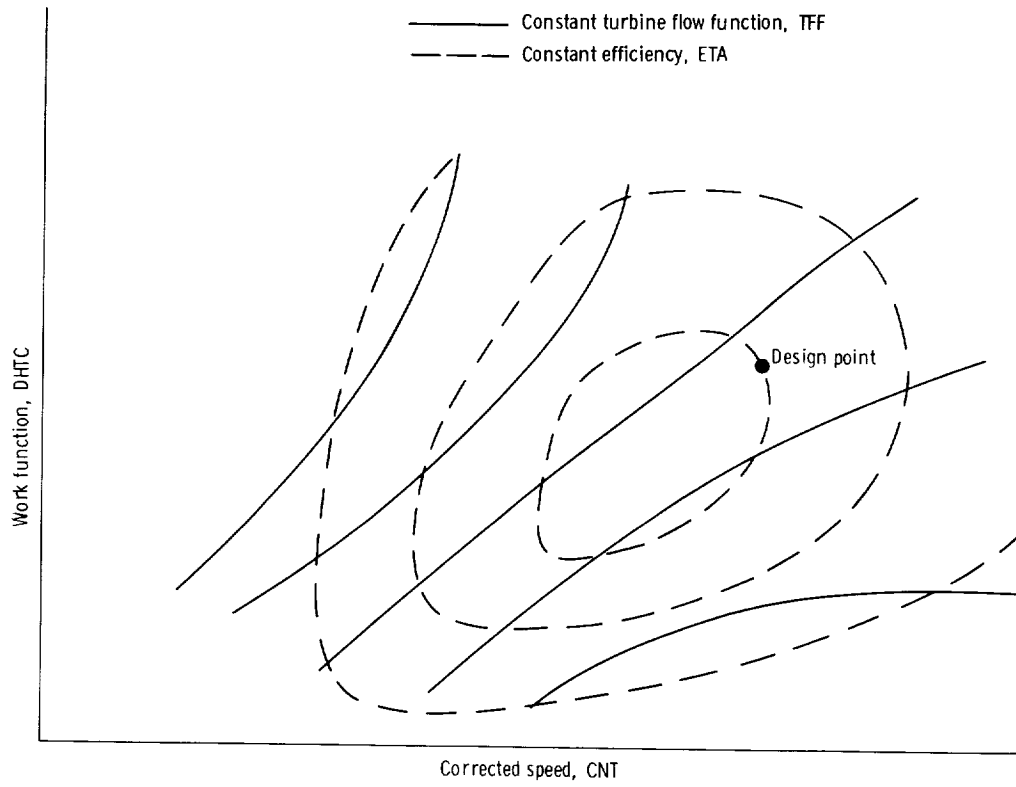
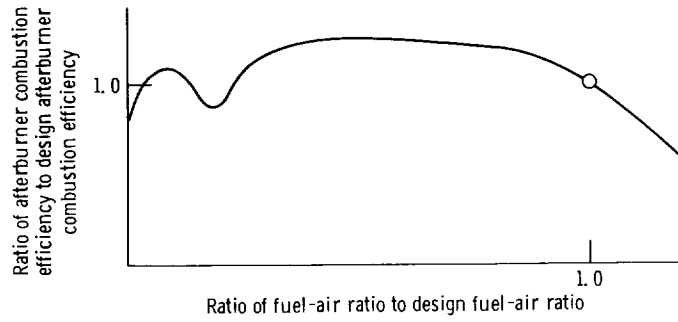
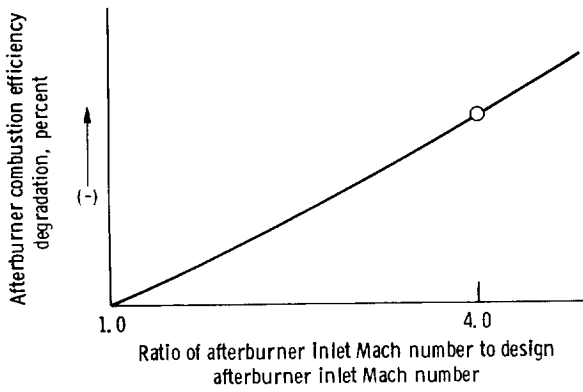


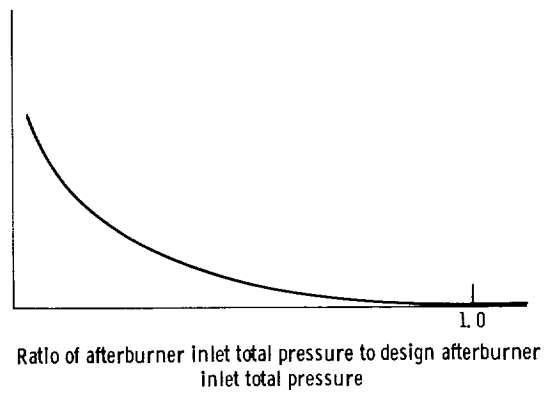
Figure 15. - Example of specific turbine map.



(a) Generalized afterburner combustion efficiency as function of fuel-air ratio.



(b) Efficiency correction factor as function of afterburner inlet Mach number.



(c) Efficiency correction factor as function of afterburner inlet total pressure.

Figure 16. - Example of generalized afterburner combustion efficiency performance map.

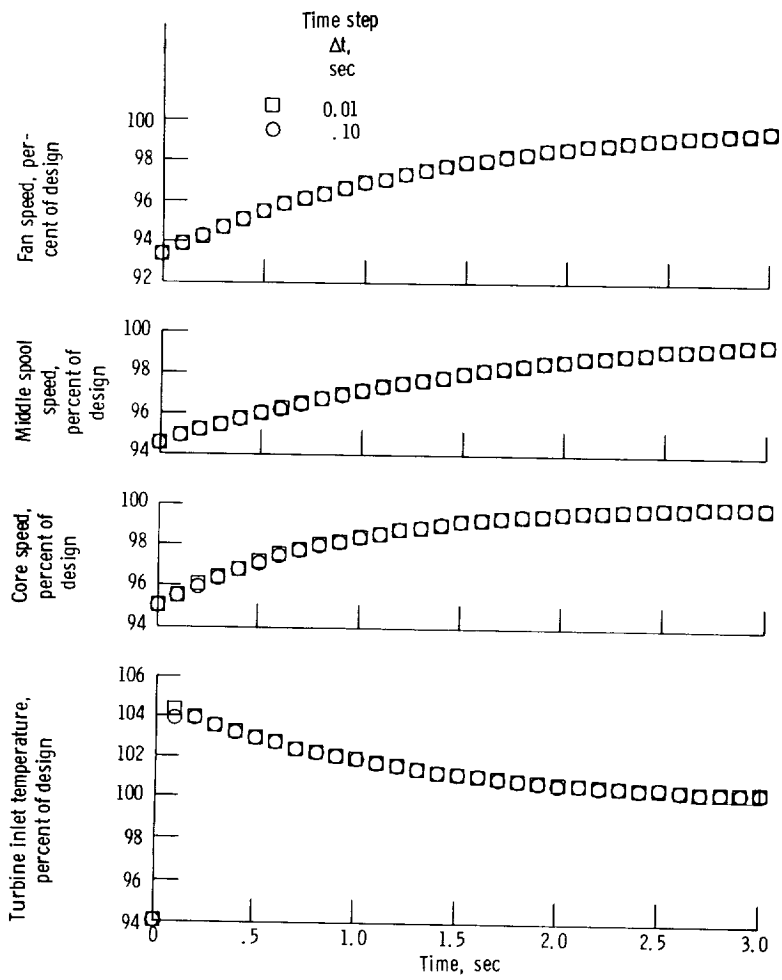


Figure 17. - Response of three-spool turbofan to fuel flow step.

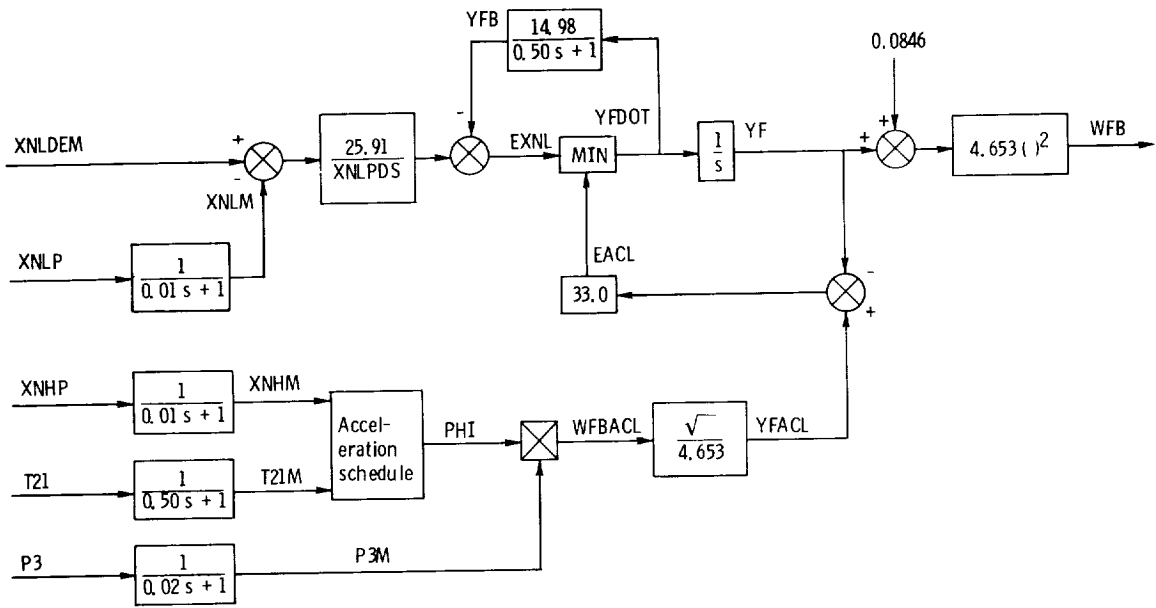


Figure 18. - Two-spool turbofan speed control.

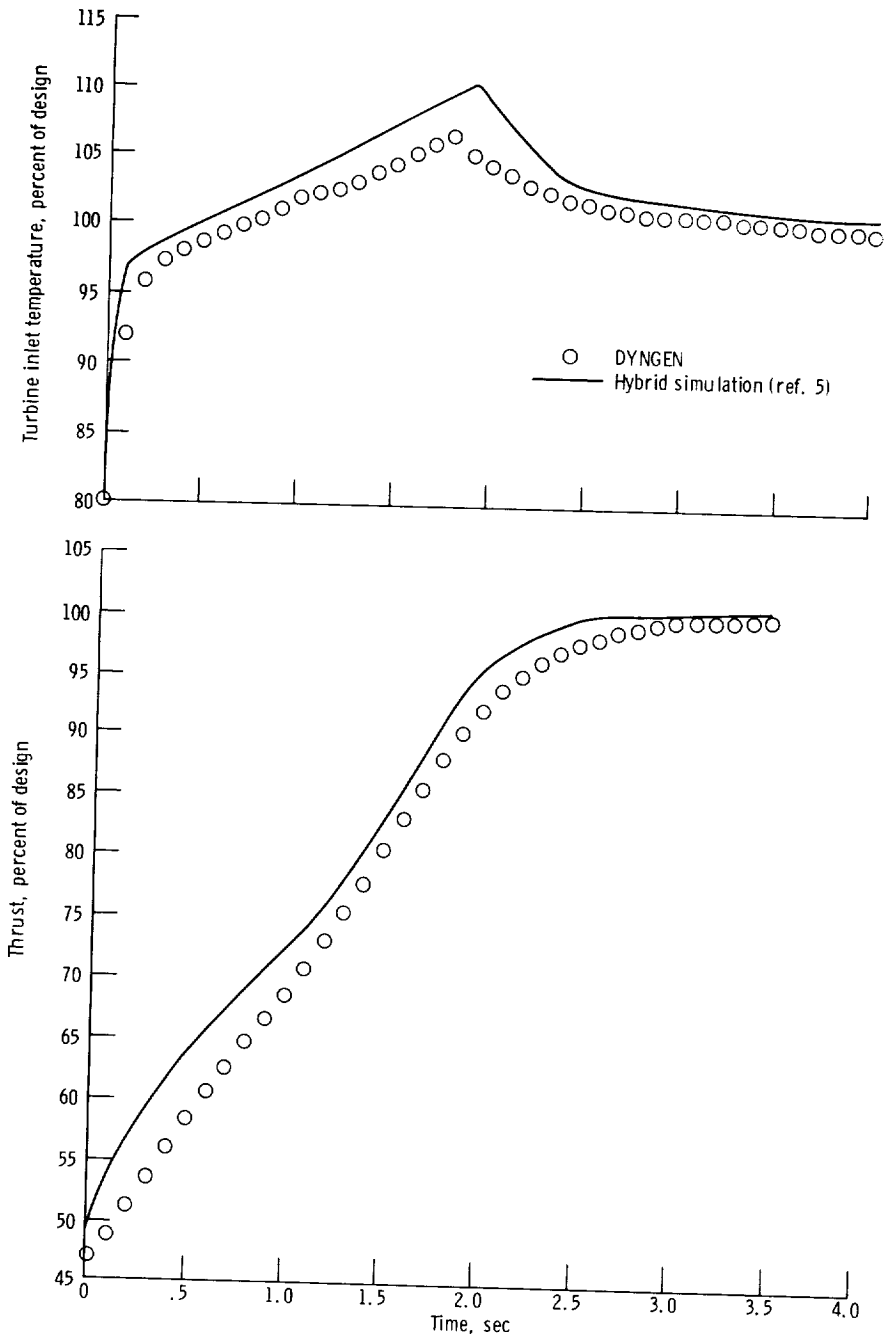
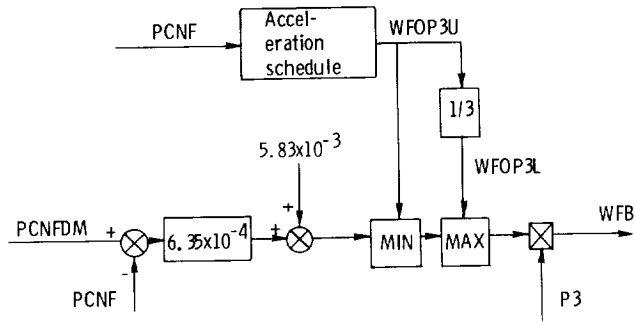
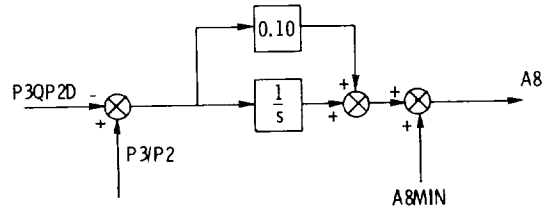


Figure 19. - Response of two-spool turbofan to throttle step.



(a) Fuel control.



(b) Nozzle control.

Figure 20. - Afterburning turbojet control system.

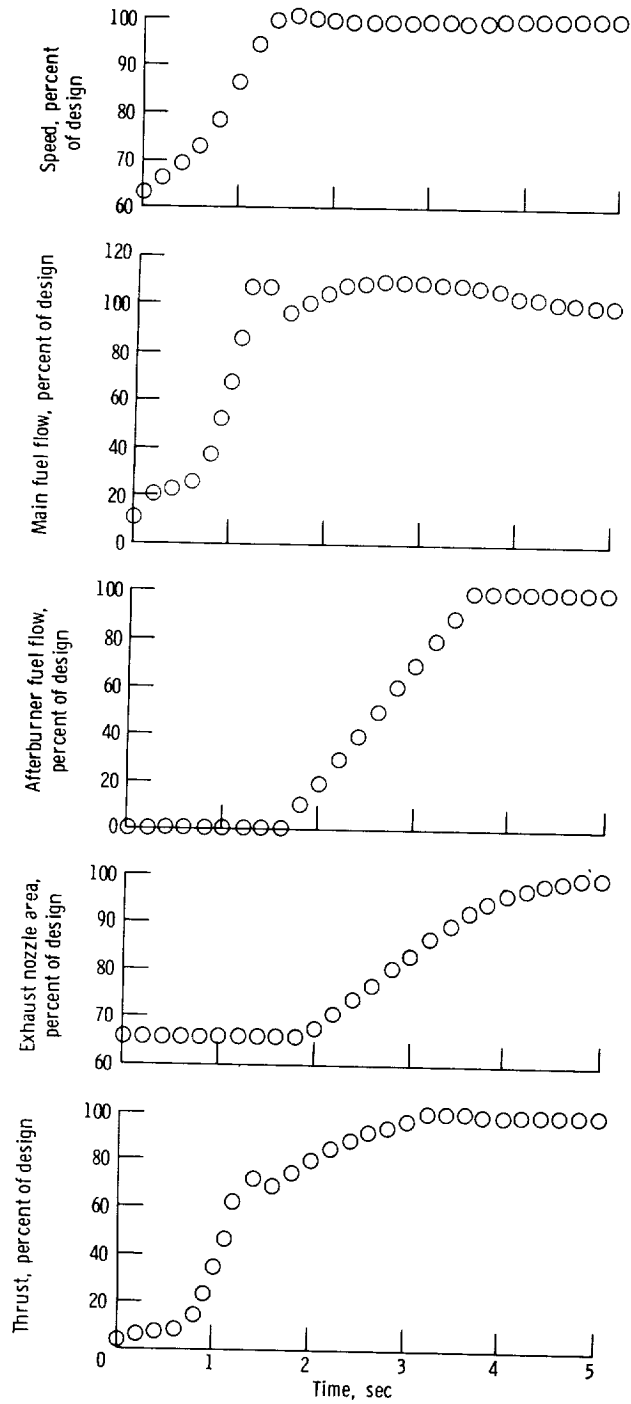


Figure 21. - Response of afterburning turbojet to throttle slam.