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GENENG — A PROGRAM FOR CALCULATING DESIGN AND OFF-DESIGN PERFORMANCE FOR TURBOJET AND TURBOFAN ENGINES

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16. Abstract

A computer program titled GENENG is described. The program uses component performance maps to enable the user to do analytical steady-state engine cycle calculations. Through a scaling procedure, each of the component maps can be used to represent a family of maps (different design values of pressure ratios, efficiency, weight flow, etc.). Either convergent or convergent-divergent nozzles may be used. Included is a complete FORTRAN IV listing of the program. Sample results and input explanations are shown for one-spool and two-spool turbojets and two-spool separate- and mixed-flow turbofans operating at design and off-design conditions. The computer program is available from the authors.

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SUMMARY

A digital computer program titled GENENG is described. The original version of the computer program is titled SMOTE (SiMulation Of Turbofan Engine) and was developed by the Turbine Engine Division of the Air Force Aero Propulsion Laboratory, Wright-Patterson Air Force Base, Ohio. SMOTE is capable of calculating only turbofan design and off-design performance using specific component performance maps. GENENG calculates steady-state design and off-design turbofan and one- and two-spool turbojet engine performance. Discussed in this report are changes to SMOTE which enable the user to do jet engine calculations of a general nature, thereby allowing the mission analyst a greater freedom in selection of engine design characteristics. Typical of these changes is an automatic redesign of fan and compressor pressure ratios when the static pressures do not balance at the mix point for mixed-flow turbofans. A convergent-divergent nozzle performance map addition is shown. Other changes that permit greater flexibility for generalized cycle studies for GENENG are described.

Included as an appendix to the report is a complete FORTRAN IV listing of GENENG. Sample results and input explanations are included for two-spool turbojet, one-spool turbojet, and two-spool turbofan engines operating at design and off-design conditions.

INTRODUCTION

For preliminary as well as in-depth studies it is often necessary to study a broad range of engines operating at both design and off-design conditions in order to find an efficient airframe/engine combination. The spectrum of flight conditions through which an engine must operate will strongly affect the optimum design parameter for that engine.

The SMOTE code (SiMulation Of Turbofan Engines), discussed in references 1 and 2,

provided a computer program having off-design-point calculation capability for either existing engines or theoretical ones - a major advance. Theoretical engines are simulated by scaling component performances from existing engines to the design conditions of the theoretical engines.

GENENG (GENeralized ENGine), a computer code derived from SMOTE, was written to improve the versatility of SMOTE. Among the changes made are as follows:

(1) One- and two-spool turbojets can be calculated, as well as turbofans.

(2) Afterburner performance maps can be used.

(3) Nozzle performance maps can be used.

(4) Fan and compressor pressure ratios are automatically redesigned for mixed-flow turbofans if the static pressures at the mix point do not match.

(5) Duct combustor pressure losses are calculated.

(6) A new method of entering data into the program is used.

A derivative program from GENENG, called GENENG II, is reported in a companion report to this one (ref. 3). GENENG II calculates performance of two- or three-spool front- or aft-fan turbofan engines with as many as three nozzles (or airstreams).

These programs have proven to be very versatile, and minor changes to them can greatly increase the number of engine configurations that can be studied. As an example, GENENG was used to study nuclear-powered turbofan engines. This was accomplished by adding a heat-exchanger subroutine as a substitute for the combustor subroutine to simulate the use of nuclear power to raise the temperature of the air entering the first turbine.

In this report are included illustrative examples of the use of GENENG to study various one- and two-spool turbojets and separate- and mixed-flow turbofans.

GENENG is available from the authors upon request. This FORTRAN IV program can be used by computing centers having an IBM 7094 Mod 2 computer. With modifications, the program can be used on all machines that have a FORTRAN compiler.

THERMODYNAMIC ANALYSIS OF ENGINE TYPES

All thermodynamic properties of air and gas are calculated by considering variable specific heats and no dissociation. The air and gas property tables of reference 4 were curve fit and are used herein.

The following discussion presents the thermodynamic analysis of the engine cycles that can be studied using GENENG.

Two-Spool Afterburning Turbofan

The basic engine, a two-spool turbofan, is shown in figure 1. All other engine types are treated as variations of this basic engine. Free-stream conditions exist at station 1 and are determined by using the U. S. Standard Atmosphere Table of 1962 (ref. 5). The conditions at station 2 are determined by flight speed and inlet recovery.

GENENG compressor maps work with corrected values of airflow. At the entrance to the fan, the corrected airflow $WA_{F,c}$ is

$$WA_{F,c} = \frac{WA_F\sqrt{T_2/518.668}}{P_2/P_{SLS}} \tag{1}$$

where P_2 and P_{SLS} are in atmospheres and P_{SLS} equals 1.0. All symbols are defined in appendix C. Some symbols are formed as the combination of other symbols; thus WA is airflow, F is for fan, and c when following a compound symbol means corrected. Station numbers are defined on the appropriate figure.

All the fan air WA_F is compressed by the fan giving rise to conditions at station 21. The power required to do this is

$$\text{Fan power} = WA_F \times (H_{21} - H_2) \tag{2}$$

Some fan air may be lost to the cycle as fan bleed Bl_F, which is expressed as a fraction of the fan airflow

$$Bl_F = PC_{Bl,F} \times WA_F \tag{3}$$

The corrected airflow into the core compressor is

$$WA_{C,c} = \frac{WA_C\sqrt{T_{21}/518.668}}{P_{21}/1.0} \tag{4}$$

The remaining air goes through the fan duct where some leakage from the core air may also enter (see eq. (11)).

$$WA_D = WA_F - Bl_F - WA_C + Bl_{DU} \tag{5}$$

The air which may be heated by a duct burner to a temperature T_{24} undergoes a pressure drop

$$P_{25} = P_{24} \times \left[1 - \left(\frac{\Delta P}{P}\right)_{DUCT}\right] \tag{6}$$

The air would have been heated by the addition of fuel, which can be expressed as a fuel-air ratio so that

$$WG_{24} = WA_{23} \times \left[1 + (f/a)_{23}\right] \tag{7}$$

The gas is then either expanded through a nozzle (station 29) to produce thrust or is mixed with the core air as shown in figure 2 (mixed-flow turbofan). The bypass ratio of the engine is defined by

$$BYPASS = \frac{WA_D}{WA_C} \tag{8}$$

The air continuing into the core is compressed to conditions at station 3. The power required is

$$\text{Compressor power} = WA_C \times (H_3 - H_{21}) = WA_3 \times (H_3 - H_{21}) \tag{9}$$

Some core bleed air Bl_C may be used for turbine cooling. Some of the air is put back into the cycle into each of the two turbines, and some is lost to the cycle as overboard bleed or leakage into the fan duct.

$$Bl_C = PC_{Bl,\,C} \times WA_3 \tag{10}$$

$$Bl_{DU} = PC_{Bl,\,DU} \times Bl_C \tag{11}$$

$$Bl_{OB} = PC_{Bl,\,OB} \times Bl_C \tag{12}$$

$$Bl_{HP} = PC_{Bl,\,HP} \times Bl_C \tag{13}$$

$$Bl_{LP} = PC_{Bl,\,LP} \times Bl_C \tag{14}$$

Since $Bl_{DU} + Bl_{OB} + Bl_{HP} + Bl_{LP} = Bl_C$, the sum of $PC_{Bl,\,DU} + PC_{Bl,\,OB} + PC_{Bl,\,HP} + PC_{Bl,\,LP}$ must be equal to 1.0.

The remaining air is

$$WA_4 = WA_3 - Bl_C \tag{15}$$

and is heated to a turbine inlet temperature T_4 while undergoing a combustor pressure drop $(\Delta P/P)_{COMB}$. The fuel required to do this is expressed as a fuel-air ratio $(f/a)_4$ so that the weight of the gas entering the first (high pressure) turbine WG_4 can be expressed as

$$WG_4 = WA_4 \times \left[1 + (f/a)_4\right] \tag{16}$$

This gas is then expanded through the turbine to conditions at station 5. The enthalpy at station 5 is first calculated by making a power balance, since this turbine drives the compressor and supplies any work extracted (HPEXT). By using equation (9),

$$WG_4 \times (H_4 - H_5) = WA_3 \times (H_3 - H_{21}) + HPEXT \tag{17}$$

In addition, the physical speeds must match

$$N_{HP,\ TURBINE} = N_{COMP} \tag{18}$$

If high-pressure-turbine bleed air Bl_{HP} is added back into the cycle at this point, H_5 must be readjusted.

$$H_5 = \frac{(Bl_{HP} \times H_3) + WG_4H_5}{WG_4 + Bl_{HP}} = \frac{(Bl_{HP} \times H_3) + WG_4H_5}{WG_5} \tag{19}$$

Similarly,

$$WG_5 \times (H_5 - H_{55}) = WA_F \times (H_{21} - H_2) \tag{20}$$

$$N_{LP,\ TURBINE} = N_{FAN} \tag{21}$$

$$H_{55} = \frac{(Bl_{LP} \times H_3) + WG_5H_{55}}{WG_5 + Bl_{LP}} = \frac{(Bl_{LP} \times H_3) + WG_5H_{55}}{WG_{55}} \tag{22}$$

For non-mixed-flow turbofans, the gas flow at station 6, WG_6, is identical with that at station 55, WG_{55}. For mixed-flow turbofans, the air in the fan duct is added.

$$WG_6 = WG_{55} + WA_D \tag{23}$$

Mixed-flow turbofans additionally require that the static pressures at station 25 and at station 55 (fig. 2) match.

$$PS_{55} = PS_{25} \tag{24}$$

The gas flow WG_6 then may be heated by an afterburner to a gas temperature T_7 and may undergo a pressure drop.

$$P_7 = P_6\left[1 - (\Delta P/P)_{\text{AFTERBURNER}}\right] \tag{25}$$

And the gas flow rate would be increased by any fuel burned.

$$WG_7 = WG_{55} + WFA$$

The gas is then expanded through the nozzle (station 9) to produce the remainder of the engine thrust.

Two-Spool Turbojet

The two-spool turbojet is equivalent to a two-spool turbofan with a BYPASS of zero. This engine is shown in figure 3. In calculating this type of engine, there is no fan duct and the air entering the inner compressor is the same as the air entering the inlet less any bleed.

$$WA_C = WA_F - Bl_F \tag{26}$$

The thermodynamic calculations proceed identically to the previous case, the two-spool turbofan case, except that any equations referring to the fan duct are eliminated.

One-Spool Turbojet

The one-spool turbojet is shown in figure 4. As can be seen, to simulate this engine the inner compressor and its driving turbine are eliminated. That is, stations 21 and 3 become identical and stations 4 and 5 become identical.

The only calculation changes required therefore are (1) to eliminate any thermodynamic equations relating to the fan duct and the inner spool of the two-spool turbofan engine and (2) to add the horsepower extracted to the power requirements of the outer turbine.

BALANCING TECHNIQUE

An off-design engine cycle calculation requires satisfying various matching con-

straints (rotational speeds, airflows, compressor and turbine work functions, and nozzle flow functions) at each specified operating condition. GENENG internally searches for compressor and turbine operating points that will satisfy the constraints. It does this by generating differential errors caused by small changes in the independent variables. The program then uses a matrix that is loaded with the differential errors to solve for the zero-error condition. This procedure is known as the Newton-Raphson iteration technique.

For the two-spool turbofan or turbojet engines a solution for a set of six simultaneous linear algebraic equations is obtained; for the one-spool turbojet a set of three simultaneous linear equations is solved. The six independent variables selected are

ZF — Ratio of pressure ratios of outer compressor (fan) along a speed line,

$$ZF = \frac{\text{(Pressure ratio along speed line) - (Low pressure ratio on speed line)}}{\text{(High pressure ratio on speed line) - (Low pressure ratio on speed line)}}$$

PCNF or T4 — Percent fan speed or turbine inlet temperature

ZC — Ratio of pressure ratios of inner compressor along speed line; calculated same as ZF

PCNC or T4 — Percent compressor speed or turbine inlet temperature

TFFHP — Inner (high pressure) turbine flow function, $WG_4\sqrt{T_4}/P_4$

TFFLP — Outer (low pressure) turbine flow function, $WG_5\sqrt{T_5}/P_5$

ZC, PCNC, and TFFHP are not used for the one-spool turbojet.

The program initially selects new (perturbed) values for the variables, based on the design values. It is then possible to proceed through the entire engine cycle, where six (or three) errors are generated. The initial values of the six (or three) variables and six (or three) errors are base values.

As per reference 1, the partial differential equations for $E = f(v)$ are

$$dE_i = \sum_{j=1}^{j_{max}} \frac{\partial E_{ij}}{\partial V_j} dV_j \tag{27}$$

for i going from 1 to j_{max} where j_{max} is 6 for two-spool engines or 3 for one-spool turbojets; E is an error; V is a variable; and ∂E_{ij} is the change in E_i caused by a change in V_j.

The assumption of a small change in the variable results in the following approxima-

tions (B refers to a base value):

$$dE = E - EB \tag{28}$$

$$dV = V - VB \tag{29}$$

$$\frac{\partial E}{\partial V} = \frac{E}{V} \tag{30}$$

With these approximations and the knowledge that E should equal zero for the balanced engine, the set of partial differential equations (eq. (27)) reduces to

$$E_i - EB_i = \sum_{j=1}^{j_{max}} \frac{\Delta E_{ij}}{\Delta V_j} dV_j = -EB_i \tag{31}$$

for i going from 1 to j_{max}.

Thus the calculations made with the perturbed variables are used to compute $\Delta E/\Delta V$, and equation (31) is solved for dV_j. The variables V are then given new values from

$$V_j = V_jB + dV_j \tag{32}$$

If the engine cycle calculations were linear functions, the engine would balance (errors within some allowable limits) with the new values of the variables. However, this is not the case, and it is usually necessary to repeat the process of changing each variable by a small amount for each pass. A change in each error because of the small change in the variable is calculated for each pass, where the new values become base values. This process occurs several times before a balance is obtained.

A subroutine (MATRIX) to determine the solution of a matrix is used to solve the set of differential equations. After each pass through the engines, a matrix array is loaded with the appropriate values; after a number of passes equal to $1 + j_{max}$ (base value plus perturbation on each of the independent variables), the matrix subroutine is used to solve the matrix. This solution (E within some allowable limit) yields the correct values of the independent variable and satisfies all the component matching constraints.

The most-often-used independent variable and the differential errors for four types of engines that can be run on GENENG are listed in table I.

SUBROUTINES AND INPUTS FOR ENGINE PERFORMANCE CALCULATIONS

Two forms of data are supplied to GENENG. Some data, such as all the constants and component map data, are in the form of a BLOCK DATA subprogram. The varying data are supplied at execution time by the use of input data cards.

The FORTRAN listings of GENENG are presented in appendix A. The function and description of the subroutines follows in the next section.

GENENG Subroutine Functions and Descriptions

A flow chart of the computer program with the subroutines is shown in figure 5. The functions of the subroutines are listed here and the purpose of each described.

GENENG	Dummy main program to initiate the calculations and cause the input of the controlled output variables. Because of the looping between subroutines, control is never transferred back to this routine.
ENGBAL	Main routine. Controls all engine balancing loops; checks tolerances and number of loops and loads matrix; calls input.
GUESS	Determines initial values of independent variable (see table I) at each point.
MATRIX	Solves error matrix.
PUTIN	Calls input subroutine package. Controls loop on static pressures for mixed-flow turbofan.
ZERO	Zeros nearly all of common and certain controls.
COINLT	Determines ram recovery and performs inlet calculations.
ATMOS	1962 U.S. Standard Atmosphere Table.
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.
COFAN	Uses BLOCK DATA to perform outer-compressor (fan) calculations.
COCOMP	Uses BLOCK DATA to perform inner-compressor calculations (two spools only).

COCOMB Uses BLOCK DATA to perform combustor calculations. May use either T4 or WFB as the main parameter.

COHPTB Uses BLOCK DATA to perform inner-turbine calculations (two spools only).

COLPTB Uses BLOCK DATA to perform outer-turbine calculations.

CODUCT Performs duct and duct-burning calculations for turbofans. May use either T24 or WFD as main parameters.

COMIX Performs gas mixing calculations if in mixed-flow mode. At design points it calculates areas either from an input static pressure PS55 or from an input Mach number AM55 if PS55 = 0. At off-design points it calculates static pressures and Mach numbers from the design areas. Calculates ERR (5). Rescales pressure ratios for mixed-flow turbofans to match duct and core static pressures just prior to mixing. COMIX also calculates afterburner entrance area A6 as a function of afterburner entrance Mach number AM6.

COAFBN Performs afterburning calculations. May use either T7 or WFA as the main parameters.

FRTOSD Dummy routine to transfer values from common FRONT to common SIDE.

FASTBK Dummy routine to transfer values from common SIDE to common BACK.

COMNOZ Controls the main nozzle.

ERROR Controls all printouts if an error occurs. Prints names of subroutine where error occurred and also prints the values of all variables in the main commons.

SYG Controls printing from UNITO8. Throughout the program and particularly in ENGBAL, certain messages, variables, and matrix values are written on UNITO8 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.

PERF Calculates performance after the engine is balanced.

OUTPUT Prints output except for controlled output. Prints the main commons after the design point.

CONOUT Controls and prints the controlled output variables.

THCOMP	Performs isentropic calculations for compressors.
PROCOM	Calculates thermodynamic gas properties for either air or a fuel-air mixture based on JP-4 using curve fits of the tables of reference 4.
SEARCH	General table lookup and interpolation routine to obtain data from the BLOCK DATA subroutines.
MAPBAC	Used when calculations result in values not on the turbine maps. Changes the map value and an independent variable (PCNF, PCNC, or T4) in an attempt to rectify the situation.
CONVRG	Performs nozzle calculations for a convergent nozzle.
CONDIV	Performs nozzle calculations for a convergent-divergent (C-D) nozzle.
THTURB	Performs isentropic calculations for turbines.
THERMO	Provides thermodynamic conditions using PROCOM.
AFQUIR	General quadratic interpolation routine.
PARABO	Parabolic curve-fit routine.
BLKFAN	Performance data for outer compressor (fan) map (BLOCK DATA).
BLKCMP	Performance data for inner compressor map (BLOCK DATA; two-spool engines).
CMBDAT	BLOCK DATA for combustor.
HPTDAT	Performance data for inner turbine map (BLOCK DATA; two-spool engines).
LPTDAT	Performance data for outer turbine map (BLOCK DATA).
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.
FRATIO	Convergent-divergent nozzle velocity coefficient (BLOCK DATA input as a function of nozzle pressure ratio and area expansion ratio).
INPUT	Package of Huff input subroutines. (The Huff Input Routine is a very versatile input mechanism further detailed in appendix B.)

Entering the Data

The Huff Input Routine, used to enter input data into the program at execution time, is discussed in appendix B. Appendix C presents the individual symbols internal to the program, station numbers, etc., from which compound names such as WAFCDS (WA + F + C + DS) are formed. Table II and appendix C present the names of the variables, the values of which are supplied on data cards.

Choice of component maps - scaling laws. - Many of the engines that are studied using GENENG are theoretical. Therefore, actual component maps for these engines will be nonexistent. The program, however, does require component maps to do off-design calculations. To alleviate this problem, GENENG 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 type being studied. In fact, several maps that the authors have obtained are identified as to the range of pressure ratio and the engine component design type for which they are valid (i.e., pressure ratio range, 4 to 8; subsonic compressor or inner compressor). Thus, for example, a high-bypass-ratio, subsonic-flight-speed, low-pressure-ratio fan map for a CF6 engine would not properly simulate a low-bypass-ratio, high-pressure-ratio, supersonic multistage fan.

The scaling equations used for the compressor maps are

$$PR = \frac{PR_{design} - 1}{PR_{map,\,design} - 1} (PR_{map} - 1) + 1$$

$$WA = \frac{WA_{design}}{WA_{map,\,design}} \times WA_{map}$$

$$ETA = \frac{ETA_{design}}{ETA_{map,\,design}} \times ETA_{map}$$

Similar equations are used for combustor and turbine map scaling. These equations are found in the appropriate subroutines. In the output are printed the correction factors used in scaling the maps. The closer these values are to 1.0 (especially pressure ratio, a primary characteristic of a given compressor map), 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 a large range of variables.

BLOCK DATA input. - The two compressor performance maps are entered into the

code as the BLOCK DATA subprograms BLKFAN and BLKCMP. The subprograms supplied by the authors with the code and shown in appendix A are not to be taken as realistic maps. These maps are only of an illustrative nature and are the ones used to run the sample calculations.

Using subprogram BLKFAN as an example (the first nine cards of which are printed here) and referring to a typical compressor map (fig. 6), the data are programmed as follows:

```
$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  1.00000,  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
```

Card 1 reminds the reader that these maps are fictitious. Card 2 identifies 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 the number of points NF 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 speed line CN=0. 3 set 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 A) set the values for each speed line.

The combustor map is also a BLOCK DATA subprogram (CMBDAT). 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 CMBDAT are reproduced here; a typical combustor map is shown in figure 7.

```
$IBFTC CMBDAT  DECK
       BLOCK DATA                                                              1
       COMMON / COMB/PSI(15),DELT(15,15),ETA(15,15),N,NP(15)                   2
       DATA N,NP / 15,15*15 /                                                  3
       DATA PSI/4.9116,9.8232,14.735,19.646,24.558,29.470,34.381,              4
      139.293,44.207,73.674,100.,200.,300.,400.,500./                          5
       DATA DELT/15*200.,15*300.,15*400.,15*500.,15*600.,15*700.,15*800.,      6
      115*900.,15*1000.,15*1100.,15*1200.,15*1300.,15*1400.,15*1500.,          7
      215*1600./                                                               8
       DATA ETA/                                                               9
      1.600,.726,.777,.806,.826,.843,.855,.865,7*.870,                        10
      2.758,.825,.858,.875,.888,.898,.906,.912,.914,6*.915,                   11
      3.868,.893,.911,.925,.935,.942,.947,.951,7*.953,                        12
      4.925,.936,.946,.955,.963,.969,.974,.977,.978,6*.979,                   13
      5.960,.966,.972,.977,.982,.985,.990,.992,.993,6*.995,                   14
      6.988,.991,.992,.994,.995,.997,.998,8*.999,                             15
      78*1.00,7*.999,120*1.00/                                                16
       END                                                                    17
```

Card 1 identifies subprogram as BLOCK DATA. Card 2 identifies common block COMB into which data are to be stored and the dimension of 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). Cards 4 and 5 assign values to each of the P3 lines from low to high pressure. Cards 6 to 8 assign values of ΔT to each of the P3 lines starting at low ΔT. The lowest value of ΔT on each of the P3 lines is given starting with the lowest value of ΔT on the lowest value of P3. Next comes the second lowest value of ΔT on each P3, etc. Again this map is unrealistic, being used for illustrative purposes only. Cards 9 to 16 assign the value of η_B in a one-to-one correspondence with the ΔT values just assigned. The order is the same. The combustor pressure loss is input as a design value (i.e., DPCODS = 0.05) for a combustor type being considered. During off-design operation, the pressure loss is related to the design value by the following equation: DPCOM = DPCODS × (WA3C/WA3CDS). This equation is found in the COCOMB routine.

Also entered as BLOCK DATA subprograms are the turbine maps (HPTDAT and LPTDAT). To illustrate the entering of turbine data, LPTDAT is used. A typical turbine map is shown in figure 8; the data are programmed as follows:

```
$IBFTC LPTDAT  DECK
       BLOCK DATA                                                          1
       COMMON / LTURB/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 /   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    0.3582,   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    1.5201,   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    2.4565,   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
```

Card 1 identifies the subprogram as BLOCK DATA. Card 2 identifies the common block 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 the number of points on each line from low to high TFF. Cards 4 and 5 set values of TFF from low to high. Cards 6 to 14 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 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 load-

ing line by inputing slight changes for the values of TFF (example: one line for TFF is 62.105, the next may be input as equal to 62.108). This will eliminate computational difficulties which would arise if constant values for TFF lines were input.

Afterburner performance has been programmed in a generalized form in subroutine COAFBN. The afterburner performance map included in the program is shown in figure 9(a). The performance map shows afterburner combustion efficiency ratio as a function of fuel-air ratio. The value of afterburner combustion efficiency correction factor ΔETAA during off-design operation is shown against design afterburner inlet Mach number ratio (fig. 9(b)) and design afterburner inlet total-pressure ratio (fig. 9(c)). Other correction factors or performance maps could be added as desired. The afterburner efficiency, fuel-air ratio, inlet total pressure, and Mach number are generalized external to the program.

A specific afterburner performance is generalized by dividing the specific off-design values by the design values, as shown here. The symbols shown are the symbols used in the ABETTA 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 ΔETAA is not a generalized value. The value of ΔETAA is an efficiency degradation. These degradations are input in ABETTA as discrete points on a curve. The values of ΔETAA are input as functions of the following:

(1) The change in efficiency as a function of EM6T is input as DELM6 (which is really ΔETAA = f(AM6)).

(2) The change in efficiency as a function of P6T is input as DELP6 (which is really ΔETAA = f(P6)).

At execution time for the design point, values of afterburner combustion efficiency ETAADS, exit total temperature T7DS, and entrance Mach number AM6DS are input. Design fuel-air ratio and entrance pressure ratio are calculated from the input values

and the other design engine characteristics.

The afterburner pressure loss is input as a design value (DPAFDS) during the design case. During afterburning the pressure loss due to combustion is calculated and the regular pressure drop is included for a total afterburner pressure loss. The equations for off-design and combustion pressure losses are contained in the COAFBN subroutines.

To achieve a reasonable accuracy in cycle calculations when using any 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 generalized performance map should be used in order to simulate the component more accurately.

SMOTE, the original code, uses a single-point input for nozzle velocity coefficients (CVMNOZ and CVDNOZ) when calculating engine performance. GENENG, however, uses a convergent-divergent nozzle velocity coefficient which is input in map form in the FRATIO subroutine. The velocity coefficient is input as a function of nozzle total-pressure ratio (P8/P1 or P28/P1). The data for the nozzle are programmed as shown below for a performance map similar to that shown in figure 10.

```
$IBFTC FRATIO  DECK
      SUBROUTINE FRASHO (PRATIO,ARATIO,CF)                                  1
      DIMENSION PR(30),AR(10),CFR(30,10),XX(3),YY(3),ZZ(2)                  2
      DATA PR/1.0,1.25,1.5,1.75,2.0,2.25,2.5,2.75,3.0,3.25,3.5,3.75,4.0,    3
     14.25,4.5,4.75,5.,5.5,6.,6.5,7.,8.,9.,11.,13.,15.,17.,19.,21.,23./     4
      DATA AR/ 1.0,1.05,1.092,1.228,1.318,1.423,1.8,1.9,1.97,2.15/          5
      DATA (CFR(I,1),I=1,180)/                                              5
     1.971,.975,.978,.980,.981,.980,.9784,.9765,.9742,.9715,                7
     2.9688,.9658,.9632,.960,.957,.9538,.9506,.9445,.938,.932,.927,.918,    8
     3.910,.897,.8855,.875,.867,.859,.8515,.844,                            9
     4.963,.966,.970,.9743,.978,.9805,.982,.9805,.9786,.9762,.974,.9718,    10
     5.9693,.967,.9645,.962,.9595,.954,.949,.944,.9395,.9308,.9238,         11
     6.9117,.901,.892,.884,.8762,.869,.862,                                 12
     7.956,.9505,.9638,.967,.970,.9731,.9754,.9775,.9795,.981,.980,.978,    13
     8.9761,.9742,.9723,.9702,.968,.9637,.9594,.9554,.9517,.945,.9387,      14
     9.9276,.9177,.9082,.8998,.891,.883,.8752,                              15
     $.947,.949,.9517,.954,.957,.9601,.9632,.9668,.971,.9737,.976,.9777,    16
     $.978,.9772,.976,.9752,.974,.970,.9665,.9637,.9603,.955,.950,.9403,    17
     $.9317,.9232,.915,.907,.8996,.892,                                     18
     $.949,.9502,.9508,.9473,.9438,.941,.939,.940,.950,.956,.9605,.964,     19
     $.967,.968,.9692,.970,.9703,.9698,.9696,.9684,.966,.960,.9444,         20
     $.9438,.9347,.9265,.9193,.9128,.9067,.901,                             21
     $.948,.9485,.9487,.9484,.947,.9435,.936,.9275,.9185,.9155,.9155,       22
     $.929,.941,.9455,.950,.953,.9558,.9591,.9608,.9609,.9601,.957,         23
     $.9531,.9448,.9362,.9279,.9188,.910,.901,.8921/                        24
```

Card 1 identifies the subroutine. Card 2 identifies the subroutine from its calling name used in the subprogram in addition to the variables that are desired to be transferred. Card 3 dimensions the program variables. Cards 4 and 5 set the value of PR(P9/P1 or P29/P1) from low to high. Card 6 sets the values of AR(A9/A8 or A29/A28) from low to high. Card 7 fills the first 30×6 array of CFR(CVMNOZ or CVDNOZ) and is followed by another data statement which fills the remaining 30×4 values. Cards 8 to 24, etc., are the first values of CFR being loaded for constant values of pressure ratio for varying

ratios going from low to high.

After the data input, the equations required to interpolate between points of the input values are included in the FRATIO subroutine.

Usually, a turbojet or a mixed-flow turbofan has a single exhaust nozzle; therefore the velocity coefficient is determined as a function of A9/A8 and P9/P1. A separate-flow turbofan is considered to have two separate nozzles; thus in addition to using A9/A8 and P9/P1, it will use the duct A29/A28 and P29/P28 to determine a velocity coefficient to correct each stream separately. When desired, however, a different nozzle map (i.e., convergent nozzle) or single-point inputs can be readily incorporated.

Inputs required at execution time. - Basically, what must be supplied are a list of the desired output variables, design values of any component existing in the engine (compressors, combustors, turbines, etc.), and engine operational controls. The variables that are to be output are selected by the first section of data cards. Any variables that are in one of the main commons (DESIGN, FRONT, SIDE, BACK, or DUMMYS) 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 the 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 previously described, but, in addition, the described 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 controlled output must be a card with "THEEND" punched in columns 1 to 6.

Table II summarizes the design inputs for the four basic engines discussed in this report.

The following control variables should always be supplied at the design point. The value used is dependent on how the user wants the engine to operate. The symbols and their purpose are listed in subroutine PUTIN but are shown here for the reader's convenience. The superscripts (1) to (4) on the symbols have the following meanings: (1) means "automatically returned to zero after each point is calculated, must be reinput if option is again desired"; (2) means "option can be used for design or off-design", whereas the other two modes can only be used at off-design; (3) means "these input values remain as input unless changed by a new input"; (4) means "before using these options which are not equal to zero, a setup case must be run where all the components are first matched, and then the identical case may be repeated exercising these options."

IDES = 1[1] For calculating design points.

[2]MODE = 0[3] Specify T4.

MODE = 1[3] Specify PCNC.

[2]MODE = 2[3] Specify WFB.

MODE = 3[3] Specify PCNF.

INIT = 0[3] Initializes point.

INIT = 1[3] Will not initialize point.

IDUMP = 0[3] Will not dump looping write-outs.

IDUMP = 1[3] Will dump looping write-outs if error occurs.

IDUMP = 2[3] Will dump looping write-outs after every point.

IAMTP = 0[3] Will use input AM and military specification ETAR.

IAMTP = 1[3] Will use input AM and input ETAR.

IAMTP = 2[3] Will use input T2 to determine T1 = 518.668 + T2 and standard P1. (T2 value needs to be input at every point or an error will occur whenever used.)

IAMTP = 3[3] Will use inputs P2 and standard T1.

IAMTP = 4[3] Will use input T2 and input P2.

IAMTP = 5[3] Will use specific schedule of ETAR located in subroutine RAMTWO.

IGASMX = -1[3] Separate flow, input A6.

IGASMX = 0[3] Separate flow, A6 = A55.

IGASMX = 1[3] Will mix fan duct and main streams, A6 = A25 + A55.

IGASMX = 2[3] Will mix fan duct and main streams, input A6.

IDBURN = 1[1] For duct burning (fan stream only), input T24.[4]

IDBURN = 2[1] For duct burning (fan stream only), input WFD.[4]

IAFTBN = 1[1]	For afterburning (main stream or mixed stream of fan and main stream), input T7.[4]
IAFTBN = 2[1]	For afterburning (main stream or mixed stream of fan and main stream), input WFA.[4]
IDCD = 1[3]	Fan duct nozzle will be convergent-divergent.
IMCD = 1[3]	Main nozzle will be convergent-divergent.
NOZFLT = 1[3]	For floating main nozzle exit area.[4]
NOZFLT = 2[3]	For floating fan duct nozzle exit area.[4]
NOZFLT = 3[3]	For floating fan duct and main nozzle exit area.[4]
ITRYS = N	Number of passes through engine before quitting.
TOLALL = X	Tolerance which the errors must satisfy before engine is matched.

The following are other input variables for which some value, depending on the engine design, should be input at the discretion of the user:

DELFG, DELFN, DELSFC	Normally input as 1.0 unless correction is desired.
A6, AM55, AM23, AM6, HPEXT, AM, ALTP	See appendix C, Input Symbols.
PCBLF, PCBLC, PCBLDU, PCBLOB	Value for bleed out of the cycle; decimal equivalent of percent compressor flow.
PCBLHP, PCBLLP	Value of total bleed returned to turbines for cycle; fractional equivalent of flow. The sum of these variables plus PCBLDU and PCBLOB should equal 1.

Inputs required for additional options to basic cycles. - To run duct-burning (available only in fan stream duct) cases load ETAD, T24 or WFDDS, and DPDUDS. To run afterburning (mixed-flow fan or unmixed fan - available only for core and fan stream) cases, load T7DS or WFADS, ETAADS, and DPAFDS. Afterburner operation is the same as in reference 2 with the exception of a generalized afterburner performance map addition. For changing the generalized map to a specific map for a specific engine design, the preceding design values are needed at the design point.

Means of Specifying Mode of Engine Operations

Shown in the section SAMPLE CALCULATIONS (pp. 21 to 46) are the methods of specifying off-design operation points. The most common one and that used exclusively herein is to select a Mach number, altitude, and turbine inlet temperature other than design values. There are, however, several other possibilities which the user may employ. For example, changing the following controls:

MODE = 0 Specify a new turbine inlet temperature T4.

MODE = 1 Specify a compressor rotational speed PCNC.

MODE = 2 Specify a fuel flow rate WFB.

MODE = 3 Specify a fan rotational speed PCNF.

If the engine has all its nozzles fixed, an input such as turbine inlet temperature, fuel flow, or speed will set the thrust level. But other means of changing engine operation can be accomplished by varying such nozzle thrust areas as

A8 Main nozzle thrust area

A28 Fan nozzle thrust area

For example, an off-design condition may exist where, in an attempt to satisfy continuity of mass flow (one of the component matching requirements), the fan operating point may lie outside the limits of the data map that was input for the component map. A fan nozzle thrust area change could be used to return the fan operating condition on the map such that a match would occur. This would indicate a possibility exists that variable fan nozzle would be required on this engine for operation at the desired condition. The area is changed by inputing (example: A28 = 1.2 × A28). Since the design areas are not known prior to running the design point, the Huff Input Routine provides the versatility in which A28 is increased by 20 percent, as was shown. It whould be noted that any area changed remains changed until it is recalculated by a new design case or altered by a new input. The preceding example and statements would also apply if changes were made instead to A8.

The nozzle exit area (such as A9 or A29) may then be fully expanded (if A8 and A28 are sonic) after component matching is achieved by using the control variables NOZFLT = 1, 2, or 3. The significance of these values was explained in the previous section.

SAMPLE CALCULATIONS

Shown in this section are complete listings of sample calculations for a single-spool turbojet, a two-spool turbojet, a separate-flow turbofan, and a mixed-flow turbofan. Detailed instructions for operating the program are disclosed through means of these sample calculations plus comments in the program listing (appendix A) and the PUTIN routine (pp. 50 to 52). The input and output data associated with one complete design and off-design computer run are shown.

Single-Spool Turbojet

Design point. - This case is for design-point operation of a single-spool turbojet engine and is represented by three groups of data printout: (1) card images of input data, (2) results, and (3) the common variables printed out only at the design point.

For this point, the component maps were loaded as BLOCK DATA and scaled to maps for the desired engine design. The common variables appearing in the printout are defined by the relative locations of the common blocks of DESIGN, FRONT, SIDE, and BACK. The code for the common variables shown on pages 23 and 24 is as follows:

```
  ZF,    PCNF,       ZC,      PCNC,    T4,       MODE

 COMMON /DESIGN/
1PCNFGJ,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,CNLPCF,ETLPCF,DHLPCF,T21DS ,
7T24DS ,WFDDS ,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 / FRONT/
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  ,BLDB  ,
5CNF   ,PRF   ,ETAF  ,WAFC  ,WAF   ,WA3   ,WG4   ,FAR4  ,
6CNC   ,PRC   ,ETAC  ,WACC  ,WAC   ,ETAB  ,DPCOM ,DUMF  ,
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,PCBLDB,PCBLHP,PCBLLP
 COMMON /  SIDE/
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
 COMMON /  BACK/
1XT55  ,XP55  ,XH55  ,XS55  ,XT25  ,XP25  ,XH25  ,XS25  ,
2XWFB  ,XWG55 ,XFAR55,XWFD  ,XWG24 ,XFAR24,XXP1  ,DUMB  ,
3T6    ,P6    ,H6    ,S6    ,T7    ,P7    ,H7    ,S7    ,
4T8    ,P8    ,H8    ,S8    ,T9    ,P9    ,H9    ,S9    ,
5WG6   ,WFA   ,WG7   ,FAR7  ,ETAA  ,DPAFT ,V55   ,V25   ,
6PS6   ,V6    ,AM6   ,TS7   ,PS7   ,V7    ,AM7   ,AM25  ,
7TS8   ,PS8   ,V8    ,AM8   ,TS9   ,PS9   ,V9    ,AM9   ,
8VA    ,FRD   ,VJD   ,FGMD  ,VJM   ,FGMM  ,FGPD  ,FGPM  ,
9FGM   ,FGP   ,WFT   ,WGT   ,FART  ,FG    ,FN    ,SFC
```

It should be noted that the program uses fixed effective areas calculated at the design point. The design case which calculates the area uses a convergent nozzle. Thus, as seen on the listing (pp. 23 and 24), A8 = A9. Before an afterburning case or before the nozzle is allowed to float (become fully expanded to a convergent-divergent nozzle), the engine components must first be matched in a setup run. Then, the next case may be run with IAFTBN or NOZFLT control cards unequal to zero and may be used as shown in the off-design cases 4 and 5 or 6 and 7. Either a convergent or a convergent-divergent subroutine may be used, depending on the input controls. If afterburning has been selected, the nozzle area is allowed to float to satisfy continuity. However, the areas are returned to their original design values after the afterburning or nozzle float points are completed.

Because the first example is a single-spool turbojet, values for the inner compressor and turbine, as well as duct parameters, are either zero or 1. The actual or corrected values of compressor exit flow (WAC or WACC, respectively) are printed out prior to any bleed extraction. The value of WA3 is the combustor entrance airflow after bleed extraction.

The first 11 lines of the following example show the storage locations reserved for the input data. The locations are relative to the common block locations shown on page 21. Only locations for which values of data will be input are required. Following the end of the storage locations are the input data which are typical for running a single-spool turbojet engine.

```
$DATA(1) #1   I N P U T   D A T A   C A R D S
$TABLE(.REAL.,22=TOLALL,34=DELFG,35=DELFN,36=DELSFC,37=ZFDS,38=PCNFDS,39=PRFDS,
40=ETAFDS,41=WAFDS,45=ZCDS,46=PCNCDS,47=PRCDS,48=ETACDS,49=WACDS,53=T4DS,54=
WFBDS,55=DTCODS,56=ETABDS,58=DPCODS,61=TFHPDS,62=CNHPDS,63=ETHPDS,69=TFLPDS,
70=CNLPDS,71=ETLPDS,82=DPBUDS,85=T7DS,88=ETAADS,90=DPAFDS,95=A6,97=A8,101=PS55,
102=AM55,103=CVDNOZ,104=CVMNOZ,113=T2,114=P2,125=T4,144=WAFCDS,152=WACCDS,
172=HPEXT,173=AM,174=ALTP,175=ETAR,177=PCNF,179=PCNC,183=PCBLF,184=PCBLC,
185=PCBLDU,186=PCBLOB,187=PCBLHP,188=PCBLLP,205=T24,225=ETAD,257=T7,270=WFA,
273=ETAA,279=AM6,313=AM23,99=A28,180=WFB,222=WFD,.INTEGER.,2=IDES,5=MODE
,7=IDUMP,8=IAMTP,9=IGASMX,10=IDBURN,11=IAFTBN,12=IDCD,13=IMCD,16=NOZFLT,17=
ITRYS,314=ISPOOL,.LOGICAL.,319=FAN) # END OF TABLE GIVING NAMES AND LOCATIONS

#0 INPUT DATA TO RUN ONE SPOOL TURBOJET
FAN=.FALSE.,ISPOOL=1,ZFDS=.83333333,PRFDS=8,WAFCDS=633,ETAFDS=.829,PCNFDS=100,
PCBLF=0,PCBLC=.097,PCBLHP=0,PCBLLP=1,PCBLOB=0,T4DS=3260,DPCODS=.056,ETABDS=.985,
ETLPDS=.903,TFLPDS=130.0,CNLPDS=2.300,HPEXT=0,AM55=.238,AM6=.238,ETAADS=.90,
T7DS=3560,DPAFDS=.048,DELFG=1,DELFN=1,DELSFC=1,TOLALL=.005,ITRYS=210,IDCD=0,
IMCD=0,IDES=1,IAMTP=0,MODE=0,IDUMP=0,AM=0,ALTP=0,
```

The following is an example of the normal design-case printout. The fan, compressor, combustor, high-pressure- and low-pressure-turbine correction factors are printed out, as are the various designated design areas. Following these are the internal engine thermodynamic characteristics and thrust and specific fuel consumption.

```
     #1 DESIGN POINT WITH NORMAL PRINTOUT WHEN IDES=1 (PRINTED OUT FOR DESIGN
     # POINT ONLY) - - NEXT PAGE HAS THE CLOSE FORMAT (SEE PAGE OF KEY TO VARIABLES)

FAN DESIGN              PRFCF= 0.17500000E+02 ETAFCF= 0.94204545E+00  WAFCF= 0.10550000E+01   T2DS= 0.51866820E+03

COMPRESSOR DESIGN       PRCCF= 0.10000000E+01 ETACCF= 0.10000000E+01  WACCF= 0.10000000E+01  T21DS= 0.10191559E+04

COMBUSTER DESIGN       WA3CDS= 0.15521097E+03 ETABCF= 0.98500000E+00 DTCDCF= 0.10000000E+01

L.P. TURBINE DESIGN    CNLPCF= 0.13132174E+01 TFLPCF= 0.42574495E+00 ETLPCF= 0.10235344E+01 DHLPCF= 0.23187937E+01

TURBINE AREA DESIGN       A55= 0.20933135E+02   AM55= 0.23823719E+00

AFTERBURNER DESIGN     WG6CDS= 0.89939300E+04

NOZZLE DESIGN             A8= 0.85851488E+01    AM8= 0.10000000E+01     A9= 0.85851488E+01    AM9= 0.10000000E+01

OUTPUT                 AM=  0.          ALTP=     0.          T4= 3260.00                              ETAR= 1.0000
                         PCNF             CNF              ZF             PRF             WAFC             WAF
                       0.100000E+03    0.100000E+01    0.833333E+00    0.800000E+01    0.633000E+03    0.633000E+03
                         PCNC             CNC              ZC             PRC             WACC             WAC
                       0.100000E+03    0.100000E+01    0.              0.100000E+01    0.110915E+03    0.633000E+03
                         T2               P2              T21            P21             T3               P3
                       0.518668E+03    0.100000E+01    0.101916E+04    0.800000E+01    0.101916E+04    0.800000E+01
                         PCBLF            BLF             PCBLC          BLC             PCBLOB           BLOB
                       0.              0.              0.970000E-01    0.614010E+02    0.              0.
                         PCBLHP           BLHP            PCBLLP         BLLP            T4               P4
                       0.              0.              0.100000E+01    0.614010E+02    0.326000E+04    0.755200E+01
                         WA3              WFB             WG4            FAR4            ETAB             DPCOM
                       0.571599E+03    0.219359E+02    0.593535E+03    0.383764E-01    0.985000E+00    0.560000E-01
                         TFFHP            CNHP            DHTCHP         DHTC            T5               P5
                       0.              0.              0.              0.              0.326000E+04    0.755200E+01
                         TFFLP            CNLP            DHTCLP         DHTF            T55              P55
                       0.305347E+03    0.175142E+01    0.171750E-01    0.129830E+03    0.269721E+04    0.378187E+01
                         PCBLDU           BLDU            T24            P24             T25              P25
                       0.              0.              0.              0.              0.101916E+04    0.800000E+01
                         WAD              WFD             WG24           FAR24           ETAD             DPDUC
                       0.              0.              0.633000E+03    0.              0.              0.
                         ETAF             ETAC            ETATHP         ETATLP          AM55             AM25
                       0.829000E+00    0.100000E+01    0.100000E+01    0.903000E+00    0.238237E+00    0.
                         T6               P6              PS6            AM6             V6               WG6
                       0.269721E+04    0.378187E+01    0.364695E+01    0.238237E+00    0.579433E+03    0.654936E+03
                         T7               WFA             WG7            FAR7            ETAA             DPAFT
                       0.269721E+04    0.              0.654936E+03    0.346539E-01    0.              0.480000E-01
                         PS8              AM8             V8             PS9             AM9              V9
                       0.198204E+01    0.100000E+01    0.228834E+04    0.198204E+01    0.100000E+01    0.228834E+04
                         PS28             AM28            V28            PS29            AM29             V29
                       0.              0.              0.              0.              0.              0.
                         BYPASS           HPEXT           WFT            WGT             VA               FRD
                       0.              0.              0.219359E+02    0.654936E+03    0.              0.
                         CVMNOZ           VJM             CVDNOZ         VJD             FGM              FGP
                       0.967632E+00    0.221427E+04    0.              0.              0.450738E+05    0.178418E+05

MAIN SONIC CONVERGENT NOZZLE          FG= 62915.60                    FN= 62915.60                    SFC= 1.25516
DUCT SHOCK OUTSIDE C-D NOZZLE

CONVERGED AFTER   1 LOOPS
```

The following shows the common variables which can be read, if desired, by referring to the common designation (p. 21).

```
COMMON          0.833333E+00    0.100000E+03   -0.000000E-19   -0.000000E-19    0.              0.100000E+03    0.3260C0E+04   0

   0.100000E+03    0.              0.326000E+04    0.100000E+03    0.              0.100000E+01    0.100000E+01    0.100000E+01
   0.833333E+00    0.100000E+03    0.800000E+01    0.829000E+00    0.633000E+03    0.175000E+02    0.942045E+00    0.105500E+01
   0.              0.              0.              0.              0.633000E+03    0.100000E+01    0.100000E+01    0.100000E+01
   0.326000E+04    0.              0.224084E+04    0.985000E+00    0.155211E+03    0.560000E-01    0.100000E+01    0.985000E+00
   0.              0.              0.              0.100000E+01    0.              0.100000E+01    0.100000E+01    0.518668E+03
   0.130000E+03    0.230000E+01    0.903000E+00    0.425745E+00    0.131322E+01    0.102353E+01    0.231879E+01    0.101916E+04
   0.              0.              0.              0.              0.              0.              0.              0.
   0.356000E+04    0.              0.              0.900000E+00    0.899393E+04    0.480000E-01    0.              0.
   0.209331E+02    0.              0.209331E+02    0.209331E+02    0.858515E+01    0.858515E+01    0.              0.
   0.364595E+01    0.238237E+00    0.              0.967632E+00    0.              0.              0.              0.

   0.518670E+03    0.100000E+01    0.123918E+03    0.159103E+01    0.518668E+03    0.100000E+01    0.123918E+03    0.159103E+01
   0.101916E+04    0.800000E+01    0.245654E+03    0.161236E+01    0.101916E+04    0.800000E+01    0.245654E+03    0.161236E+01
   0.326000E+04    0.755200E+01    0.916119E+03    0.196079E+01    0.326000E+04    0.755200E+01    0.916119E+03    0.196079E+01
   0.269721E+04    0.378187E+01    0.735604E+03    0.194649E+01    0.              0.614010E+02    0.              0.
   0.100000E+01    0.800000E+01    0.829000E+00    0.633000E+03    0.633000E+03    0.571599E+03    0.593535E+03    0.383764E-01
   0.100000E+01    0.100000E+01    0.100000E+01    0.110915E+03    0.633000E+03    0.985000E+00    0.560000E-01    0.
   0.100000E+01    0.100000E+01    0.              0.              0.              0.593535E+03    0.383764E-01    0.111699E+04
   0.230000E+01    0.903000E+00    0.398252E-01    0.129830E+03    0.614010E+02    0.654936E+03    0.346539E-01    0.
   0.              0.              0.100000E+01    0.833333E+00    0.100000E+03    0.              0.100000E+03    0.219359E+02
   0.              0.130000E+03    0.              0.970000E-01    0.              0.              0.              0.100000E+01
```

```
0.100000E+01  0.633000E+03  0.633000E+03  0.          0.          0.245654E+03  0.          0.
0.101916E+04  0.800000E+01  0.245654E+03  0.161236E+01  0.          0.          0.          0.
0.            0.            0.            0.          0.101916E+04  0.800000E+01  0.245654E+03  0.161236E+01
0.            0.            0.            0.          0.          0.          0.          0.
0.            0.            0.633000E+03  0.          0.          0.          0.          0.
0.            0.            0.            0.          0.          0.          0.          0.

0.269721E+04  0.378187E+01  0.735604E+03  0.194649E+01  0.101916E+04  0.800000E+01  0.245654E+03  0.161236E+01
0.219359E+02  0.654936E+03  0.346539E-01  0.          0.633000E+03  0.          0.100000E+01  0.
0.269721E+04  0.378187E+01  0.735604E+03  0.194649E+01  0.269721E+04  0.360034E+01  0.735601E+03  0.194987E+01
0.269721E+04  0.360034E+01  0.735601E+03  0.194987E+01  0.269721E+04  0.360034E+01  0.735601E+03  0.194987E+01
0.654936E+03  0.            0.654936E+03  0.346539E-01  0.          0.480000E-01  0.579433E+03  0.
0.364685E+01  0.579433E+03  0.238237E+00  0.267322E+04  0.345885E+01  0.610475E+03  0.251101E+00  0.
0.235513E+04  0.198204E+01  0.228834E+04  0.100000E+01  0.235513E+04  0.198204E+01  0.228834E+04  0.100000E+01
0.            0.            0.            0.          0.221427E+04  0.450738E+05  0.          0.178418E+05
0.450738E+05  0.178418E+05  0.219359E+02  0.654936E+03  0.346539E-01  0.629156E+05  0.629156E+05  0.125516E+01
```

Off-design. - In the following cases, only the input data that are changed are printed out as input. The other data (normal design-case printout, p. 23) are not affected. The common variables are not repeated because IDES was set to zero internally in the program. That printout is eliminated and the design printout converts to the normal off-design printout format.

Case 1: The engine is operating at a reduced turbine inlet temperature T4 at a sea-level-static condition. The only input change required is T4.

```
     $D(1),T4=2660,$1 PART POWER ENGINE OPERATION -- OFF-DESIGN
     $     RESULTS N O R M A L   O F F - D E S I G N   O U T P U T

OUTPUT                AM=  0.          ALTP=      0.          T4= 2660.00                          ETAR= 1.0000
                        PCNF                        CNF                         ZF                        PRF                       WAFC                       WAF
                     0.843207E+02  0.843207E+00  0.766751E+00  0.584906E+01  0.525128E+03  0.525128E+03
                        PCNC                        CNC                         ZC                        PRC                       WACC                       WAC
                     0.949398E+02  0.100000E+01  0.100000E+01  0.100000E+01  0.119482E+03  0.525128E+03
                        T2                          P2                          T21                       P21                       T3                         P3
                     0.518668E+03  0.100000E+01  0.918624E+03  0.584906E+01  0.918615E+03  0.584906E+01
                        PCBLF                       BLF                         PCBLC                     BLC                       PCBLOB                     BLOB
                     0.            0.            0.970000E-01  0.509374E+02  0.            0.
                        PCBLHP                      BLHP                        PCBLLP                    BLLP                      T4                         P4
                     0.            0.            0.100000E+01  0.509374E+02  0.266000E+04  0.549621E+01
                        WA3                         WFB                         WG4                       FAR4                      ETAB                       DPCOM
                     0.474191E+03  0.133727E+02  0.487563E+03  0.282011E-01  0.985000E+00  0.603254E-01
                        TFFHP                       CVHP                        DHTCHP                    DHTC                      T5                         P5
                     0.            0.            0.            0.            0.266000E+04  0.549621E+01
                        TFFLP                       CVLP                        DHTCLP                    DHTF                      T55                        P55
                     0.311322E+03  0.163491E+01  0.169092E-01  0.104294E+03  0.219476E+04  0.278698E+01
                        PCBLDU                      BLDU                        T24                       P24                       T25                        P25
                     0.            0.            0.            0.            0.918624E+03  0.584906E+01
                        WAD                         WFD                         WG24                      FAR24                     ETAD                       DPDUC
                     0.            0.            0.525128E+03  0.            0.            0.
                        ETAF                        ETAC                        ETATHP                    ETATLP                    AM55                       AM25
                     0.843568E+00  0.100000E+01  0.100000E+01  0.907545E+00  0.238077E+00  0.
                        T6                          P6                          PS6                       AM6                       V6                         WG6
                     0.219476E+04  0.278698E+01  0.269024E+01  0.238077E+00  0.525868E+03  0.538501E+03
                        T7                          WFA                         WG7                       FAR7                      ETAA                       DPAFT
                     0.219476E+04  0.            0.538501E+03  0.254656E-01  0.            0.483102E-01
                        PS8                         AM8                         V8                        PS9                       AM9                        V9
                     0.145228E+01  0.100000E+01  0.207131E+04  0.145228E+01  0.100000E+01  0.207131E+04
                        PS28                        AM28                        V28                       PS29                      AM29                       V29
                     0.            0.            0.            0.            0.            0.
                        BYPASS                      HPEXT                       WFT                       WGT                       VA                         FRD
                     0.            0.            0.133727E+02  0.538501E+03  0.            0.
                        CVMNOZ                      VJM                         CVDNOZ                    VJD                       FGM                        FGP
                     0.977273E+00  0.202425E+04  0.            0.            0.338801E+05  0.821708E+04

MAIN SONIC CONVERGENT NOZZLE          FG= 42097.19                              FN= 42097.19                              SFC= 1.1435
DUCT SHOCK OUTSIDE C-D NOZZLE

CONVERGED AFTER  14 LOOPS
```

Case 2: The engine is operating at design turbine inlet temperature at sea-level-static condition. The engine components must always be matched at the desired turbine inlet temperature prior to running the engine at afterburning conditions.

```
$D(1), T4=3260., # SET UP FOR AFTERBURNER OPERATION

OUTPUT                  AM=  0.          ALTP=     0.          T4= 3260.00                          ETAR= 1.0000
                          PCNF             CNF              ZF               PRF              WAFC             WAF
                       0.100000E+03    0.100000E+01     0.833333E+00     0.800000E+01     0.633000E+03     0.633000E+03
                          PCNC             CNC              ZC               PRC              WACC             WAC
                       0.100000E+03    0.100000E+01     0.               0.100000E+01     0.110915E+03     0.633000E+03
                          T2               P2               T21              P21              T3               P3
                       0.518668E+03    0.100000E+01     0.101916E+04     0.800000E+01     0.101916E+04     0.800000E+01
                          PCBLF            BLF              PCBLC            BLC              PCBLOB           BLOB
                       0.               0.               0.970000E-01     0.614010E+02     0.               0.
                          PCBLHP           BLHP             PCBLLP           BLLP             T4               P4
                       0.               0.               0.100000E+01     0.614010E+02     0.326000E+04     0.755200E+01
                          WA3              WFB              WG4              FAR4             ETAB             DPCOM
                       0.571599E+03    0.219359E+02     0.593535E+03     0.383764E-01     0.985000E+00     0.560000E-01
                          TFFHP            CNHP             DHTCHP           DHTC             T5               P5
                       0.               0.               0.               0.               0.326000E+04     0.755200E+01
                          TFFLP            CNLP             DHTCLP           DHTF             T55              P55
                       0.305347E+03    0.175142E+01     0.171750E-01     0.129830E+03     0.269721E+04     0.378187E+01
                          PCBLDU           BLDU             T24              P24              T25              P25
                       0.               0.               0.               0.               0.101916E+04     0.800000E+01
                          WAD              WFD              WG24             FAR24            ETAD             DPDUC
                       0.               0.               0.633000E+03     0.               0.               0.
                          ETAF             ETAC             ETATHP           ETATLP           AM55             AM25
                       0.829000E+00    0.100000E+01     0.100000E+01     0.903000E+00     0.238190E+00     0.
                          T6               P6               PS6              AM6              V6               WG6
                       0.269721E+04    0.378187E+01     0.365225E+01     0.238190E+00     0.579408E+03     0.654936E+03
                          T7               WFA              WG7              FAR7             ETAA             DPAFT
                       0.269721E+04    0.               0.654936E+03     0.345539E-01     0.               0.480000E-01
                          PS8              AM8              V8               PS9              AM9              V9
                       0.198204E+01    0.100000E+01     0.228834E+04     0.198204E+01     0.100000E+01     0.228834E+04
                          PS28             AM28             V28              PS29             AM29             V29
                       0.               0.               0.               0.               0.               0.
                          BYPASS           HPEXT            WFT              WGT              VA               FRD
                       0.               0.               0.219359E+02     0.654936E+03     0.               0.
                          CVMNOZ           VJM              CVDNOZ           VJD              FGM              FGP
                       0.967632E+00    0.221427E+04     0.               0.               0.450738E+05     0.178418E+05

MAIN SCNIC CONVERGENT NOZZLE          FG= 62915.60                      FN= 62915.60                      SFC= 1.25516
DUCT SHOCK OUTSIDE C-D NOZZLE

CONVERGED AFTER   1 LOOPS
```

Case 3: The engine is operating at maximum design afterburner temperature at sea-level-static condition. Once the engine components are matched at the desired turbine inlet temperature, the engine performance for any afterburner temperature that is greater than the turbine exit temperature may be calculated.

A new value of A8 is computed when afterburning to account for the temperature, pressure, and mass flow changes. A9 is allowed to float to provide for complete expansion to PS9 = PS0 at station 9. The new values of A8 and A9 are printed at the top of the normal off-design output page. The value of IAFTBN is set to zero after each case; therefore, IAFTBN = 1 must be used for each afterburning case.

```
$D(1),T4=3260,T7=3560,IAFTBN=1, # AFTERBURNER OPERATION AT DESIGN TEMP
#     RESULTS N O R M A L   O F F - D E S I G N   OUTPUT

NOZZLE DESIGN          A8= 0.10260896E+02    AM8= 0.10000000E+01     A9= 0.12334022E+02    AM9= 0.15117356E+01

OUTPUT                  AM=  0.          ALTP=     0.          T4= 3260.00          T7= 3560.00          ETAR= 1.0000
                          PCNF             CNF              ZF               PRF              WAFC             WAF
                       0.100000E+03    0.100000E+01     0.833333E+00     0.800000E+01     0.633000E+03     0.633000E+03
                          PCNC             CNC              ZC               PRC              WACC             WAC
                       0.100000E+03    0.100000E+01     0.               0.100000E+01     0.110915E+03     0.633000E+03
                          T2               P2               T21              P21              T3               P3
                       0.518668E+03    0.100000E+01     0.101916E+04     0.800000E+01     0.101916E+04     0.800000E+01
                          PCBLF            BLF              PCBLC            BLC              PCBLOB           BLOB
                       0.               0.               0.970000E-01     0.614010E+02     0.               0.
                          PCBLHP           BLHP             PCBLLP           BLLP             T4               P4
                       0.               0.               0.100000E+01     0.614010E+02     0.326000E+04     0.755200E+01
                          WA3              WFB              WG4              FAR4             ETAB             DPCOM
                       0.571599E+03    0.219359E+02     0.593535E+03     0.383764E-01     0.985000E+00     0.560000E-01
                          TFFHP            CNHP             DHTCHP           DHTC             T5               P5
                       0.               0.               0.               0.               0.326000E+04     0.755200E+01
                          TFFLP            CNLP             DHTCLP           DHTF             T55              P55
                       0.305347E+03    0.175142E+01     0.171750E-01     0.129830E+03     0.269721E+04     0.378187E+01
                          PCBLDU           BLDU             T24              P24              T25              P25
                       0.               0.               0.               0.               0.101916E+04     0.800000E+01
                          WAD              WFD              WG24             FAR24            ETAD             DPDUC
                       0.               0.               0.633000E+03     0.               0.               0.
```

```
  ETAF            ETAC            ETATHP          ETATLP          AM55            AM25
0.829000E+00    0.100000E+01    0.100000E+01    0.903000E+00    0.238190E+00    0.
  T6              P6              PS6             AM6             V6              WG6
0.269721E+04    0.378187E+01    0.365225E+01    0.238190E+00    0.579408E+03    0.654936E+03
  T7              WFA             WG7             FAR7            ETAA            DPAFT
0.356000E+04    0.106971E+02    0.665633E+03    0.515530E-01    0.900029E+00    0.480000E-01
  PS8             AM8             V8              PS9             AM9             V9
0.196671E+01    0.100000E+01    0.261777E+04    0.100000E+01    0.151174E+01    0.369243E+04
  PS28            AM28            V28             PS29            AM29            V29
0.              0.              0.              0.              0.              0.
  BYPASS          HPEXT           WFT             WGT             VA              FRD
0.              0.              0.326330E+02    0.665633E+03    0.              0.
  CVMNOZ          VJM             CVDNOZ          VJD             FGM             FGP
0.977004E+00    0.360752E+04    0.              0.              0.746342E+05    0.

MAIN SHOCK OUTSIDE C-D NOZZLE          FG= 74634.20                    FN= 74634.20                    SFC= 1.57406
DUCT SHOCK OUTSIDE C-D NOZZLE

CONVERGED AFTER   1 LOOPS
```

Case 4: The engine is operating at a subsonic Mach number (0.7) at 25 000 feet altitude with a turbine inlet temperature less than design. The performance shown is for A8 = A9 (i.e., the engine is using a convergent nozzle). If desired, a convergent-divergent nozzle could have been simulated by using this case as a setup and having an additional case with NOZFLT = 1 or IMCD = 1 for complete expansion to occur.

```
      $D(1),AM=.7,ALTP=25000,T4=2760, * PART POWER OPERATION AT CRUISE CONDITION
      *     RESULTS N O R M A L   O F F - D E S I G N   O U T P U T

OUTPUT                AM=  0.700        ALTP= 25000.          T4= 2760.00                     ETAR= 1.0000
                        PCNF            CNF             ZF              PRF             WAFC            WAF
                      0.900352E+02    0.944024E+00    0.806890E+00    0.714555E+01    0.594428E+03    0.320887E+03
                        PCNC            CNC             ZC              PRC             WACC            WAC
                      0.936879E+02    0.100000E+01    0.100000E+01    0.100000E+01    0.114549E+03    0.320887E+03
                        T2              P2              T21             P21             T3              P3
                      0.471789E+03    0.514853E+00    0.894556E+03    0.367891E+01    0.894555E+03    0.367891E+01
                        PCBLF           BLF             PCBLC           BLC             PCBLOB          BLOR
                      0.              0.              0.970000E-01    0.311261E+02    0.              0.
                        PCBLHP          BLHP            PCBLLP          BLLP            T4              P4
                      0.              0.              0.100000E+01    0.311261E+02    0.276000E+04    0.346614E+01
                        WA3             WFB             WG4             FAR4            ETAB            DPCOM
                      0.289761E+03    0.882030E+01    0.298582E+03    0.304399E-01    0.985000E+00    0.578352E-01
                        TFFHP           CNHP            DHTCHP          DHTC            T5              P5
                      0.              0.              0.              0.              0.276000E+04    0.346614E+01
                        TFFLP           CNLP            DHTCLP          DHTF            T55             P55
                      0.307945E+03    0.171379E+01    0.171341E-01    0.109754E+03    0.227177E+04    0.173692E+01
                        PCBLDU          BLDU            T24             P24             T25             P25
                      0.              0.              0.              0.              0.894556E+03    0.367891E+01
                        WAD             WFD             WG24            FAR24           ETAD            DPDUC
                      0.              0.              0.320887E+03    0.              0.              0.
                        ETAF            ETAC            ETATHP          ETATLP          AM55            AM25
                      0.836023E+00    0.100000E+01    0.100000E+01    0.905173E+00    0.238293E+00    0.
                        T6              P6              PS6             AM6             V6              WG6
                      0.227177E+04    0.173692E+01    0.167666E+01    0.238293E+00    0.534812E+03    0.329708E+03
                        T7              WFA             WG7             FAR7            ETAA            DPAFT
                      0.227177E+04    0.              0.329708E+03    0.274872E-01    0.              0.482863E-01
                        PS8             AM8             V8              PS9             AM9             V9
                      0.906790E+00    0.100000E+01    0.210597E+04    0.906790E+00    0.100000E+01    0.210597E+04
                        PS28            AM28            V28             PS29            AM29            V29
                      0.              0.              0.              0.              0.              0.
                        BYPASS          HPEXT           WFT             WGT             VA              FRD
                      0.              0.              0.882030E+01    0.329708E+03    0.711594E+03    0.709707E+04
                        CVMNOZ          VJM             CVDNOZ          VJD             FGM             FGP
                      0.957531E+00    0.201653E+04    0.              0.              0.206646E+05    0.973258E+04

MAIN SONIC CONVERGENT NOZZLE           FG= 30397.21                    FN= 23300.14                    SFC= 1.3627
DUCT SHOCK OUTSIDE C-D NOZZLE

CONVERGED AFTER   7 LOOPS
```

Case 5: The engine is operating at the same subsonic condition as in case 4, but at the design turbine inlet temperature. Afterburner operation may be added at this point. If a different turbine inlet temperature is desired, a new setup case, as in case 4, must be calculated for component matching purposes immediately prior to running the afterburner case.

```
$D(1),T4=3260,* DESIGN T4 AT FLIGHT CONDITION
*     RESULTS N O R M A L   O F F - D E S I G N   O U T P U T

OUTPUT                AM=  0.700      ALTP= 25000.          T4= 3260.00                    ETAR= 1.0000
                       PCNF                CNF                 ZF                  PRF                 WAFC                WAF
                     0.984253E+02      0.103200E+01        0.856827E+00        0.869637E+01        0.660746E+03        0.356688E+03
                       PCNC                CNC                 ZC                  PRC                 WACC                WAC
                     0.976137E+02      0.100000E+01        0.100000E+01        0.100000E+01        0.109007E+03        0.356688E+03
                       T2                  P2                  T21                 P21                 T3                  P3
                     0.471789E+03      0.514853E+00        0.971095E+03        0.447735E+01        0.971092E+03        0.447735E+01
                       PCBLF               BLF                 PCBLC               BLC                 PCBLOB              BLOB
                     0.                0.                  0.970000E-01        0.345987E+02        0.                  0.
                       PCBLHP              BLHP                PCBLLP              BLLP                T4                  P4
                     0.                0.                  0.100000E+01        0.345987E+02        0.326000E+04        0.423093E+01
                       WA3                 WFB                 WG4                 FAR4                ETAB                DPCOM
                     0.322089E+03      0.125982E+02        0.334688E+03        0.391140E-01        0.985000E+00        0.550366E-01
                       TFFHP               CNHP                DHTCHP              DHTC                T5                  P5
                     0.                0.                  0.                  0.                  0.326000E+04        0.423093E+01
                       TFFLP               CNLP                DHTCLP              DHTF                T55                 P55
                     0.307336E+03      0.172385E+01        0.171404E-01        0.128965E+03        0.269690E+04        0.213226E+01
                       PCBLDU              BLDU                T24                 P24                 T25                 P25
                     0.                0.                  0.                  0.                  0.971095E+03        0.447735E+01
                       WAD                 WFD                 WG24                FAR24               ETAD                DPDUC
                     0.                0.                  0.356688E+03        0.                  0.                  0.
                       ETAF                ETAC                ETATHP              ETATLP              AM55                AM25
                     0.800114E+00      0.100000E+01        0.100000E+01        0.904580E+00        0.238236E+00        0.
                       T6                  P6                  PS6                 AM6                 V6                  WG6
                     0.269690E+04      0.213226E+01        0.205917E+01        0.238236E+00        0.579402E+03        0.369286E+03
                       T7                  WFA                 WG7                 FAR7                ETAA                DPAFT
                     0.269690E+04      0.                  0.369286E+03        0.353199E-01        0.                  0.480007E-01
                       PS8                 AM8                 V8                  PS9                 AM9                 V9
                     0.111781E+01      0.100000E+01        0.228808E+04        0.111781E+01        0.100000E+01        0.228808E+04
                       PS28                AM28                V28                 PS29                AM29                V29
                     0.                0.                  0.                  0.                  0.                  0.
                       BYPASS              HPEXT               WFT                 WGT                 VA                  FRD
                     0.                0.                  0.125982E+02        0.369286E+03        0.711594E+03        0.788888E+04
                       CVMNOZ              VJM                 CVDNOZ              VJD                 FGM                 FGP
                     0.944853E+00      0.216190E+04        0.                  0.                  0.248138E+05        0.135664E+05

MAIN SCNIC CONVERGENT NOZZLE          FG= 38380.11                            FN= 30491.23                        SFC= 1.4E743
DUCT SHOCK OUTSIDE C-D NOZZLE

CONVERGED AFTER  14 LOOPS
```

Case 6: The engine is now operating at a supersonic flight Mach number (2.5) at an altitude of 50 000 feet. The engine components are matched with an engine nozzle throat area A8 equal to the sea-level-static design value. This case is a setup case for matching the components only.

```
$D(1),AM=2.5,ALTP=50000,T4=3260,* SET UP FOR MATCHING ONLY

OUTPUT                AM=  2.500      ALTP= 50000.          T4= 3260.00                    ETAR= 0.8703
                       PCNF                CNF                 ZF                  PRF                 WAFC                WAF
                     0.832186E+02      0.640467E+00        0.665972E+00        0.361453E+01        0.385510E+03        0.505199E+03
                       PCNC                CNC                 ZC                  PRC                 WACC                WAC
                     0.114102E+03      0.100000E+01        0.100000E+01        0.100000E+01        0.131289E+03        0.505199E+03
                       T2                  P2                  T21                 P21                 T3                  P3
                     0.875661E+03      0.170275E+01        0.132686E+04        0.615464E+01        0.132686E+04        0.615464E+01
                       PCBLF               BLF                 PCBLC               BLC                 PCBLOB              BLOB
                     0.                0.                  0.970000E-01        0.490043E+02        0.                  0.
                       PCBLHP              BLHP                PCBLLP              BLLP                T4                  P4
                     0.                0.                  0.100000E+01        0.490043E+02        0.326000E+04        0.574667E+01
                       WA3                 WFB                 WG4                 FAR4                ETAB                DPCOM
                     0.456195E+03      0.153057E+02        0.471501E+03        0.335508E-01        0.985000E+00        0.662867E-01
                       TFFHP               CNHP                DHTCHP              DHTC                T5                  P5
                     0.                0.                  0.                  0.                  0.326000E+04        0.574667E+01
                       TFFLP               CNLP                DHTCLP              DHTF                T55                 P55
                     0.318769E+03      0.145751E+01        0.160734E-01        0.121704E+03        0.274010E+04        0.302911E+01
                       PCBLDU              BLDU                T24                 P24                 T25                 P25
                     0.                0.                  0.                  0.                  0.132686E+04        0.615464E+01
                       WAD                 WFD                 WG24                FAR24               ETAD                DPDUC
                     0.                0.                  0.505199E+03        0.                  0.                  0.
                       ETAF                ETAC                ETATHP              ETATLP              AM55                AM25
                     0.815437E+00      0.100000E+01        0.100000E+01        0.909909E+00        0.238010E+00        0.
                       T6                  P6                  PS6                 AM6                 V6                  WG6
                     0.274010E+04      0.302911E+01        0.292530E+01        0.238010E+00        0.583946E+03        0.520505E+03
                       T7                  WFA                 WG7                 FAR7                ETAA                DPAFT
                     0.274010E+04      0.                  0.520505E+03        0.302964E-01        0.                  0.480047E-01
                       PS8                 AM8                 V8                  PS9                 AM9                 V9
                     0.158578E+01      0.100000E+01        0.230699E+04        0.158578E+01        0.100000E+01        0.230699E+04
                       PS28                AM28                V28                 PS29                AM29                V29
                     0.                0.                  0.                  0.                  0.                  0.
                       BYPASS              HPEXT               WFT                 WGT                 VA                  FRD
                     0.                0.                  0.153057E+02        0.520505E+03        0.242123E+04        0.380184E+05
                       CVMNOZ              VJM                 CVDNOZ              VJD                 FGM                 FGP
                     0.835769E+00      0.192812E+04        0.                  0.                  0.311927E+05        0.267311E+05

MAIN SCNIC CONVERGENT NOZZLE          FG= 57923.74                            FN= 19905.36                        SFC= 2.76813
DUCT SHOCK OUTSIDE C-D NOZZLE

CONVERGED AFTER   8 LOOPS
```

Case 7: The performance data from this case reflect an expansion to the maximum attainable area ratio for A9/A8, thus simulating a convergent-divergent nozzle. Performance is calculated such that the nozzle static pressure PS9 is equal to the free-stream static pressure PS0. This is accomplished by setting NOZFLT equal to 1. The improvement in thrust and specific fuel consumption from case 6 should be noted.

Although engine performance is calculated as if complete expansion occurred (A9/A8 = 3.449), a performance penalty from the fully expanded case resulted because this particular nozzle has a physical expansion limit A9/A8 of 2.15. This means that the nozzle has a lower-than-optimum thrust coefficient, resulting in a performance penalty.

```
    $D(1),NOZFLT=1,* PERFORMANCE DATA WITH MAXIMUM ATTAINABLE NOZZLE RATIO

NOZZLE DESIGN              A8= 0.85821256E+01    AM8= 0.10000000E+01     A9= 0.29598886E+02    AM9= 0.27020654E+01

ARATIO=  3.449    OUT OF RANGE,USE DATA FOR   2.150

OUTPUT                  AM=  2.500        ALTP= 50000.          T4= 3260.00                          ETAR= 0.8703
                         PCNF              CNF               ZF                PRF               WAFC              WAF
                        0.832186E+02      0.640467E+00      0.665972E+00      0.361453E+01      0.385510E+03      0.505199E+03
                         PCNC              CNC               ZC                PRC               WACC              WAC
                        0.114102E+03      0.100000E+01      0.100000E+01      0.100000E+01      0.131289E+03      0.505199E+03
                         T2                P2                T21               P21               T3                P3
                        0.875661E+03      0.170275E+01      0.132686E+04      0.615464E+01      0.132686E+04      0.615464E+01
                         PCBLF             BLF               PCBLC             BLC               PCBLOB            BLOB
                        0.                0.                0.970000E-01      0.490043E+02      0.                0.
                         PCBLHP            BLHP              PCBLLP            BLLP              T4                P4
                        0.                0.                0.100000E+01      0.490043E+02      0.326000E+04      0.574667E+01
                         WA3               WFB               WG4               FAR4              ETAB              DPCOM
                        0.456195E+03      0.153057E+02      0.471501E+03      0.335508E-01      0.985000E+00      0.662867E-01
                         TFFHP             CNHP              DHTCHP            DHTC              T5                P5
                        0.                0.                0.                0.                0.326000E+04      0.574667E+01
                         TFFLP             CNLP              DHTCLP            DHTF              T55               P55
                        0.318769E+03      0.145751E+01      0.160734E-01      0.121704E+03      0.274010E+04      0.302911E+01
                         PCBLDU            BLDU              T24               P24               T25               P25
                        0.                0.                0.                0.                0.132686E+04      0.615464E+01
                         WAD               WFD               WG24              FAR24             ETAD              DPDUC
                        0.                0.                0.505199E+03      0.                0.                0.
                         ETAF              ETAC              ETATHP            ETATLP            AM55              AM25
                        0.815437E+00      0.100000E+01      0.100000E+01      0.909909E+00      0.238010E+00      0.
                         T6                P6                PS6               AM6               V6                WG6
                        0.274010E+04      0.302911E+01      0.292530E+01      0.238010E+00      0.583946E+03      0.520505E+03
                         T7                WFA               WG7               FAR7              ETAA              DPAFT
                        0.274010E+04      0.                0.520505E+03      0.302964E-01      0.                0.480047E-01
                         PS8               AM8               V8                PS9               AM9               V9
                        0.158634E+01      0.100000E+01      0.230699E+04      0.114456E+00      0.270307E+01      0.462581E+04
                         PS28              AM28              V28               PS29              AM29              V29
                        0.                0.                0.                0.                0.                0.
                         BYPASS            HPEXT             WFT               WGT               VA                FRD
                        0.                0.                0.153057E+02      0.520505E+03      0.242123E+04      0.380184E+05
                         CVMNOZ            VJM               CVDNOZ            VJD               FGM               FGP
                        0.958966E+00      0.443600E+04      0.                0.                0.717646E+05      0.

MAIN SHOCK OUTSIDE C-D NOZZLE          FG= 71764.62                    FN= 33746.24                    SFC= 1.62279
DUCT SHOCK OUTSIDE C-D NOZZLE

CONVERGED AFTER   1 LOOPS
```

Case 8: The engine is operating in the supersonic flight condition with partial afterburning. This case illustrates that for an afterburning condition (IAFTBN = 1), the program automatically expands the nozzle so PS9 is equal to PS0. There is no need to input NOZFLT = 1 as in the previous case.

```
$D(1),T4=3260,T7=2900,IAFTBN=1,# PARTIAL AFTERBURNING DURING SUPERSONIC OPER.

NOZZLE DESIGN              A8= 0.88924085E+01    AM8= 0.10000000E+01     A9= 0.30845876E+02    AM9= 0.26977559E+01

ARATIO=  3.469    OUT OF RANGE,USE DATA FOR   2.150

OUTPUT                AM=  2.500        ALTP= 50000.          T4= 3260.00        T7= 2900.00       ETAR= 0.8703
                        PCNF              CNF               ZF                PRF               WAFC              WAF
                      0.832186E+02      0.640467E+00      0.665972E+00      0.361453E+01      0.385510E+03      0.505199E+03
                        PCNC              CNC               ZC                PRC               WACC              WAC
                      0.114102E+03      0.100000E+01      0.100000E+01      0.100000E+01      0.131289E+03      0.505199E+03
                        T2                P2                T21               P21               T3                P3
                      0.875661E+03      0.170275E+01      0.132686E+04      0.615464E+01      0.132686E+04      0.615464E+01
                        PCBLF             BLF               PCBLC             BLC               PCBLOB            BLOB
                      0.                0.                0.970000E-01      0.490043E+02      0.                0.
                        PCBLHP            BLHP              PCBLLP            BLLP              T4                P4
                      0.                0.                0.100000E+01      0.490043E+02      0.326000E+04      0.574667E+01
                        WA3               WFB               WG4               FAR4              ETAB              DPCOM
                      0.456196E+03      0.153057E+02      0.471501E+03      0.335508E-01      0.985000E+00      0.662867E-01
                        TFFHP             CNHP              DHTCHP            DHTC              T5                P5
                      0.                0.                0.                0.                0.326000E+04      0.574667E+01
                        TFFLP             CNLP              DHTCLP            DHTF              T55               P55
                      0.318769E+03      0.145751E+01      0.160734E-01      0.121704E+03      0.274010E+04      0.302911E+01
                        PCBLDU            BLDU              T24               P24               T25               P25
                      0.                0.                0.                0.                0.132686E+04      0.615464E+01
                        WAD               WFD               WG24              FAR24             ETAD              DPDUC
                      0.                0.                0.505199E+03      0.                0.                0.
                        ETAF              ETAC              ETATHP            ETATLP            AM55              AM25
                      0.815437E+00      0.100000E+01      0.100000E+01      0.909909E+00      0.238010E+00      0.
                        T6                P6                PS6               AM6               V6                WG6
                      0.274010E+04      0.302911E+01      0.292530E+01      0.238010E+00      0.583946E+03      0.520505E+03
                        T7                WFA               WG7               FAR7              ETAA              DPAFT
                      0.290000E+04      0.160194E+01      0.522107E+03      0.334673E-01      0.866827E+00      0.480047E-01
                        PS8               AM8               V8                PS9               AM9               V9
                      0.158508E+01      0.100000E+01      0.237121E+04      0.114456E+00      0.269776E+01      0.476814E+04
                        PS28              AM28              V28               PS29              AM29              V29
                      0.                0.                0.                0.                0.                0.
                        BYPASS            HPEXT             WFT               WGT               VA                FRD
                      0.                0.                0.169076E+02      0.522107E+03      0.242123E+04      0.380184E+05
                        CVMNOZ            VJM               CVDNOZ            VJD               FGM               FGP
                      0.959036E+00      0.457282E+04      0.                0.                0.742059E+05      0.

MAIN SHOCK OUTSIDE C-D NOZZLE          FG= 74209.85                        FN= 36187.47                        SFC= 1.68201
DUCT SHOCK OUTSIDE C-D NOZZLE

CONVERGED AFTER   1 LOOPS
```

Case 9: The engine is operating in the supersonic condition at the maximum design afterburner temperature.

```
$D(1),T4=3260,T7=3560,IAFTBN=1,#  MAX AFTERBURNING AT SUPERSONIC OPERATION

NOZZLE DESIGN              A8= 0.10150120E+02    AM8= 0.10000000E+01     A9= 0.36281996E+02    AM9= 0.26857718E+01

ARATIO=  3.575    OUT OF RANGE,USE DATA FOR   2.150

OUTPUT                AM=  2.500        ALTP= 50000.          T4= 3260.00        T7= 3560.00       ETAR= 0.8703
                        PCNF              CNF               ZF                PRF               WAFC              WAF
                      0.832186E+02      0.640467E+00      0.665972E+00      0.361453E+01      0.385510E+03      0.505199E+03
                        PCNC              CNC               ZC                PRC               WACC              WAC
                      0.114102E+03      0.100000E+01      0.100000E+01      0.100000E+01      0.131289E+03      0.505199E+03
                        T2                P2                T21               P21               T3                P3
                      0.875661E+03      0.170275E+01      0.132686E+04      0.615464E+01      0.132686E+04      0.615464E+01
                        PCBLF             BLF               PCBLC             BLC               PCBLOB            BLOB
                      0.                0.                0.970000E-01      0.490043E+02      0.                0.
                        PCBLHP            BLHP              PCBLLP            BLLP              T4                P4
                      0.                0.                0.100000E+01      0.490043E+02      0.326000E+04      0.574667E+01
                        WA3               WFB               WG4               FAR4              ETAB              DPCOM
                      0.456196E+03      0.153057E+02      0.471501E+03      0.335508E-01      0.985000E+00      0.662867E-01
                        TFFHP             CNHP              DHTCHP            DHTC              T5                P5
                      0.                0.                0.                0.                0.326000E+04      0.574667E+01
                        TFFLP             CNLP              DHTCLP            DHTF              T55               P55
                      0.318769E+03      0.145751E+01      0.160734E-01      0.121704E+03      0.274010E+04      0.302911E+01
                        PCBLDU            BLDU              T24               P24               T25               P25
                      0.                0.                0.                0.                0.132686E+04      0.615464E+01
                        WAD               WFD               WG24              FAR24             ETAD              DPDUC
                      0.                0.                0.505199E+03      0.                0.                0.
                        ETAF              ETAC              ETATHP            ETATLP            AM55              AM25
                      0.815437E+00      0.100000E+01      0.100000E+01      0.909909E+00      0.238010E+00      0.
                        T6                P6                PS6               AM6               V6                WG6
                      0.274010E+04      0.302911E+01      0.292530E+01      0.238010E+00      0.583946E+03      0.520505E+03
                        T7                WFA               WG7               FAR7              ETAA              DPAFT
                      0.356000E+04      0.794422E+01      0.528449E+03      0.460213E-01      0.908862E+00      0.480047E-01
                        PS8               AM8               V8                PS9               AM9               V9
                      0.157511E+01      0.100000E+01      0.261903E+04      0.114456E+00      0.268577E+01      0.532344E+04
                        PS28              AM28              V28               PS29              AM29              V29
                      0.                0.                0.                0.                0.                0.
                        BYPASS            HPEXT             WFT               WGT               VA                FRD
                      0.                0.                0.232499E+02      0.528449E+03      0.242123E+04      0.380184E+05
                        CVMNOZ            VJM               CVDNOZ            VJD               FGM               FGP
                      0.959380E+00      0.510720E+04      0.                0.                0.838843E+05      0.

MAIN SHOCK OUTSIDE C-D NOZZLE          FG= 83884.25                        FN= 45865.87                        SFC= 1.82498
DUCT SHOCK OUTSIDE C-D NOZZLE

CONVERGED AFTER   1 LOOPS
```

Case 10: Ability to fix the mechanical shaft speed PCNF is a revision to reference 2 which was supplied by its author. This engine operation method is accomplished by setting the control MODE equal to 3. MODE = 3 allows the engine to run at some desired value of shaft speed while the primary stream area A8 is varied. The value of turbine inlet temperature necessary to properly match the components is calculated in the program.

The supersonic flight condition is used for illustrative purposes. Any condition desired could have been used. In case 9, the outer compressor shaft speed was considerably less than 100 percent when the design turbine inlet temperature T4 and area A8 were used. By using MODE = 3 instead of MODE = 0, the design T4 was exceeded when a 100-percent shaft speed was specified. A8 was increased by 1 percent. An attempt was made to run the design value of A8; but the T4 exceeded the program limit value of 4000° R and the components did not match. The limit value of a 4000° R temperature is used because the equations for the gas properties do not account for the dissociation of the products of combustion which would become significant at higher temperatures.

```
$D(1),MODE=3,PCNF=100,A8=8.586*1.01,NOZFLT=0,$ SETUP FOR 100 PERCENT COMP. SPEED

OUTPUT                  AM=  2.500        ALTP= 50000.          T4= 3962.97                    ETAR= 0.8703
                          PCNF              CNF               ZF                PRF               WAFC              WAF
                        0.100000E+03      0.769621E+00      0.736343E+00      0.502448E+01      0.473919E+03      0.621058E+03
                          PCNC              CNC               ZC                PRC               WACC              WAC
                        0.119204E+03      0.100000E+01      0.100000E+01      0.100000E+01      0.121299E+03      0.621058E+03
                          T2                P2                T21               P21               T3                P3
                        0.875661E+03      0.170275E+01      0.144819E+04      0.855543E+01      0.144819E+04      0.855543E+01
                          PCBLF             BLF               PCBLC             BLC               PCBLOB            BLOB
                        0.                0.                0.970000E-01      0.602426E+02      0.                0.
                          PCBLHP            BLHP              PCBLLP            BLLP              T4                P4
                        0.                0.                0.100000E+01      0.602426E+02      0.396297E+04      0.803147E+01
                          WA3               WFB               WG4               FAR4              ETAB              DPCOM
                        0.560815E+03      0.259670E+02      0.586782E+03      0.463022E-01      0.985000E+00      0.612431E-01
                          TFFHP             CNHP              DHTCHP            DHTC              T5                P5
                        0.                0.                0.                0.                0.396297E+04      0.803147E+01
                          TFFLP             CNLP              DHTCLP            DHTF              T55               P55
                        0.312963E+03      0.158851E+01      0.167439E-01      0.153692E+03      0.332634E+04      0.412729E+01
                          PC9LDU            BLDU              T24               P24               T25               P25
                        0.                0.                0.                0.                0.144819E+04      0.855543E+01
                          WAD               WFD               WG24              FAR24             ETAD              DPDUC
                        0.                0.                0.621058E+03      0.                0.                0.
                          ETAF              ETAC              ETATHP            ETATLP            AM55              AM25
                        0.840396E+00      0.100000E+01      0.100000E+01      0.908362E+00      0.240982E+00      0.
                          T6                P6                PS6               AM6               V6                WG6
                        0.332634E+04      0.412729E+01      0.398387E+01      0.240982E+00      0.647423E+03      0.647025E+03
                          T7                WFA               WG7               FAR7              ETAA              DPAFT
                        0.332634E+04      0.                0.647025E+03      0.418109E-01      0.                0.482537E-01
                          PS8               AM8               V8                PS9               AM9               V9
                        0.217407E+01      0.100000E+01      0.253416E+04      0.217407E+01      0.100000E+01      0.253416E+04
                          PS28              AM28              V28               PS29              AM29              V29
                        0.                0.                0.                0.                0.                0.
                          BYPASS            HPEXT             WFT               WGT               VA                FRD
                        0.                0.                0.259670E+02      0.647025E+03      0.242123E+04      0.467372E+05
                          CVMNOZ            VJM               CVDNOZ            VJD               FGM               FGP
                        0.801550E+00      0.203126E+04      0.                0.                0.408489E+05      0.377970E+05

MAIN SONIC CONVERGENT NOZZLE          FG= 78645.91                  FN= 31908.72                  SFC= 2.92964
DUCT SHOCK OUTSIDE C-D NOZZLE

CONVERGED AFTER   7 LOOPS
```

Case 11: This case indicates that if MODE = 3 and the area is changed, T4 will change. The nozzle throat area has been opened to 120 percent of its design value ($A8 = 8.586 \times 1.20$). The engine components match at a point where the calculated T4 is less than the design value and the compressor shaft speed is 100 percent of design. Area

variation A8 and compressor speed variations are the options that are available when MODE = 3. The engine components are matched in all setup cases with the engine operating with the throat area A8 equal to A9 as if the engine has a convergent nozzle. In order to return to a convergent nozzle, an input of the control variable NOZFLT = 0 is required when a new setup case is run because NOZFLT is not reset to zero internally. This case is a setup case and illustrates only one of the many options available for operation of the GENENG program.

```
$D(1),NOZFLT=1,* PERFORMANCE WITH BEST NOZZLE AREA RATIO

NOZZLE DESIGN              A8= 0.86801134E+01    AM8= 0.10000000E+01     A9= 0.37183272E+02    AM9= 0.28765206E+01

ARATIO=  4.284    OUT OF RANGE,USE DATA FOR   2.150

OUTPUT                AM=  2.500        ALTP= 50000.          T4= 3962.97                          ETAR= 0.8703
                       PCNF              CNF               ZF                PRF               WAFC              WAF
                     0.100000E+03      0.769620E+00      0.736343E+00      0.502448E+01      0.473919E+03      0.621058E+03
                       PCNC              CNC               ZC                PRC               WACC              WAC
                     0.119204E+03      0.100000E+01      0.100000E+01      0.100000E+01      0.121299E+03      0.621058E+03
                       T2                P2                T21               P21               T3                P3
                     0.875661E+03      0.170275E+01      0.144819E+04      0.855543E+01      0.144819E+04      0.855543E+01
                       PCBLF             BLF               PCBLC             BLC               PCBLOB            BLOB
                     0.                0.                0.970000E-01      0.602426E+02      0.                0.
                       PCBLHP            BLHP              PCBLLP            BLLP              T4                P4
                     0.                0.                0.100000E+01      0.602426E+02      0.396297E+04      0.803147E+01
                       WA3               WFB               WG4               FAR4              ETAB              DPCOM
                     0.560815E+03      0.259670E+02      0.586782E+03      0.463022E-01      0.985000E+00      0.612431E-01
                       TFFHP             CNHP              DHTCHP            DHTC              T5                P5
                     0.                0.                0.                0.                0.396297E+04      0.803147E+01
                       TFFLP             CNLP              DHTCLP            DHTF              T55               P55
                     0.312963E+03      0.159851E+01      0.167439E-01      0.153692E+03      0.332634E+04      0.412729E+01
                       PCBLDU            BLDU              T24               P24               T25               P25
                     0.                0.                0.                0.                0.144819E+04      0.855543E+01
                       WAD               WFD               WG24              FAR24             ETAD              DPDUC
                     0.                0.                0.621058E+03      0.                0.                0.
                       ETAF              ETAC              ETATHP            ETATLP            AM55              AM25
                     0.840396E+00      0.100000E+01      0.100000E+01      0.908362E+00      0.240982E+00      0.
                       T6                P6                PS6               AM6               V6                WG6
                     0.332634E+04      0.412729E+01      0.398386E+01      0.240982E+00      0.647423E+03      0.647025E+03
                       T7                WFA               WG7               FAR7              ETAA              DPAFT
                     0.332634E+04      0.                0.647025E+03      0.418109E-01      0.                0.482536E-01
                       PS8               AM8               V8                PS9               AM9               V9
                     0.217200E+01      0.100000E+01      0.253416E+04      0.114456E+00      0.287652E+01      0.529546E+04
                       PS28              AM28              V28               PS29              AM29              V29
                     0.                0.                0.                0.                0.                0.
                       BYPASS            HPEXT             WFT               WGT               VA                FRD
                     0.                0.                0.259670E+02      0.647025E+03      0.242123E+04      0.467372E+05
                       CVMNOZ            VJM               CVDNOZ            VJD               FGM               FGP
                     0.948016E+00      0.502018E+04      0.                0.                0.100956E+06      0.

MAIN SHOCK OUTSIDE C-D NOZZLE          FG=100956.46                        FN= 54219.26                        SFC= 1.72413
DUCT SHOCK OUTSIDE C-D NOZZLE

CONVERGED AFTER   1 LOOPS
```

Case 12: The final example case is the performance for the previous case (11) when the maximum attainable area expansion is used (PS9 = PS0).

```
$D(1),MODE=3,PCNF=100,A8=8.586*1.20,NOZFLT=0,* SET UP FOR 100 PERCENT

OUTPUT                AM=  2.500        ALTP= 50000.          T4= 3157.72                          ETAR= 0.8703
                       PCNF              CNF               ZF                PRF               WAFC              WAF
                     0.100000E+03      0.769620E+00      0.613211E+00      0.435150E+01      0.488534E+03      0.640210E+03
                       PCNC              CNC               ZC                PRC               WACC              WAC
                     0.117487E+03      0.100000E+01      0.100000E+01      0.100000E+01      0.142298E+03      0.640210E+03
                       T2                P2                T21               P21               T3                P3
                     0.875661E+03      0.170275E+01      0.140676E+04      0.740952E+01      0.140676E+04      0.740952E+01
                       PCBLF             BLF               PCBLC             BLC               PCBLOB            BLOB
                     0.                0.                0.970000E-01      0.621004E+02      0.                0.
                       PCBLHP            BLHP              PCBLLP            BLLP              T4                P4
                     0.                0.                0.100000E+01      0.621004E+02      0.315772E+04      0.687718E+01
                       WA3               WFB               WG4               FAR4              ETAB              DPCOM
                     0.578110E+03      0.174823E+02      0.595592E+03      0.302405E-01      0.985000E+00      0.718451E-01
                       TFFHP             CNHP              DHTCHP            DHTC              T5                P5
                     0.                0.                0.                0.                0.315772E+04      0.687718E+01
                       TFFLP             CNLP              DHTCLP            DHTF              T55               P55
                     0.331151E+03      0.177956E+01      0.196409E-01      0.144425E+03      0.258009E+04      0.311714E+01
```

```
  PCBLDU          BLDU            T24             P24             T25             P25
0.              0.              0.              0.              0.140676E+04    0.740952E+01
  WAD             WFD             WG24            FAR24           ETAD            DPDUC
0.              0.              0.640210E+03    0.              0.              0.
  ETAF            ETAC            ETATHP          ETATLP          AM55            AM25
0.810314E+00    0.100000E+01    0.100000E+01    0.917729E+00    0.287188E+00    0.
  T6              P6              PS6             AM6             V6              WG6
0.258009E+04    0.311714E+01    0.296110E+01    0.287188E+00    0.683798E+03    0.657693E+03
  T7              WFA             WG7             FAR7            ETAA            DPAFT
0.258009E+04    0.              0.657693E+03    0.273072E-01    0.              0.571973E-01
  PS8             AM8             V8              PS9             AM9             V9
0.161452E+01    0.100000E+01    0.224079E+04    0.161452E+01    0.100000E+01    0.224079E+04
  PS28            AM28            V28             PS29            AM29            V29
0.              0.              0.              0.              0.              0.
  BYPASS          HPEXT           WFT             WGT             VA              FRD
0.              0.              0.174823E+02    0.657693E+03    0.242123E+04    0.481785E+05
  CVMNOZ          VJM             CVDNOZ          VJD             FGM             FGP
0.833962E+00    0.186873E+04    0.              0.              0.382001E+05    0.327071E+05

MAIN SONIC CONVERGENT NOZZLE          FG= 70907.18                FN= 22728.66                SFC= 2.769C3
DUCT SHOCK OUTSIDE C-D NOZZLE

CONVERGED AFTER   8 LOOPS
```

Two-Spool Turbojet

Design point. - An example is given for design-point operation of a two-spool turbojet. For the design point the data are printed out in three groups: (1) card images of the input data that were changed from the original input data, (2) results, and (3) common variables at the design point. The card images show two cards having $D(1), IDES = 1, imprinted. These two cards in sequence recall the original design inputs. This method can be used as many times as desired in any computer run to design a new engine. A typical use for this may be a study of several engines where design-point performance only is sufficient. Thus, only changes in engine design characteristics need be input and a new engine is run. Or, as in this case, the engine was changed from a single-spool turbojet to a two-spool turbojet by changing ISPOOL = 1 to ISPOOL = 2 and by inputing the design pressure ratio and efficiency of the inner compressor and the design efficiency speed and flow function of the inner turbine. Also a change to the front compressor pressure ratio was made to have an overall pressure ratio of 8:1. The MODE was reset to zero (MODE = 0) from the previous cases of the single-spool turbojet engine.

```
$D(1),IDES=1, * FIRST OF TWO IDES=1 CARDS NECESSARY TO CHANGE DESIGN POINT
$D(1),IDES=1, * SECOND OF TWO IDES=1 CARDS NECESSARY TO CHANGE DESIGN POINT
ISPOOL=2,* TWO SPOOL TURBOJET
PRFDS=2,PRCDS=4,ETACDS=.85,PCNCDS=100,ZCDS=.81433225, * OVERALL P RATIO STILL 8
TFHPDS=50.00,CNHPDS=2.000,ETHPDS=.90,MODE=0, * ADDITIONAL INPUT WAS REQUIRED TO
* RUN TWO SPOOL TURBOJETS, MODE =0 RESETS TO USE OF T4 RATHER THAN SPEED

FAN DESIGN              PRFCF= 0.25000000E+01 ETAFCF= 0.94204545E+00  WAFCF= 0.10550000E+01   T2DS= 0.51866820E+03

COMPRESSOR DESIGN       PRCCF= 0.42857143E+00 ETACCF= 0.98837209E+00  WACCF= 0.35584073E+01  T21DS= 0.655622C0E+03

COMBUSTER DESIGN       WA3CDS= 0.15548823E+03 ETABCF= 0.98500000E+00 DTCOCF= 0.10000000E+01

H.P. TURBINE DESIGN    CNHPCF= 0.11419282E+01 TFHPCF= 0.16375691E+00 ETHPCF= 0.10000000E+01 DHHPCF= 0.48959067E+0C

L.P. TURBINE DESIGN    CNLPCF= 0.12507844E+01 TFLPCF= 0.27070545E+00 ETLPCF= 0.10235344E+01 DHLPCF= 0.68989028E+0C

TURBINE AREA DESIGN       A55= 0.21028949E+02   AM55= 0.2382373TE+00

AFTERBURNER DESIGN     WG6CDS= 0.90353905E+04

NOZZLE DESIGN             A8= 0.86244577E+01    AM8= 0.10000000E+01     A9= 0.86244577E+01    AM9= 0.10CC0C0CE+01
```

```
OUTPUT                  AM=  0.          ALTP=     0.          T4= 3260.00                              ETAR= 1.0000
                          PCNF             CNF              ZF              PRF             WAFC             WAF
                       0.100000E+03    0.100000E+01    0.833333E+00    0.200000E+01    0.633000E+03    0.633000E+03
                          PCNC             CNC              ZC              PRC             WACC             WAC
                       0.100000E+03    0.100000E+01    0.814332E+00    0.400000E+01    0.355841E+03    0.633000E+03
                          T2               P2               T21             P21             T3               P3
                       0.518668E+03    0.100000E+01    0.655622E+03    0.200000E+01    0.102280E+04    0.800000E+01
                          PCBLF            BLF              PCBLC           BLC             PCBLOB           BLOB
                       0.               0.               0.970000E-01    0.614010E+02    0.               0.
                          PCBLHP           BLHP             PCBLLP          BLLP            T4               P4
                       0.               0.               0.100000E+01    0.614010E+02    0.326000E+04    0.755200E+01
                          WA3              WFB              WG4             FAR4            ETAB             DPCOM
                       0.571599E+03    0.219038E+02    0.593503E+03    0.383203E-01    0.985000E+00    0.560000E-01
                          TFFHP            CVHP             DHTCHP          DHTC            T5               P5
                       0.305331E+03    0.175142E+01    0.600000E-01    0.957639E+02    0.295739E+04    0.457332E+01
                          TFFLP            CVLP             DHTCLP          DHTF            T55              P55
                       0.480227E+03    0.183885E+01    0.171750E-01    0.350417E+02    0.269456E+04    0.376248E+01
                          PCBLOU           BLOU             T24             P24             T25              P25
                       0.               0.               0.              0.              0.655622E+03    0.200000E+01
                          WAD              WFD              WG24            FAR24           ETAD             DPDUC
                       0.               0.               0.633000E+03    0.              0.               0.
                          ETAF             ETAC             ETATHP          ETATLP          AM55             AM25
                       0.829000E+00    0.850000E+00    0.900000E+00    0.903000E+00    0.238237E+00    0.
                          T6               P6               PS6             AM5             V6               WG6
                       0.269456E+04    0.376248E+01    0.362824E+01    0.238237E+00    0.579167E+03    0.654904E+03
                          T7               WFA              WG7             FAR7            ETAA             DPAFT
                       0.269456E+04    0.               0.654904E+03    0.345032E-01    0.               0.480000E-01
                          PS8              AM8              V8              PS9             AM9              V9
                       0.197183E+01    0.100000E+01    0.228725E+04    0.197183E+01    0.100000E+01    0.228725E+04
                          PS28             AM28             V28             PS29            AM29             V29
                       0.               0.               0.              0.              0.               0.
                          BYPASS           HPEXT            WFT             WGT             VA               FRD
                       0.               0.               0.219038E+02    0.654904E+03    0.               0.
                          CVMNOZ           VJM              CVDNOZ          VJD             FGM              FGP
                       0.967850E+00    0.221372E+04    0.              0.              0.450603E+05    0.177371E+05
MAIN SONIC CONVERGENT NOZZLE            FG= 62797.45                     FN= 62797.45                     SFC= 1.25568
DUCT SHOCK OUTSIDE C-D NOZZLE

CONVERGED AFTER   1 LOOPS


COMMON          0.833333E+00    0.100000E+03   -0.000000E-19   -0.000000E-19    0.814332E+00    0.100000E+03    0.326000E+04   0

    0.100000E+03    0.100000E+03    0.326000E+04    0.100000E+03    0.              0.100000E+01    0.100000E+01    0.100000E+01
    0.833333E+00    0.100000E+03    0.200000E+01    0.829000E+00    0.633000E+03    0.250000E+01    0.942045E+00    0.105500E+01
    0.814332E+00    0.100000E+03    0.400000E+01    0.850000E+00    0.633000E+03    0.428571E+00    0.988372E+00    0.355841E+01
    0.326000E+04    0.              0.223720E+04    0.985000E+00    0.155488E+03    0.560000E-01    0.100000E+01    0.985000E+00
    0.500000E+02    0.200000E+01    0.900000E+00    0.163757E+00    0.114193E+01    0.100000E+01    0.489591E+00    0.518668E+03
    0.130000E+03    0.230000E+01    0.903000E+00    0.270705E+00    0.125078E+01    0.102353E+01    0.689890E+00    0.655622E+03
    0.              0.              0.              0.              0.              0.              0.              0.
    0.356000E+04    0.              0.              0.900000E+00    0.903539E+04    0.480000E-01    0.              0.
    0.210299E+02    0.              0.210289E+02    0.210289E+02    0.862446E+01    0.862446E+01    0.              0.
    0.362824E+01    0.238237E+00    0.              0.967850E+00    0.              0.              0.              0.

    0.518670E+03    0.100000E+01    0.123918E+03    0.159103E+01    0.518668E+03    0.100000E+01    0.123918E+03    0.159103E+01
    0.655622E+03    0.200000E+01    0.156774E+03    0.159970E+01    0.102280E+04    0.800000E+01    0.246562E+03    0.161325E+01
    0.326000E+04    0.755200E+01    0.916050E+03    0.196075E+01    0.295739E+04    0.457332E+01    0.820286E+03    0.196436E+01
    0.269456E+04    0.376248E+01    0.734740E+03    0.194651E+01    0.              0.614010E+02    0.              0.
    0.100000E+01    0.200000E+01    0.829000E+00    0.633000E+03    0.633000E+03    0.571599E+03    0.593503E+03    0.383203E-01
    0.100000E+01    0.400000E+01    0.850000E+00    0.355841E+03    0.633000E+03    0.985000E+00    0.560000E-01    0.
    0.200000E+01    0.900000E+00    0.293754E-01    0.957639E+02    0.              0.593503E+03    0.383203E-01    0.111699E+04
    0.230000E+01    0.903000E+00    0.118488E-01    0.350417E+02    0.614010E+02    0.654904E+03    0.346032E-01    0.
    0.              0.              0.100000E+01    0.833333E+00    0.100000E+03    0.814332E+00    0.100000E+03    0.219038E+02
    0.500000E+02    0.130000E+03    0.              0.970000E-01    0.              0.              0.              0.100000E+01

    0.100000E+01    0.633000E+03    0.633000E+03    0.              0.              0.246562E+03    0.              0.
    0.655622E+03    0.200000E+01    0.156774E+03    0.159970E+01    0.              0.              0.              0.
    0.              0.              0.              0.              0.655622E+03    0.200000E+01    0.156774E+03    0.159970E+01
    0.              0.              0.              0.              0.              0.              0.              0.
    0.              0.              0.633000E+03    0.              0.              0.              0.              0.
    0.              0.              0.              0.              0.              0.              0.              0.

    0.269456E+04    0.376248E+01    0.734740E+03    0.194651E+01    0.655622E+03    0.200000E+01    0.156774E+03    0.159970E+01
    0.219038E+02    0.654904E+03    0.346032E-01    0.              0.633000E+03    0.              0.100000E+01    0.
    0.269456E+04    0.376248E+01    0.734740E+03    0.194651E+01    0.269456E+04    0.358188E+01    0.734737E+03    0.194989E+01
    0.269456E+04    0.358188E+01    0.734737E+03    0.194989E+01    0.269456E+04    0.358188E+01    0.734737E+03    0.194989E+01
    0.654904E+03    0.              0.654904E+03    0.346032E-01    0.              0.480000E-01    0.579167E+03    0.
    0.362824E+01    0.579167E+03    0.238237E+00    0.267059E+04    0.344111E+01    0.610194E+03    0.251101E+00    0.
    0.235272E+04    0.197183E+01    0.228725E+04    0.100000E+01    0.235272E+04    0.197183E+01    0.228725E+04    0.100000E+01
    0.              0.              0.              0.              0.221372E+04    0.450603E+05    0.              0.177371E+05
    0.450603E+05    0.177371E+05    0.219038E+02    0.654904E+03    0.346032E-01    0.627974E+05    0.627974E+05    0.125568E+01
```

Off-design. - The following cases are off-design cases for the two-spool turbojet.

Case 1: The engine is operating at a reduced turbine inlet temperature at sea-level-static condition. The input change of T4 was required. The compressor shaft speed of both compressors is reduced as are the pressure ratios, airflows, etc., all of which are representative of part-power operation.

```
$D(1),T4=2660,#1 PART POWER ENGINE OPERATION
#     RESULTS N O R M A L  O F F - D E S I G N  O U T P U T

OUTPUT                AM=  0.          ALTP=     0.          T4= 2660.00                          ETAR= 1.0000
                       PCNF             CNF              ZF               PRF              WAFC             WAF
                     0.836241E+02     0.836241E+00     0.849728E+00     0.175763E+01     0.503176E+03     0.503176E+03
                       PCNC             CNC              ZC               PRC              WACC             WAC
                     0.904097E+02     0.925609E+00     0.709173E+00     0.324591E+01     0.314397E+03     0.503194E+03
                       T2               P2               T21              P21              T3               P3
                     0.518668E+03     0.100000E+01     0.625500E+03     0.175763E+01     0.930191E+03     0.570511E+01
                       PCBLF            BLF              PCBLC            BLC              PCBLOB           BLOB
                     0.               0.               0.970000E-01     0.488098E+02     0.               0.
                       PCBLHP           BLHP             PCBLLP           BLLP             T4               P4
                     0.               0.               0.100000E+01     0.488098E+02     0.266000E+04     0.536548E+01
                       WA3              WFB              WG4              FAR4             ETAB             DPCOM
                     0.454384E+03     0.127365E+02     0.467120E+03     0.280302E-01     0.985000E+00     0.595301E-01
                       TFFHP            CNHP             DHTCHP           DHTC             T5               P5
                     0.305536E+03     0.175297E+01     0.613448E-01     0.797926E+02     0.239574E+04     0.320282E+01
                       TFFLP            CNLP             DHTCLP           DHTF             T55              P55
                     0.485755E+03     0.170849E+01     0.166673E-01     0.275883E+02     0.218600E+04     0.265090E+01
                       PCBLDU           BLDU             T24              P24              T25              P25
                     0.               0.               0.               0.               0.625500E+03     0.175763E+01
                       WAD              WFD              WG24             FAR24            ETAD             DPDUC
                     0.               0.               0.503176E+03     0.               0.               0.
                       ETAF             ETAC             ETATHP           ETATLP           AM55             AM25
                     0.848567E+00     0.809756E+00     0.897395E+00     0.906332E+00     0.238214E+00     0.
                       T6               P6               PS6              AM6              V6               WG6
                     0.218600E+04     0.265090E+01     0.255886E+01     0.238214E+00     0.525189E+03     0.515930E+03
                       T7               WFA              WG7              FAR7             ETAA             DPAFT
                     0.218600E+04     0.               0.515930E+03     0.253113E-01     0.               0.483412E-01
                       PS8              AM8              V8               PS9              AM9              V9
                     0.138197E+01     0.100000E+01     0.206732E+04     0.138197E+01     0.100000E+01     0.206732E+04
                       PS28             AM28             V28              PS29             AM29             V29
                     0.               0.               0.               0.               0.               0.
                       BYPASS           HPEXT            WFT              WGT              VA               FRD
                     0.               0.               0.127365E+02     0.515913E+03     0.               0.
                       CVMNOZ           VJM              CVDNOZ           VJD              FGM              FGP
                     0.978239E+00     0.202233E+04     0.               0.               0.324293E+05     0.697137E+04

MAIN SCNIC CONVERGENT NOZZLE          FG= 39400.71                      FN= 39400.71                      SFC= 1.16372
DUCT SHOCK OUTSIDE C-D NOZZLE

CONVERGED AFTER  13 LOOPS
```

Case 2: The engine is now operating at a supersonic flight Mach number (2.5) at an altitude of 50 000 feet. The engine components are matched with an engine nozzle throat area A8 equal to the sea-level-static design value. This case is a setup case for matching components only.

```
$D(1),T4=3260,AM=2.5,ALTP=50000,# SET UP FOR COMPONENT MATCHING ONLY
#     RESULTS N O R M A L  O F F - D E S I G N  O U T P U T

OUTPUT                AM=  2.500       ALTP= 50000.          T4= 3260.00                          ETAR= 0.8703
                       PCNF             CNF              ZF               PRF              WAFC             WAF
                     0.851964E+02     0.655689E+00     0.823071E+00     0.148416E+01     0.373082E+03     0.488914E+03
                       PCNC             CNC              ZC               PRC              WACC             WAC
                     0.102605E+03     0.832254E+00     0.556194E+00     0.245472E+01     0.268143E+03     0.488881E+03
                       T2               P2               T21              P21              T3               P3
                     0.875661E+03     0.170275E+01     0.996510E+03     0.252716E+01     0.135728E+04     0.620347E+01
                       PCBLF            BLF              PCBLC            BLC              PCBLOB           BLOB
                     0.               0.               0.970000E-01     0.474215E+02     0.               0.
                       PCBLHP           BLHP             PCBLLP           BLLP             T4               P4
                     0.               0.               0.100000E+01     0.474215E+02     0.326000E+04     0.580489E+01
                       WA3              WFB              WG4              FAR4             ETAB             DPCOM
                     0.441460E+03     0.145963E+02     0.456056E+03     0.330637E-01     0.985000E+00     0.642514E-01
                       TFFHP            CNHP             DHTCHP           DHTC             T5               P5
                     0.305235E+03     0.179705E+01     0.618535E-01     0.982400E+02     0.294654E+04     0.346287E+01
                       TFFLP            CNLP             DHTCLP           DHTF             T55              P55
                     0.486451E+03     0.156951E+01     0.157361E-01     0.319779E+02     0.271686E+04     0.289862E+01
                       PCBLDU           BLDU             T24              P24              T25              P25
                     0.               0.               0.               0.               0.996510E+03     0.252716E+01
                       WAD              WFD              WG24             FAR24            ETAD             DPDUC
                     0.               0.               0.488914E+03     0.               0.               0.
                       ETAF             ETAC             ETATHP           ETATLP           AM55             AM25
                     0.840476E+00     0.758931E+00     0.898441E+00     0.905158E+00     0.238434E+00     0.
                       T6               P6               PS6              AM6              V6               WG6
                     0.271686E+04     0.289862E+01     0.279887E+01     0.238434E+00     0.582650E+03     0.503478E+03
                       T7               WFA              WG7              FAR7             ETAA             DPAFT
                     0.271686E+04     0.               0.503478E+03     0.293565E-01     0.               0.480968E-01
                       PS8              AM8              V8               PS9              AM9              V9
                     0.151968E+01     0.100000E+01     0.229751E+04     0.151968E+01     0.100000E+01     0.229751E+04
                       PS28             AM28             V28              PS29             AM29             V29
                     0.               0.               0.               0.               0.               0.
                       BYPASS           HPEXT            WFT              WGT              VA               FRD
                     0.               0.               0.145963E+02     0.503510E+03     0.242123E+04     0.367928E+05
                       CVMNOZ           VJM              CVDNOZ           VJD              FGM              FGP
                     0.839848E+00     0.192956E+04     0.               0.               0.301948E+05     0.256471E+05

MAIN SCNIC CONVERGENT NOZZLE          FG= 55841.86                      FN= 19049.05                      SFC= 2.75849
DUCT SHOCK OUTSIDE C-D NOZZLE

CONVERGED AFTER  20 LOOPS
```

Case 3: The performance data for this case reflect an expansion to the maximum attainable area ratio for A9/A8, thus simulating a convergent-divergent nozzle. Performance is calculated such that the nozzle static pressure PS9 is equal to the free-stream static pressure PS0. This is accomplished by setting NOZFLT = 1.

```
    $D(1),NOZFLT=1, * PERFORMANCE WITH MAX ATTAINABLE AREA RATIO
    *     RESULTS N O R M A L   O F F - D E S I G N   O U T P U T

NOZZLE DESIGN              A8= 0.86367638E+01    AM8= 0.10000000E+01     A9= 0.28983159E+02    AM9= 0.26768298E+01

ARATIO=  3.356    OUT OF RANGE,USE DATA FOR   2.150

OUTPUT                AM=  2.500        ALTP= 50000.          T4= 3260.00                          ETAR= 0.8703
                       PCNF              CNF               ZF                PRF               WAFC              WAF
                     0.851964E+02      0.655689E+00      0.823071E+00      0.148416E+01      0.373082E+03      0.488914E+03
                       PCNC              CNC               ZC                PRC               WACC              WAC
                     0.102605E+03      0.832254E+00      0.556194E+00      0.245472E+01      0.268143E+03      0.488881E+03
                       T2                P2                T21               P21               T3                P3
                     0.875661E+03      0.170275E+01      0.996510E+03      0.252716E+01      0.135728E+04      0.620347E+01
                       PCBLF             BLF               PCBLC             BLC               PCBLOB            BLOB
                     0.                0.                0.970000E-01      0.474215E+02      0.                0.
                       PCBLHP            BLHP              PCBLLP            BLLP              T4                P4
                     0.                0.                0.100000E+01      0.474215E+02      0.326000E+04      0.580489E+01
                       WA3               WFB               WG4               FAR4              ETAB              DPCOM
                     0.441460E+03      0.145963E+02      0.456056E+03      0.330637E-01      0.985000E+00      0.642514E-01
                       TFFHP             CNHP              DHTCHP            DHTC              T5                P5
                     0.305235E+03      0.179705E+01      0.618535E-01      0.982400E+02      0.294654E+04      0.346287E+01
                       TFFLP             CNLP              DHTCLP            DHTF              T55               P55
                     0.486451E+03      0.156951E+01      0.157361E-01      0.319779E+02      0.271686E+04      0.289862E+01
                       PCBLDU            BLDU              T24               P24               T25               P25
                     0.                0.                0.                0.                0.996510E+03      0.252716E+01
                       WAD               WFD               WG24              FAR24             ETAD              DPDUC
                     0.                0.                0.488914E+03      0.                0.                0.
                       ETAF              ETAC              ETATHP            ETATLP            AM55              AM25
                     0.840476E+00      0.758931E+00      0.898441E+00      0.906158E+00      0.238434E+00      0.
                       T6                P6                PS6               AM6               V6                WG6
                     0.271686E+04      0.289862E+01      0.279887E+01      0.238434E+00      0.582650E+03      0.503478E+03
                       T7                WFA               WG7               FAR7              ETAA              DPAFT
                     0.271686E+04      0.                0.503478E+03      0.298565E-01      0.                0.480968E-01
                       PS8               AM8               V8                PS9               AM9               V9
                     0.151752E+01      0.100000E+01      0.229751E+04      0.114456E+00      0.267683E+01      0.458357E+04
                       PS28              AM28              V28               PS29              AM29              V29
                     0.                0.                0.                0.                0.                0.
                       BYPASS            HPEXT             WFT               WGT               VA                FRD
                     0.                0.                0.145963E+02      0.503510E+03      0.242123E+04      0.367928E+05
                       CVMNOZ            VJM               CVDNOZ            VJD               FGM               FGP
                     0.960271E+00      0.440147E+04      0.                0.                0.688767E+05      0.

MAIN SHOCK OUTSIDE C-D NOZZLE          FG= 68876.71                        FN= 32083.89                        SFC= 1.63779
DUCT SHOCK OUTSIDE C-D NOZZLE

CONVERGED AFTER   1 LOOPS
```

Case 4: The engine is operating in the supersonic flight condition with partial afterburning. No new setup case was required because the components are still matched from the previous two cases (2 and 3). IAFTBN = 1 automatically expands the nozzle so PS9 = PS0. It also adjusts A8 for the new temperature and pressure condition such that the nozzle throat is sonic. Both A8 and A9 are printed out at the top of the listing.

```
    $D(1),T7=2900,IAFTBN=1, * PARTIAL AFTERBURNING AT SUPERSONIC OPERATION
    *     RESULTS N O R M A L   O F F - D E S I G N   O U T P U T

NOZZLE DESIGN              A8= 0.89961808E+01    AM8= 0.10000000E+01     A9= 0.30389738E+02    AM9= 0.26712209E+01

ARATIO=  3.378    OUT OF RANGE,USE DATA FOR   2.150

OUTPUT                AM=  2.500        ALTP= 50000.          T4= 3260.00          T7= 2900.00          ETAR= 0.8703
                       PCNF              CNF               ZF                PRF               WAFC              WAF
                     0.851964E+02      0.655689E+00      0.823071E+00      0.148416E+01      0.373082E+03      0.488914E+03
                       PCNC              CNC               ZC                PRC               WACC              WAC
                     0.102605E+03      0.832254E+00      0.556194E+00      0.245472E+01      0.268143E+03      0.488881E+03
                       T2                P2                T21               P21               T3                P3
                     0.875661E+03      0.170275E+01      0.996510E+03      0.252716E+01      0.135728E+04      0.620347E+01
                       PCBLF             BLF               PCBLC             BLC               PCBLOB            BLOB
                     0.                0.                0.970000E-01      0.474215E+02      0.                0.
                       PCBLHP            BLHP              PCBLLP            BLLP              T4                P4
                     0.                0.                0.100000E+01      0.474215E+02      0.326000E+04      0.580489E+01
```

```
  WA3                WF8                WG4                FAR4               ETAB               DPCOM
 0.441460E+03       0.145963E+02       0.456056E+03       0.330637E-01       0.985000E+00       0.642514E-01
  TFFHP              CNHP               DHTCHP             DHTC               T5                 P5
 0.305235E+03       0.179705E+01       0.618535E-01       0.982400E+02       0.294654E+04       0.346287E+01
  TFFLP              CNLP               DHTCLP             DHTF               T55                P55
 0.486451E+03       0.156951E+01       0.157361E-01       0.319779E+02       0.271686E+04       0.289862E+01
  PCBLDU             BLDU               T24                P24                T25                P25
 0.                 0.                 0.                 0.                 0.996510E+03       0.252716E+01
  WAD                WFD                WG24               FAR24              ETAD               DPDUC
 0.                 0.                 0.488914E+03       0.                 0.                 0.
  ETAF               ETAC               ETATHP             ETATLP             AM55               AM25
 0.840476E+00       0.758931E+00       0.898441E+00       0.906158E+00       0.238435E+00       0.
  T6                 P6                 PS6                AM6                V6                 WG6
 0.271686E+04       0.289862E+01       0.279887E+01       0.238435E+00       0.582650E+03       0.503477E+03
  T7                 WFA                WG7                FAR7               ETAA               DPAFT
 0.290000E+04       0.171925E+01       0.505197E+03       0.333732E-01       0.893552E+00       0.480968E-01
  PS8                AM8                V8                 PS9                AM9                V9
 0.151599E+01       0.100000F+01       0.237123E+04       0.114456E+00       0.267122E+01       0.474598E+04
  PS28               AM28               V28                PS29               AM29               V29
 0.                 0.                 0.                 0.                 0.                 0.
  BYPASS             HPEXT              WFT                WGT                VA                 FRD
 0.                 0.                 0.163155E+02       0.505229E+03       0.242123E+04       0.367928E+05
  CVMNOZ             VJM                CVDNOZ             VJD                FGM                FGP
 0.960350E+00       0.455780E+04       0.                 0.                 0.715666E+05       0.

MAIN SHOCK OUTSIDE C-D NOZZLE          FG= 71566.56                          FN= 34773.74                          SFC= 1.66909
DUCT SHOCK OUTSIDE C-D NOZZLE

CONVERGED AFTER   1 LOOPS
```

Case 5: The engine is operating in the supersonic flight condition at design afterburner temperature.

```
     $D(1),T7=3500,IAFTBN=1,* MAX AFTERBURNING AT SUPERSONIC OPERATION
     *     RESULTS N O R M A L   O F F - D E S I G N   O U T P U T

NOZZLE DESIGN                A8= 0.10154220E+02    AM8= 0.10000000E+01     A9= 0.35230915E+02    AM9= 0.26607638E+01

ARATIO=  3.470    OUT OF RANGE,USE DATA FOR   2.150

OUTPUT                 AM=  2.500        ALTP= 50000.          T4= 3260.00        T7= 3500.00        ETAR= 0.8703
                        PCNF               CNF                ZF                 PRF                WAFC               WAF
                       0.851964E+02       0.655689E+00       0.823071E+00       0.148416E+01       0.373082E+03       0.488914E+03
                        PCNC               CNC                ZC                 PRC                WACC               WAC
                       0.102605E+03       0.832254E+00       0.556194E+00       0.245472E+01       0.268143E+03       0.488881E+03
                        T2                 P2                 T21                P21                T3                 P3
                       0.875661E+03       0.170275E+01       0.996510E+03       0.252716E+01       0.135728E+04       0.620347E+01
                        PCBLF              BLF                PCBLC              BLC                PCBLOR             BLOB
                       0.                 0.                 0.970000E-01       0.474215E+02       0.                 0.
                        PCBLHP             BLHP               PCBLLP             BLLP               T4                 P4
                       0.                 0.                 0.100000E+01       0.474215E+02       0.326000E+04       0.580489E+01
                        WA3                WF8                WG4                FAR4               ETAB               DPCOM
                       0.441460E+03       0.145963E+02       0.456056E+03       0.330637E-01       0.985000E+00       0.642514E-01
                        TFFHP              CNHP               DHTCHP             DHTC               T5                 P5
                       0.305235E+03       0.179705E+01       0.618535E-01       0.982400E+02       0.294654E+04       0.346287E+01
                        TFFLP              CNLP               DHTCLP             DHTF               T55                P55
                       0.486451E+03       0.156951E+01       0.157361E-01       0.319779E+02       0.271686E+04       0.289862E+01
                        PCBLDU             BLDU               T24                P24                T25                P25
                       0.                 0.                 0.                 0.                 0.996510E+03       0.252716E+01
                        WAD                WFD                WG24               FAR24              ETAD               DPDUC
                       0.                 0.                 0.488914E+03       0.                 0.                 0.
                        ETAF               ETAC               ETATHP             ETATLP             AM55               AM25
                       0.840476E+00       0.758931E+00       0.898441E+00       0.906158E+00       0.238435E+00       0.
                        T6                 P6                 PS6                AM6                V6                 WG6
                       0.271686E+04       0.289862E+01       0.279887E+01       0.238435E+00       0.582650E+03       0.503477E+03
                        T7                 WFA                WG7                FAR7               ETAA               DPAFT
                       0.350000E+04       0.724094E+01       0.510718E+03       0.446677E-01       0.919029E+00       0.480968E-01
                        PS8                AM8                V8                 PS9                AM9                V9
                       0.150725E+01       0.100000F+01       0.259758E+04       0.114456E+00       0.266076E+01       0.524976E+04
                        PS28               AM28               V28                PS29               AM29               V29
                       0.                 0.                 0.                 0.                 0.                 0.
                        BYPASS             HPEXT              WFT                WGT                VA                 FRD
                       0.                 0.                 0.218372E+02       0.510751E+03       0.242123E+04       0.367928E+05
                        CVMNOZ             VJM                CVDNOZ             VJD                FGM                FGP
                       0.960653E+00       0.504319E+04       0.                 0.                 0.800537E+05       0.

MAIN SHOCK OUTSIDE C-D NOZZLE          FG= 80053.69                          FN= 43260.88                          SFC= 1.81721
DUCT SHOCK OUTSIDE C-D NOZZLE

CONVERGED AFTER   1 LOOPS
```

Separate-Flow Turbofan

Design point. - This is the design case for the separate-flow turbofan. For the design point, the data that were changed are shown on the top of the following example.

The control card FAN = .TRUE. designates that there is now a bypass ratio. Thus the front compressor (fan) flow does not equal the inner compressor flow. Consequently, a value for the inner compressor flow must be input. This value determines the engine bypass ratio. Also, a duct Mach number AM23 must be input. If the design is to be a duct-burning turbofan engine, AM23 should remain low (i.e., similar to an afterburner inlet Mach number - between 0.15 and 0.25) to keep friction losses at a minimum in the burner. Also a computational problem could arise when the duct burner is operating if AM23 is too high. The large temperature increase due to fuel addition will cause choking at engine duct station 24, consequently a printout error would occur.

The values of AM and ALTP are input to zero which are the conditions designated for the engine design point. A duct pressure loss DPDUDS is also input.

In the output of the results, the duct parameters now have values associated with the engine design, which includes area (A28 and A29) and duct Mach numbers.

```
      $D(1),IDES=1,
      $O(1),IDES=1,
      PRFDS=2.5,PRCDS=10,WAFCDS=500,WACCDS=100,ALTP=0,AM=0,IGASMX=0,AM23=.15,
      FAN=.TRUE.,ISPOOL=2,DPDUDS=.02,
      *   SEPARATE FLOW TURBOFAN ENGINE--DESIGN CASE

FAN DESIGN              PRFCF= 0.37500000E+01 ETAFCF= 0.94204545E+00  WAFCF= 0.83333334E+00   T2DS= 0.51866820E+03

COMPRESSOR DESIGN       PRCCF= 0.12857143E+01 ETACCF= 0.98837209E+00  WACCF= 0.10000000E+01  T21DS= 0.70574329E+03

COMBUSTER DESIGN       WA3CDS= 0.19974841E+02 ETABCF= 0.98500000E+00 DTJDCF= 0.10000000E+01

H.P. TURBINE DESIGN    CNHPCF= 0.11419282E+01 TFHPCF= 0.15210490E+01 ETHPCF= 0.10000000E+01 DHHPCF= 0.10CE9C18E+01

L.P. TURBINE DESIGN    CNLPCF= 0.11782237E+01 TFLPCF= 0.14620719E+01 ETLPCF= 0.10235344E+01 DHLPCF= 0.249E7145E+01

DUCT NOZZLE DESIGN       A28= 0.27472096E+01   AM28= 0.10000000E+01    A29= 0.27472096E+01   AM29= 0.100C000CE+01

TURBINE AREA DESIGN      A55= 0.64546229E+01   AM55= 0.23825740E+00

AFTERBURNER DESIGN     WG6CDS= 0.27906742E+04

NOZZLE DESIGN            A8= 0.26471373E+01    AM8= 0.10000000E+01     A9= 0.26471373E+01    AM9= 0.100C000CE+01

OUTPUT                  AM=  0.          ALTP=      0.          T4= 3260.00                              ETAR= 1.0000
                         PCNF                CNF                 ZF                  PRF                 WAFC                WAF
                       0.100000E+03        0.100000E+01        0.833333E+00        0.250000E+01        0.500000E+03        0.50000CE+03
                         PCNC                CNC                 ZC                  PRC                 WACC                WAC
                       0.100000E+03        0.100000E+01        0.814332E+00        0.100000E+02        0.100000E+03        0.214319E+03
                         T2                  P2                  T21                 P21                 T3                  P3
                       0.518668E+03        0.100000E+01        0.705743E+03        0.250000E+01        0.143796E+04        0.25000CE+02
                         PCBLF               BLF                 PCBLC               BLC                 PCBLOB              BLOB
                       0.                  0.                  0.970000E-01        0.207890E+02        0.                  0.
                         PCBLHP              BLHP                PCBLLP              BLLP                T4                  P4
                       0.                  0.                  0.100000E+01        0.207890E+02        0.326000E+04        0.23600CE+02
                         WA3                 WFB                 WG4                 FAR4                ETAB                DPCOM
                       0.193530E+03        0.614714E+01        0.199678E+03        0.317632E-01        0.985000E+00        0.56000CE-01
                         TFFHP               CNHP                DHTCHP              DHTC                T5                  P5
                       0.328721E+02        0.175142E+01        0.600000E-01        0.197341E+03        0.262422E+04        0.782808E+01
                         TFFLP               CNLP                DHTCLP              DHTF                T55                 P55
                       0.889149E+02        0.195209E+01        0.171750E-01        0.112529E+03        0.218109E+04        0.368952E+01
                         PCBLDU              BLDU                T24                 P24                 T25                 P25
                       0.                  0.                  0.705743E+03        0.245000E+01        0.705743E+03        0.245000E+01
                         WAD                 WFD                 WG24                FAR24               ETAD                DPDUC
                       0.285681E+03        0.                  0.285681E+03        0.                  0.                  0.20000CE-01
                         ETAF                ETAC                ETATHP              ETATLP              AM55                AM25
                       0.829000E+00        0.850000E+00        0.900000E+00        0.903000E+00        0.238257E+00        0.157446E+00
                         T6                  P6                  PS6                 AM6                 V6                  WG6
                       0.218104E+04        0.368952E+01        0.355616E+01        0.238257E+00        0.524239E+03        0.220466E+03
                         T7                  WFA                 WG7                 FAR7                ETAA                DPAFT
                       0.218109E+04        0.                  0.220466E+03        0.285822E-01        0.                  0.480000E-01
                         PS8                 AM8                 V8                  PS9                 AM9                 V9
                       0.192429E+01        0.100000E+01        0.206441E+04        0.192429E+01        0.100000E+01        0.206441E+04
                         PS28                AM28                V28                 PS29                AM29                V29
                       0.129756E+01        0.100000E+01        0.118926E+04        0.129756E+01        0.100000E+01        0.118926E+04
                         BYPASS              HPEXT               WFT                 WGT                 VA                  FRD
                       0.133297E+01        0.                  0.614714E+01        0.506147E+03        0.                  0.
                         CVMNOZ              VJM                 CVDNOZ              VJD                 FGM                 FGP
                       0.963650E+00        0.199971E+04        0.978768E+00        0.115401E+04        0.240381E+05        0.690771E+04

MAIN SONIC CONVERGENT NOZZLE          FG= 30945.83                FN= 30945.83                SFC= 0.71511
DUCT SONIC CONVERGENT NOZZLE

CONVERGED AFTER   1 LOOPS
```

```
COMMON          0.833333E+00  0.100000E+03 -0.000000E-19 -0.000000E-19  0.814332E+00  0.100000E+03  0.326000E+04  0
 0.100000E+03  0.100000E+03  0.326000E+04  0.100000E+03  0.           0.100000E+01  0.100000E+01  0.100000E+01
 0.833333E+00  0.100000E+03  0.250000E+01  0.829000E+00  0.500000E+03  0.375000E+01  0.942045E+00  0.833333E+00
 0.814332E+00  0.100000E+03  0.100000E+02  0.850000E+00  0.214319E+03  0.128571E+01  0.988372E+00  0.100000E+01
 0.326000E+04  0.           0.182204E+04  0.985000E+00  0.199748E+02  0.560000E-01  0.100000E+01  0.985000E+00
 0.500000E+02  0.200000E+01  0.900000E+00  0.152105E+01  0.114193E+01  0.100000E+01  0.100890E+01  0.518668E+03
 0.130000E+03  0.230000E+01  0.903000E+00  0.146207E+01  0.117822E+01  0.102353E+01  0.249671E+01  0.705743E+03
 0.           0.           0.           0.           0.303574E+04  0.200000E-01  0.           0.
 0.356000E+04  0.           0.           0.900000E+00  0.279067E+04  0.480000E-01  0.           0.
 0.645462E+01  0.           0.645462E+01  0.645462E+01  0.264714E+01  0.264714E+01  0.274721E+01  0.274721E+01
 0.355615E+01  0.238257E+00  0.978768E+00  0.968658E+00  0.           0.           0.           0.

 0.518670E+03  0.100000E+01  0.123918E+03  0.159103E+01  0.518668E+03  0.100000E+01  0.123918E+03  0.159103E+01
 0.705743E+03  0.250000E+01  0.168857E+03  0.160216E+01  0.143796E+04  0.250000E+02  0.352717E+03  0.162209E+01
 0.326000E+04  0.236000E+02  0.907906E+03  0.187798E+01  0.262422E+04  0.782808E+01  0.710565E+03  0.188645E+01
 0.218109E+04  0.368952E+01  0.574903E+03  0.188086E+01  0.           0.207890E+02  0.           0.
 0.100000E+01  0.250000E+01  0.829000E+00  0.500000E+03  0.500000E+03  0.193530E+03  0.199678E+03  0.317632E-01
 0.100000E+01  0.100000E+02  0.850000E+00  0.100000E+03  0.214319E+03  0.985000E+00  0.560000E-01  0.
 0.200000E+01  0.900000E+00  0.605341E-01  0.197341E+03  0.           0.199678E+03  0.317632E-01  0.111699E+04
 0.230000E+01  0.903000E+00  0.428810E-01  0.112529E+03  0.207890E+02  0.220466E+03  0.286822E-01  0.
 0.           0.           0.100000E+01  0.833333E+00  0.100000E+03  0.814332E+00  0.100000E+03  0.614714E+01
 0.500000E+02  0.130000E+03  0.           0.970000E-01  0.           0.           0.           0.100000E+01

 0.100000E+01  0.300000E+03  0.214319E+03  0.           0.           0.352717E+03  0.           0.
 0.705743E+03  0.250000E+01  0.168857E+03  0.160216E+01  0.705743E+03  0.250000E+01  0.168857E+03  0.160216E+01
 0.705743E+03  0.245000E+01  0.168857E+03  0.160355E+01  0.705743E+03  0.245000E+01  0.168857E+03  0.160355E+01
 0.705743E+03  0.245000E+01  0.168857E+03  0.160355E+01  0.705743E+03  0.245000E+01  0.168857E+03  0.160355E+01
 0.285681E+03  0.           0.285681E+03  0.           0.           0.200000E-01  0.133297E+01  0.
 0.588488E+03  0.129756E+01  0.118926E+04  0.100000E+01  0.588488E+03  0.129756E+01  0.118926E+04  0.100000E+01

 0.218109E+04  0.368952E+01  0.574903E+03  0.188086E+01  0.705743E+03  0.245000E+01  0.168857E+03  0.160355E+01
 0.614714E+01  0.220466E+03  0.286822E-01  0.           0.285681E+03  0.           0.100000E+01  0.
 0.218109E+04  0.368952E+01  0.574903E+03  0.188086E+01  0.218109E+04  0.351242E+01  0.574905E+03  0.188423E+01
 0.218109E+04  0.351242E+01  0.574905E+03  0.188423E+01  0.218109E+04  0.351242E+01  0.574905E+03  0.188423E+01
 0.220466E+03  0.           0.220466E+03  0.286822E-01  0.           0.480000E-01  0.524239E+03  0.
 0.355615E+01  0.524239E+03  0.238257E+00  0.216058E+04  0.337259E+01  0.552311E+03  0.251121E+00  0.157446E+00
 0.188980E+04  0.192429E+01  0.206441E+04  0.100000E+01  0.188980E+04  0.192429E+01  0.206441E+04  0.100000E+01
 0.           0.           0.116401E+04  0.103355E+05  0.199971E+04  0.137026E+05  0.172992E+04  0.517779E+04
 0.240361E+05  0.690771E+04  0.614714E+01  0.506147E+03  0.122943E-01  0.309458E+05  0.309458E+05  0.715112E+00
```

Off-design. - The following are the off-design cases for the separate-flow turbofan engine.

Case 1: The engine is operating at Mach 2.5 at an altitude of 50 000 feet. The engine components are matched, with the duct and primary nozzle throat areas (A28 and A8) equal to the sea-level-static design value. This is a setup case for matching components only. However, note the very low thrust of the turbofan engine at this flight condition because the ram drag FRD is nearly equal to the gross thrust of the two streams FG.

```
    $D(1),AM=2.5,ALTP=50000,       #1
    #   OFF DESIGN OPERATION AT MAX T4 (SETUP CASE)

OUTPUT              AM=  2.500       ALTP= 50000.          T4= 3260.00                          ETAR= 0.8703
                     PCNF             CNF              ZF               PRF              WAFC             WAF
                    0.709714E+02     0.546211E+00     0.652696E+00     0.141563E+01     0.254159E+03     0.333068E+03
                     PCNC             CNC              ZC               PRC              WACC             WAC
                    0.792542E+02     0.670088E+00     0.657516E+00     0.479978E+01     0.574781E+02     0.100423E+03
                     T2               P2               T21              P21              T3               P3
                    0.875661E+03     0.170275E+01     0.987251E+03     0.241047E+01     0.179093E+04     0.115697E+02
                     PCBLF            BLF              PCBLC            BLC              PCBLOB           BLOB
                    0.               0.               0.970000E-01     0.974107E+01     0.               0.
                     PCBLHP           BLHP             PCBLLP           BLLP             T4               P4
                    0.               0.               0.100000E+01     0.974107E+01     0.326000E+04     0.108562E+02
                     WA3              WFB              WG4              FAR4             ETAB             DPCOM
                    0.906823E+02     0.248834E+01     0.931707E+02     0.274401E-01     0.985000E+00     0.616665E-01
                     TFFHP            CNHP             DHTCHP           DHTC             T5               P5
                    0.333433E+02     0.138808E+01     0.607172E-01     0.199384E+03     0.261240E+04     0.332216E+01
                     TFFLP            CNLP             DHTCLP           DHTF             T55              P55
                    0.975392E+02     0.138856E+01     0.150943E-01     0.984124E+02     0.223271E+04     0.173915E+01
                     PCBLDU           BLDU             T24              P24              T25              P25
                    0.               0.               0.987251E+03     0.236231E+01     0.987251E+03     0.236231E+01
                     WAD              WFD              WG24             FAR24            ETAD             DPDUC
                    0.232645E+03     0.               0.232645E+03     0.               0.               0.199789E-01
                     ETAF             ETAC             ETATHP           ETATLP           AM55             AM25
                    0.796334E+00     0.715568E+00     0.855728E+00     0.912016E+00     0.238583E+00     0.158118E+00
                     T6               P6               PS6              AM6              V6               WG6
                    0.223271E+04     0.173915E+01     0.167855E+01     0.238583E+00     0.531377E+03     0.102912E+03
                     T7               WFA              WG7              FAR7             ETAA             DPAFT
                    0.223271E+04     0.               0.102912E+03     0.247785E-01     0.               0.480925E-01
                     PS8              AM8              V8               PS9              AM9              V9
```

```
                0.908306E+00   0.100000E+01   0.208880E+04   0.908306E+00   0.100000E+01   0.20888CE+04
                  PS28           AM28           V28            PS29           AM29           V29
                0.125681E+01   0.100000E+01   0.140492E+04   0.125681E+01   0.100000E+01   0.140492E+04
                  BYPASS         HPEXT          WFT            WGT            VA             FRD
                0.231664E+01   0.             0.248834E+01   0.335557E+03   0.242123E+04   0.250648E+05
                  CVMNOZ         VJM            CVDNOZ         VJD            FGM            FGP
                0.878349E+00   0.183469E+04   0.852815E+00   0.119813E+04   0.145319E+05   0.110884E+05

MAIN SONIC CONVERGENT NOZZLE          FG= 25620.31                  FN=   555.53                SFC=16.12516
DUCT SONIC CONVERGENT NOZZLE

CONVERGED AFTER  34 LOOPS
```

Case 2: The same flight condition and engine operation is shown in this case as in case 1 because it is a continuation of the previous setup case. However, the engine is now duct burning. Therefore T24, IDBURN, and ETAD must be input. The duct burner does not have a performance map included in the subprogram as was the situation with the afterburner. Consequently, every duct-burning case requires the input of the burner efficiency (ETAD) and the control card (IDBURN = 1) in order to operate.

A new throat area (A28) is calculated reflecting the change in temperature, pressure, and mass flow of the gas in order that the nozzle is sonic. The value of A8 remains at the design value unless it is altered with a separate input. A permanent change in A8 would require a new setup case prior to running a duct-burning case.

```
     $DC11,T24=3460,ETAD=.90,IDBURN=1,
     *   OFF DESIGN OPERATION WITH DUCTBURNING

DUCT NOZZLE DESIGN          A28= 0.58485843E+01   AM28= 0.10000000E+01    A29= 0.18051276E+02   AM29= 0.25474720E+01

ARATIO=  3.086     OUT OF RANGE,USE DATA FOR   2.150

OUTPUT                  AM=  2.500        ALTP= 50000.          T4= 3260.00        T24= 3460.00        ETAR= 0.8703
                          PCNF             CNF              ZF               PRF              WAFC             WAF
                        0.709714E+02   0.546211E+00   0.652696E+00   0.141563E+01   0.254159E+03   0.333068E+03
                          PCNC             CNC              ZC               PRC              WACC             WAC
                        0.792542E+02   0.670088E+00   0.657516E+00   0.479978E+01   0.574781E+02   0.100423E+03
                          T2               P2               T21              P21              T3               P3
                        0.875661E+03   0.170275E+01   0.987251E+03   0.241047E+01   0.170093E+04   0.115697E+02
                          PCBLF            BLF              PCBLC            BLC              PCBLOB           BLOB
                        0.             0.             0.970000E-01   0.974107E+01   0.             0.
                          PCBLHP           BLHP             PCBLLP           BLLP             T4               P4
                        0.             0.             0.100000E+01   0.974107E+01   0.326000E+04   0.108562E+02
                          WA3              WFB              WG4              FAR4             ETAB             DPCOM
                        0.906823E+02   0.248834E+01   0.931707E+02   0.274401E-01   0.985000E+00   0.616665E-01
                          TFFHP            CNHP             DHTCHP           DHTC             T5               P5
                        0.333433E+02   0.138808E+01   0.607172E-01   0.199384E+03   0.261240E+04   0.332216E+01
                          TFFLP            CNLP             DHTCLP           DHTF             T55              P55
                        0.975392E+02   0.138856E+01   0.150943E-01   0.984124E+02   0.223271E+04   0.173915E+01
                          PCBLDU           BLDU             T24              P24              T25              P25
                        0.             0.             0.346000E+04   0.224230E+01   0.346000E+04   0.224230E+01
                          WA0              WFD              WG24             FAR24            ETAD             DPDUC
                        0.232645E+03   0.109448E+02   0.243590E+03   0.470450E-01   0.900000E+00   0.199789E-01
                          ETAF             ETAC             ETATHP           ETATLP           AM55             AM25
                        0.796334E+00   0.715568E+00   0.855728E+00   0.912016E+00   0.238583E+00   0.268149E+07
                          T6               P6               PS6              AM6              V6               WG6
                        0.223271E+04   0.173915E+01   0.167855E+01   0.238583E+00   0.531377E+03   0.102912E+03
                          T7               WFA              WG7              FAR7             ETAA             DPAFT
                        0.223271E+04   0.             0.102912E+03   0.247785E-01   0.             0.480924E-01
                          PS8              AM8              V8               PS9              AM9              V9
                        0.908306E+00   0.100000E+01   0.208880E+04   0.908306E+00   0.100000E+01   0.208880E+04
                          PS28             AM28             V28              PS29             AM29             V29
                        0.124170E+01   0.100000E+01   0.258242E+04   0.114456E+00   0.254747E+01   0.510859E+04
                          BYPASS           HPEXT            WFT              WGT              VA               FRD
                        0.231664E+01   0.             0.134331E+02   0.346501E+03   0.242123E+04   0.250648E+05
                          CVMNOZ           VJM              CVDNOZ           VJD              FGM              FGP
                        0.878349E+00   0.183469E+04   0.965722E+00   0.493348E+04   0.432198E+05   0.444708E+04

MAIN SONIC CONVERGENT NOZZLE          FG= 47666.88                  FN= 22602.09                SFC= 2.13959
DUCT SHOCK OUTSIDE C-D NOZZLE

CONVERGED AFTER   1 LOOPS
```

Mixed-Flow Turbofan

Design point. - A mixed-flow turbofan engine is designed by using the input IGASMX = 1 and resetting the AM and ALTP to the desired value (sea-level-static in the example). This output listing shows the rebalancing of the fan and inner compressor pressure ratio to a value such that the static pressures at stations 25 and 55 will match. The overall compressor pressure ratio remains fixed. The values of the combination are not necessarily the optimum values; but it does give an indication, for the selected design values, as to what combination can be considered. Once the static-pressure values are satisfied, the program operates in a normal design mode. The other input cards are those required for the afterburner design. These values of design efficiency and temperature must be input for the design case in order to scale the generalized afterburner map to the proper design conditions. The afterburning takes place in the completely mixed streams - similar to an afterburning turbojet. The mixed-flow turbofan engine uses a single exhaust nozzle. The design areas are then printed out for this type of operation.

```
$D(1),IDES=1, #1
$D(1),IDES=1,
AM=0,ALTP=0,IGASMX=1, # MIXED FLOW TURBOFAN - DESIGN CASE
T7DS=3460,ETAADS=.89,AM6=.15,DPAPDS=.05, # AFTERBURNER DESIGN VALUES
FAN DESIGN              PRFCF= 0.37500000E+01 ETAFCF= 0.94204545E+00  WAFCF= 0.83333334E+00   T2DS= 0.51866820E+03
COMPRESSOR DESIGN       PRCCF= 0.12857143E+01 ETACCF= 0.98837209E+00  WACCF= 0.10000000E+01  T21DS= 0.70574329E+03
COMBUSTER DESIGN       WA3CDS= 0.19974841E+02 ETABCF= 0.98500000E+00 DTCDCF= 0.10000000E+01
H.P. TURBINE DESIGN    CNHPCF= 0.11419282E+01 TFHPCF= 0.15210490E+01 ETHPCF= 0.10000000E+01 DHHPCF= 0.10089018E+01
L.P. TURBINE DESIGN    CNLPCF= 0.11782237E+01 TFLPCF= 0.14620719E+01 ETLPCF= 0.10235344E+01 DHLPCF= 0.24967145E+01
CHANGE PRFDS FROM    2.500  TO    3.701  AND PRCDS FROM    10.000  TO     6.754
FAN DESIGN              PRFCF= 0.67532611E+01 ETAFCF= 0.94204545E+00  WAFCF= 0.83333334E+00   T2DS= 0.51866820E+03
COMPRESSOR DESIGN       PRCCF= 0.82205365E+00 ETACCF= 0.98837209E+00  WACCF= 0.10000000E+01  T21DS= 0.80123660E+03
COMBUSTER DESIGN       WA3CDS= 0.27828602E+02 ETABCF= 0.98500000E+00 DTCDCF= 0.10000000E+01
H.P. TURBINE DESIGN    CNHPCF= 0.11419282E+01 TFHPCF= 0.10948068E+01 ETHPCF= 0.10000000E+01 DHHPCF= 0.89296639E+00
L.P. TURBINE DESIGN    CNLPCF= 0.11947035E+01 TFLPCF= 0.11955020E+01 ETLPCF= 0.10235344E+01 DHLPCF= 0.26482349E+01
CHANGE PRFDS FROM    2.500  TO    4.057  AND PRCDS FROM    10.000  TO     6.163
FAN DESIGN              PRFCF= 0.76415902E+01 ETAFCF= 0.94204545E+00  WAFCF= 0.83333334E+00   T2DS= 0.51866820E+03
COMPRESSOR DESIGN       PRCCF= 0.73753452E+00 ETACCF= 0.98837209E+00  WACCF= 0.10000000E+01  T21DS= 0.82458885E+03
COMBUSTER DESIGN       WA3CDS= 0.30070055E+02 ETABCF= 0.98500000E+00 DTCDCF= 0.10000000E+01
H.P. TURBINE DESIGN    CNHPCF= 0.11419282E+01 TFHPCF= 0.10136263E+01 ETHPCF= 0.10000000E+01 DHHPCF= 0.86269610E+00
L.P. TURBINE DESIGN    CNLPCF= 0.11989344E+01 TFLPCF= 0.11433495E+01 ETLPCF= 0.10235344E+01 DHLPCF= 0.26415626E+01
CHANGE PRFDS FROM    2.500  TO    4.215  AND PRCDS FROM    10.000  TO     5.931
FAN DESIGN              PRFCF= 0.80373937E+01 ETAFCF= 0.94204545E+00  WAFCF= 0.83333334E+00   T2DS= 0.51866820E+03
COMPRESSOR DESIGN       PRCCF= 0.70446542E+00 ETACCF= 0.98837209E+00  WACCF= 0.10000000E+01  T21DS= 0.83507622E+03
COMBUSTER DESIGN       WA3CDS= 0.31058852E+02 ETABCF= 0.98500000E+00 DTCDCF= 0.10000000E+01
H.P. TURBINE DESIGN    CNHPCF= 0.11419282E+01 TFHPCF= 0.98150524E+00 ETHPCF= 0.10000000E+01 DHHPCF= 0.84959365E+00
L.P. TURBINE DESIGN    CNLPCF= 0.12007443E+01 TFLPCF= 0.11225456E+01 ETLPCF= 0.10235344E+01 DHLPCF= 0.26351416E+01
TURBINE/DUCT AREA DESIGN   A55= 0.87603192E+01   AM55= 0.23825511E+00    A25= 0.10494306E+02   AM25= 0.57661657E-01
AFTERBURNER DESIGN     WG6CDS= 0.51521512E+04
NOZZLE DESIGN              A8= 0.48660238E+01    AM8= 0.10000000E+01     A9= 0.48660238E+01    AM9= 0.10000000E+01
```

```
OUTPUT                  AM=  0.          ALTP=      0.          T4= 3260.00                              ETAR= 1.0000
                         PCNF             CNF              ZF              PRF             WAFC             WAF
                      0.100000E+03    0.100000E+01    0.833333E+00    0.421496E+01    0.500000E+03    0.500000E+03
                         PCNC             CNC              ZC              PRC             WACC             WAC
                      0.100000E+03    0.100000E+01    0.814332E+00    0.593126E+01    0.100000E+03    0.332181E+03
                         T2               P2               T21             P21             T3               P3
                      0.518667E+03    0.100000E+01    0.835076E+03    0.421496E+01    0.144718E+04    0.250000E+02
                         PCBLF            BLF              PCBLC           BLC             PCBLOB           BLOB
                      0.              0.               0.970000E-01    0.322216E+02    0.              0.
                         PCBLHP           BLHP             PCBLLP          BLLP            T4               P4
                      0.              0.               0.100000E+01    0.322216E+02    0.326000E+04    0.236000E+02
                         WA3              WFB              WG4             FAR4            ETAB             DPCOM
                      0.299959E+03    0.948284E+01    0.309442E+03    0.316137E-01    0.985000E+00    0.560000E-01
                         TFFHP            CNHP             DHTCHP          DHTC            T5               P5
                      0.509427E+02    0.175142E+01    0.600000E-01    0.165259E+03    0.272550E+04    0.949214E+01
                         TFFLP            CNLP             DHTCLP          DHTF            T55              P55
                      0.115803E+03    0.191548E+01    0.171750E-01    0.123352E+03    0.224356E+04    0.427559E+01
                         PCBLDU           BLDU             T24             P24             T25              P25
                      0.              0.               0.835076E+03    0.413066E+01    0.835076E+03    0.413066E+01
                         WAD              WFD              WG24            FAR24           ETAD             DPDUC
                      0.167819E+03    0.              0.167819E+03    0.              0.              0.200000E-01
                         ETAF             ETAC             ETATHP          ETATLP          AM55             AM25
                      0.829000E+00    0.850000E+00    0.900000E+00    0.903000E+00    0.238255E+00    0.578617E-01
                         T6               P6               PS6             AM6             V6               WG6
                      0.181619E+04    0.421426E+01    0.415724E+01    0.143360E+00    0.290659E+03    0.509483E+03
                         T7               WFA              WG7             FAR7            ETAA             DPAFT
                      0.181619E+04    0.              0.509483E+03    0.189657E-01    0.              0.500000E-01
                         PS8              AM8              V8              PS9             AM9              V9
                      0.217954E+01    0.100000E+01    0.189038E+04    0.217954E+01    0.100000E+01    0.189038E+04
                         PS28             AM28             V28             PS29            AM29             V29
                      0.              0.               0.              0.              0.              0.
                         BYPASS           HPEXT            WFT             WGT             VA               FRD
                      0.505203E+00    0.              0.948284E+01    0.509483E+03    0.              0.
                         CVMNOZ           VJM              CVDNOZ          VJD             FGM              FGP
                      0.963159E+00    0.182074E+04    0.              0.              0.288318E+05    0.121464E+05

 MAIN SCNIC CONVERGENT NOZZLE          FG= 40978.13                     FN= 40978.13                     SFC= 0.83308

 CONVERGED AFTER   1 LOOPS


COMMON          0.833333E+00    0.100000E+03   -0.000000E-19   -0.000000E-19    0.814332E+00    0.100000E+03    0.326000E+04   0

   0.100000E+03    0.100000E+03    0.326000E+04    0.100000E+03    0.              0.100000E+01    0.100000E+01    0.100000E+01
   0.833333E+00    0.100000E+03    0.421496E+01    0.829000E+00    0.500000E+03    0.803739E+01    0.942045E+00    0.833333E+00
   0.814332E+00    0.100000E+03    0.593126E+01    0.850000E+00    0.332181E+03    0.704465E+00    0.988372E+00    0.100000E+01
   0.326000E+04    0.              0.181282E+04    0.985000E+00    0.310589E+02    0.560000E-01    0.100000E+01    0.985000E+00
   0.500000E+02    0.200000E+01    0.900000E+00    0.981505E+00    0.114193E+01    0.100000E+01    0.849994E+00    0.518668E+03
   0.130000E+03    0.230000E+01    0.903000E+00    0.112255E+01    0.120074E+01    0.102353E+01    0.263514E+01    0.835076E+03
   0.              0.              0.              0.              0.115056E+04    0.200000E-01    0.              0.
   0.346000E+04    0.              0.              0.890000E+00    0.515215E+04    0.500000E-01    0.              0.
   0.876032E+01    0.104943E+02    0.192546E+02    0.192546E+02    0.486602E+01    0.486602E+01    0.              0.
   0.412124E+01    0.238255E+00    0.              0.963159E+00    0.              0.              0.              0.

   0.518670E+03    0.100000E+01    0.123918E+03    0.159103E+01    0.518668E+03    0.100000E+01    0.123918E+03    0.159103E+01
   0.835076E+03    0.421496E+01    0.200259E+03    0.160719E+01    0.144718E+04    0.250000E+02    0.355137E+03    0.162376E+01
   0.326000E+04    0.236000E+02    0.907719E+03    0.187788E+01    0.272550E+04    0.949214E+01    0.741460E+03    0.188473E+01
   0.224356E+04    0.427559E+01    0.593308E+03    0.187903E+01    0.              0.322216E+02    0.              0.
   0.100000E+01    0.421496E+01    0.829000E+00    0.500000E+03    0.500000E+03    0.299959E+03    0.309442E+03    0.316137E-01
   0.100000E+01    0.593126E+01    0.850000E+00    0.100000E+03    0.332181E+03    0.985000E+00    0.560000E-01    0.
   0.200000E+01    0.900000E+00    0.509996E-01    0.166259E+03    0.              0.309442E+03    0.316137E-01    0.111699E+04
   0.230000E+01    0.903000E+00    0.452585E-01    0.123352E+03    0.322216E+02    0.341664E+03    0.285472E-01    0.
   0.              0.              0.100000E+01    0.833333E+00    0.100000E+03    0.814332E+00    0.100000E+03    0.948284E+01
   0.500000E+02    0.130000E+03    0.              0.970000E-01    0.              0.              0.              0.100000E+01

   0.100000E+01    0.500000E+03    0.332181E+03    0.              0.              0.355137E+03    0.              0.
   0.835076E+03    0.421496E+01    0.200259E+03    0.160719E+01    0.835076E+03    0.421496E+01    0.200259E+03    0.160719E+01
   0.835076E+03    0.413066E+01    0.200259E+03    0.160858E+01    0.835076E+03    0.413066E+01    0.200259E+03    0.160858E+01
   0.              0.              0.              0.              0.              0.              0.              0.
   0.167819E+03    0.              0.167819E+03    0.              0.              0.200000E-01    0.505203E+00    0.
   0.              0.              0.              0.              0.              0.              0.              0.

   0.224356E+04    0.427559E+01    0.593308E+03    0.187903E+01    0.835076E+03    0.413066E+01    0.200259E+03    0.160858E+01
   0.948284E+01    0.341664E+03    0.285472E-01    0.              0.167819E+03    0.              0.100000E+01    0.
   0.181619E+04    0.421426E+01    0.463844E+03    0.181456E+01    0.181619E+04    0.400355E+01    0.463844E+03    0.181808E+01
   0.181619E+04    0.400355E+01    0.463844E+03    0.181808E+01    0.181619E+04    0.400355E+01    0.463844E+03    0.181808E+01
   0.509483E+03    0.              0.509483E+03    0.189657E-01    0.              0.500000E-01    0.531343E+03    0.816543E+02
   0.415724E+01    0.290659E+03    0.143360E+00    0.181019E+04    0.394954E+01    0.306344E+03    0.151095E+00    0.578617E-01
   0.155960E+04    0.217954E+01    0.189038E+04    0.100000E+01    0.155960E+04    0.217954E+01    0.189038E+04    0.100000E+01
   0.              0.              0.              0.              0.182074E+04    0.288318E+05    0.              0.121464E+05
   0.288318E+05    0.121464E+05    0.948284E+01    0.509483E+03    0.189657E-01    0.409781E+05    0.409781E+05    0.833084E+00
```

Off-design. - The following are off-design cases for the mixed-flow turbofan.

Case 1: The off-design case was selected to be supersonic Mach number (2.5) at 50 000 feet altitude. Case 1 illustrates a setup case for the afterburning case (case 2) which follows immediately after. Since the engine is operating at the design T4, the only input cards required are the AM and ALTP cards.

```
$D(1),AM=2.5,ALTP=50000,   $1
*   OFF DESIGN OPERATION AT MAX T4 (SETUP CASE)

CUTPUT          AM=  2.500      ALTP= 50000.      T4= 3260.00                    ETAR= 0.8703
                  PCNF            CNF             ZF              PRF             WAFC            WAF
                0.563944E+02    0.434023E+00    0.435777E+00    0.140745E+01    0.222610E+03    0.291724E+03
                  PCNC            CNC             ZC              PRC             WACC            WAC
                0.856482E+02    0.786044E+00    0.696801E+00    0.370696E+01    0.683886E+02    0.118544E+03
                  T2              P2              T21             P21             T3              P3
                0.875661E+03    0.170275E+01    0.991445E+03    0.239654E+01    0.153061E+04    0.888387E+01
                  PCBLF           BLF             PCBLC           BLC             PCBLOB          BLOB
                0.              0.              0.970000E-01    0.114987E+02    0.              0.
                  PCBLHP          BLHP            PCBLLP          BLLP            T4              P4
                0.              0.              0.100000E+01    0.114987E+02    0.326000E+04    0.837006E+01
                  WA3             WFB             WG4             FAR4            ETAB            DPCOM
                0.107045E+03    0.323859E+01    0.110283E+03    0.302545E-01    0.985000E+00    0.578362E-01
                  TFFHP           CNHP            DHTCHP          DHTC            T5              P5
                0.511908E+02    0.150006E+01    0.538222E-01    0.148746E+03    0.278122E+04    0.369848E+01
                  TFFLP           CNLP            DHTCLP          DHTF            T55             P55
                0.107005E+03    0.106935E+01    0.103248E-01    0.755756E+02    0.244645E+04    0.231426E+01
                  PCBLDU          BLDU            T24             P24             T25             P25
                0.              0.              0.991445E+03    0.230175E+01    0.991445E+03    0.230175E+01
                  WAD             WFD             WG24            FAR24           ETAD            DPDUC
                0.173180E+03    0.              0.173180E+03    0.              0.              0.395519E-01
                  ETAF            ETAC            ETATHP          ETATLP          AM55            AM25
                0.753899E+00    0.773388E+00    0.889117E+00    0.889316E+00    0.161228E+00    0.117851E+00
                  T6              P6              PS6             AM5             V6              WG6
                0.163458E+04    0.230603E+01    0.227469E+01    0.143137E+00    0.276685E+03    0.294962E+03
                  T7              WFA             WG7             FAR7            ETAA            DPAFT
                0.163458E+04    0.              0.294962E+03    0.111016E-01    0.              0.501864E-01
                  PS8             AM8             V8              PS9             AM9             V9
                0.118688E+01    0.100000E+01    0.179734E+04    0.118688E+01    0.100000E+01    0.179734E+04
                  PS28            AM28            V28             PS29            AM29            V29
                0.              0.              0.              0.              0.              0.
                  BYPASS          HPEXT           WFT             WGT             VA              FRD
                0.146090E+01    0.              0.323859E+01    0.294962E+03    0.242123E+04    0.219534E+05
                  CVMNOZ          VJM             CVDNOZ          VJD             FGM             FGP
                0.858472E+00    0.154296E+04    0.              0.              0.141454E+05    0.110434E+05

MAIN SCNIC CONVERGENT NOZZLE    FG= 25188.82                    FN=  3235.39                    SFC= 3.6C356

CONVERGED AFTER  21 LOOPS
```

Case 2: The previous setup case is used here for an afterburning example. Values of afterburner efficiency ETAA, pressure loss DPAFT, and Mach number AM6 indicate values selected from the afterburner performance map at off-design. The expanded nozzle areas are shown; a printout indicating that a nozzle having a greater expansion ratio than the convergent-divergent nozzle map used would have been more optimum (instead of 2.150). Consequently, a slight loss in velocity coefficient due to an under-expanded nozzle occurred.

```
$D(1), T7=3460,IAFTBN=1, *  AFTERBURNING CASE

NOZZLE DESIGN          A8= 0.76637719E+01    AM8= 0.10000000E+01    A9= 0.23089376E+02    AM9= 0.25228365E+01

ARATIO=  3.013    OUT OF RANGE,USE DATA FOR   2.150

OUTPUT          AM=  2.500      ALTP= 50000.      T4= 3260.00     T7= 3460.00     ETAR= 0.8703
                  PCNF            CNF             ZF              PRF             WAFC            WAF
                0.563944E+02    0.434023E+00    0.435777E+00    0.140745E+01    0.222610E+03    0.291724E+03
                  PCNC            CNC             ZC              PRC             WACC            WAC
                0.856482E+02    0.786044E+00    0.696801E+00    0.370696E+01    0.683886E+02    0.118544E+03
                  T2              P2              T21             P21             T3              P3
                0.875661E+03    0.170275E+01    0.991445E+03    0.239654E+01    0.153061E+04    0.888387E+01
                  PCBLF           BLF             PCBLC           BLC             PCBLOB          BLOB
                0.              0.              0.970000E-01    0.114987E+02    0.              0.
                  PCBLHP          BLHP            PCBLLP          BLLP            T4              P4
                0.              0.              0.100000E+01    0.114987E+02    0.326000E+04    0.837006E+01
                  WA3             WFB             WG4             FAR4            ETAB            DPCOM
                0.107045E+03    0.323859E+01    0.110283E+03    0.302545E-01    0.985000E+00    0.578362E-01
                  TFFHP           CNHP            DHTCHP          DHTC            T5              P5
                0.511908E+02    0.150006E+01    0.538222E-01    0.148746E+03    0.278122E+04    0.369848E+01
                  TFFLP           CNLP            DHTCLP          DHTF            T55             P55
                0.107005E+03    0.106935E+01    0.103248E-01    0.755756E+02    0.244645E+04    0.231426E+01
                  PCBLDU          BLDU            T24             P24             T25             P25
                0.              0.              0.991445E+03    0.230175E+01    0.991445E+03    0.230175E+01
                  WAD             WFD             WG24            FAR24           ETAD            DPDUC
                0.173180E+03    0.              0.173180E+03    0.              0.              0.395519E-01
                  ETAF            ETAC            ETATHP          ETATLP          AM55            AM25
                0.753899E+00    0.773388E+00    0.889117E+00    0.889316E+00    0.161228E+00    0.117851E+00
```

```
                T6              P6              PS6             AM5             V6              WG6
              0.163458E+04    0.230603E+01    0.227468E+01    0.143137E+00    0.276685E+03    0.294962E+03
                T7              WFA             WG7             FAR7            ETAA            DPAFT
              0.346000E+04    0.109850E+02    0.305947E+03    0.487570E-01    0.774686E+00    0.501864E-01
                PS8             AM8             V8              PS9             AM9             V9
              0.119096E+01    0.100000E+01    0.258203E+04    0.114456E+00    0.252284E+01    0.508533E+04
                PS28            AM28            V28             PS29            AM29            V29
              0.              0.              0.              0.              0.              0.
                BYPASS          HPEXT           WFT             WGT             VA              FRD
              0.146096E+01    0.              0.142236E+02    0.305947E+03    0.242123E+04    0.219534E+05
                CVMNOZ          VJM             CVDNOZ          VJD             FGM             FGP
              0.966656E+00    0.491576E+04    0.              0.              0.467446E+05    0.

MAIN SHOCK OUTSIDE C-D NOZZLE          FG= 46744.62                    FN= 24791.19                    SFC= 2.06544

CONVERGED AFTER   1 LOOPS
```

Design case without pressure ratio rematch. - The mixed-flow turbofan engine is shown again. However, the design fan and compressor pressure ratios were picked such that no rematch was required to balance the static pressures. This is another design case. As many design cases as desired can be run in succession. Care must always be taken to include the variables in input that need to be changed from the previous design case.

```
     $D(1),IDES=1,
     $D(1),IDES=1,
     PRFDS=5.0,PRCDS=5.0,AM=0,ALTP=0,# MIXED FLOW TURBOFAN WITHOUT REQUIRED P REMATCH

FAN DESIGN                PRFCF= 0.10000000E+02 ETAFCF= 0.94204545E+00  WAFCF= 0.83333334E+00   T2DS= 0.51866820E+03

COMPRESSOR DESIGN         PRCCF= 0.57142857E+00 ETACCF= 0.98837209F+00  WACCF= 0.10000000E+01  T21DS= 0.88129484E+03

COMBUSTER DESIGN         WA3CDS= 0.35881686E+02 ETABCF= 0.98500000E+00 DTCOCF= 0.10000000E+01

H.P. TURBINE DESIGN      CNHPCF= 0.11419282E+01 TFHPCF= 0.85001019E+00 ETHPCF= 0.10000000E+01 DHHPCF= 0.78992675E+00

L.P. TURBINE DESIGN      CNLPCF= 0.12091271E+01 TFLPCF= 0.10362098E+01 ETLPCF= 0.10235344E+01 DHLPCF= 0.25841324E+01

TURBINE/DUCT AREA DESIGN    A55= 0.93469959E+01   AM55= 0.23825344E+00     A25= 0.10994153E+01   AM25= 0.35644379E+00

AFTERBURNER DESIGN       WG6CDS= 0.48604900E+04

NOZZLE DESIGN                A8= 0.46035268E+01    AM8= 0.10000000E+01      A9= 0.46035268E+01    AM9= 0.10000000E+01

OUTPUT                   AM=  0.          ALTP=      0.          T4= 3260.00                          ETAR= 1.0000
                           PCNF            CNF             ZF              PRF             WAFC            WAF
                         0.100000E+03    0.100000E+01    0.833333E+00    0.500000E+01    0.500000E+03    0.500000E+03
                           PCNC            CNC             ZC              PRC             WACC            WAC
                         0.100000E+03    0.100000E+01    0.814332E+00    0.500000E+01    0.100000E+03    0.383577E+03
                           T2              P2              T21             P21             T3              P3
                         0.518668E+03    0.100000E+01    0.881300E+03    0.500000E+01    0.144858E+04    0.250000E+02
                           PCBLF           BLF             PCBLC           BLC             PCBLOB          BLOB
                         0.              0.              0.970000E-01    0.372070E+02    0.              0.
                           PCBLHP          BLHP            PCBLLP          BLLP            T4              P4
                         0.              0.              0.100000E+01    0.372070E+02    0.326000E+04    0.236000E+02
                           WA3             WFB             WG4             FAR4            ETAB            DPCOM
                         0.346370E+03    0.109422E+02    0.357312E+03    0.315911E-01    0.985000E+00    0.560000E-01
                           TFFHP           CNHP            DHTCHP          DHTC            T5              P5
                         0.588222E+02    0.175142E+01    0.600000E-01    0.154510E+03    0.276368E+04    0.101882E+02
                           TFFLP           CNLP            DHTCLP          DHTF            T55             P55
                         0.125457E+03    0.190220E+01    0.171750E-01    0.122659E+03    0.228157E+04    0.466804E+01
                           PCBLDU          BLDU            T24             P24             T25             P25
                         0.              0.              0.881300E+03    0.490000E+01    0.881300E+03    0.490000E+01
                           WAD             WFD             WG24            FAR24           ETAD            DPDUC
                         0.116423E+03    0.              0.116423E+03    0.              0.              0.200000E-01
                           ETAF            ETAC            ETATHP          ETATLP          AM55            AM25
                         0.929000E+00    0.850000E+00    0.900000E+00    0.903000E+00    0.238253E+00    0.356444E+00
                           T6              P6              PS6             AM6             V6              WG6
                         0.199038E+04    0.468986E+01    0.449153E+01    0.256683E+00    0.541234E+03    0.510942E+03
                           T7              WFA             WG7             FAR7            ETAA            DPAFT
                         0.199038E+04    0.              0.510942E+03    0.218844E-01    0.              0.500000E-01
                           PS8             AM8             V8              PS9             AM9             V9
                         0.243248E+01    0.100000E+01    0.197586E+04    0.243248E+01    0.100000E+01    0.197586E+04
                           PS28            AM28            V28             PS29            AM29            V29
                         0.              0.              0.              0.              0.              0.
                           BYPASS          HPEXT           WFT             WGT             VA              FRD
                         0.303516E+00    0.              0.109422E+02    0.510942E+03    0.              0.
                           CVMNOZ          VJM             CVDNOZ          VJD             FGM             FGP
                         0.957521E+00    0.189192E+04    0.              0.              0.300448E+05    0.139553E+05

MAIN SONIC CONVERGENT NOZZLE           FG= 44000.11                    FN= 44000.11                    SFC= 0.85527

CONVERGED AFTER   1 LOOPS
```

COMMON	0.833333E+00	0.100000E+03	-0.000000E-19	-0.000000E-19	0.814332E+00	0.100000E+03	0.326000E+04	0
0.100000E+03	0.100000E+03	0.326000E+04	0.100000E+03	0.	0.100000E+01	0.100000E+01	0.100000E+01	
0.833333E+00	0.100000E+03	0.500000E+01	0.829000E+00	0.500000E+03	0.100000E+02	0.942045E+00	0.833333E+00	
0.814332E+00	0.100000E+03	0.500000E+01	0.850000E+00	0.383577E+03	0.571429E+00	0.988372E+00	0.100000E+01	
0.326000E+04	0.	0.181142E+04	0.985000E+00	0.358817E+02	0.560000E-01	0.100000E+01	0.985000E+00	
0.500000E+02	0.200000E+01	0.900000E+00	0.850010E+00	0.114193E+01	0.100000E+01	0.789927E+00	0.518668E+03	
0.130000E+03	0.230000E+01	0.903000E+00	0.103621E+01	0.120913E+01	0.102353E+01	0.258413E+01	0.881300E+03	
0.	0.	0.	0.	0.691241E+03	0.200000E-01	0.	0.	
0.346000E+04	0.	0.	0.890000E+00	0.486049E+04	0.500000E-01	0.	0.	
0.934700E+01	0.109942E+01	0.104464E+02	0.104464E+02	0.460353E+01	0.460353E+01	0.	0.	
0.449964E+01	0.238253E+00	0.	0.957521E+00	0.	0.	0.	0.	
0.518670E+03	0.100000E+01	0.123918E+03	0.159103E+01	0.518668E+03	0.100000E+01	0.123918E+03	0.159103E+01	
0.881300E+03	0.500000E+01	0.211573E+03	0.160867E+01	0.144858E+04	0.250000E+02	0.355503E+03	0.162402E+01	
0.326000E+04	0.236000E+02	0.907691E+03	0.187786E+01	0.276368E+04	0.101882E+02	0.753181E+03	0.188413E+01	
0.228157E+04	0.466804E+01	0.604585E+03	0.187798E+01	0.	0.372070E+02	0.	0.	
0.100000E+01	0.500000E+01	0.829000E+00	0.500000E+03	0.500000E+03	0.346370E+03	0.357312E+03	0.315911E-01	
0.100000E+01	0.500000E+01	0.850000E+00	0.100000E+03	0.383577E+03	0.985000E+00	0.560000E-01	0.	
0.200000E+01	0.900000E+00	0.473956E-01	0.154510E+03	0.	0.357312E+03	0.315911E-01	0.111699E+04	
0.230000E+01	0.903000E+00	0.443824E-01	0.122659E+03	0.372070E+02	0.394519E+03	0.285267E-01	0.	
0.	0.	0.100000E+01	0.833333E+00	0.100000E+03	0.814332E+00	0.100000E+03	0.109422E+02	
0.500000E+02	0.130000E+03	0.	0.970000E-01	0.	0.	0.	0.100000E+01	
0.100000E+01	0.500000E+03	0.383577E+03	0.	0.	0.355503E+03	0.	0.	
0.881300E+03	0.500000E+01	0.211573E+03	0.160867E+01	0.881300E+03	0.500000E+01	0.211573E+03	0.160867E+01	
0.881300E+03	0.490000E+01	0.211573E+03	0.161005E+01	0.881300E+03	0.490000E+01	0.211573E+03	0.161005E+01	
0.	0.	0.	0.	0.	0.	0.	0.	
0.116423E+03	0.	0.116423E+03	0.	0.	0.200000E-01	0.303518E+00	0.	
0.	0.	0.	0.	0.	0.	0.	0.	
0.228157E+04	0.466804E+01	0.604585E+03	0.187798E+01	0.881300E+03	0.490000E+01	0.211573E+03	0.161005E+01	
0.109422E+02	0.394519E+03	0.285267E-01	0.	0.116423E+03	0.	0.100000E+01	0.	
0.199038E+04	0.468986E+01	0.515033E+03	0.183454E+01	0.199038E+04	0.445537E+01	0.515033E+03	0.183806E+01	
0.199038E+04	0.445537E+01	0.515033E+03	0.183806E+01	0.199038E+04	0.445537E+01	0.515033E+03	0.183806E+01	
0.510942E+03	0.	0.510942E+03	0.218844E-01	0.	0.500000E-01	0.535611E+03	0.510401E+03	
0.449153E+01	0.541234E+03	0.256683E+00	0.196783E+04	0.424783E+01	0.571843E+03	0.271337E+00	0.356444E+00	
0.171607E+04	0.243248E+01	0.197586E+04	0.100000E+01	0.171607E+04	0.243248E+01	0.197586E+04	0.100000E+01	
0.	0.	0.	0.	0.189192E+04	0.300448E+05	0.	0.139553E+05	
0.300448E+05	0.139553E+05	0.109422E+02	0.510942E+03	0.218844E-01	0.440001E+05	0.440001E+05	0.895270E+00	

CONCLUDING REMARKS

The computer code (GENENG) presented herein has proven to be an indispensable tool for steady-state cycle analysis of various types of jet engines, namely two-spool mixed- or unmixed-flow turbofans and one- or two-spool turbojets.

This program has been found to be valuable for many applications because it has the capability of studying a broad range of engine types having different design characteristics, while it also has low-execution-time requirements. The laborious task of matching components manually at off-design operating has been eliminated.

The program has proven itself to be easy to use, especially in terms of input requirements. It is felt that with a minimum of effort the reader can become proficient in using the computer code.

The code is available to be reproduced on the requestor's tape upon application to the authors.

Lewis Research Center,
National Aeronautics and Space Administration,
Cleveland, Ohio, October 1, 1971,
132-15.

APPENDIX A

GENENG PROGRAM LISTING

```
$IBFTC GENENG  DECK
       COMMON /POINT/IDATPT                                                    1
       COMMON/LOOPPR/KKGO,PRFNEW,PRCNEW                                        2
       DATAIII/0/                                                              3
       DIMENSION XLO(5),XHI(5)                                                 4
       EQUIVALENCE(XLO,DHLOSV),(XHI,DHHISV)                                    5
       COMMON/ALL/X(28)/DESIGN/Y(80)/FRONT/Z(80)/SIDE/W(48)/BACK/V(72)         6
       COMMON/DUMMYS/DUMMY(100)                                                7
       EQUIVALENCE (P6DSAV,DUMMY(7)),(AM6DSV,DUMMY(8)),(ETAASV,DUMMY(9)),      8
      1(FAR7SV,DUMMY(10))                                                      9
       LOGICAL ERRER,CLEAR                                                    10
       DATA CLEAR/.TRUE./                                                     11
       COMMON/ERER/ERRER                                                      12
       ERRER=.FALSE.                                                          13
       IF (.NOT.CLEAR) CALL ENGBAL                                            14
       CLEAR=.FALSE.                                                          15
       DO 1 J=1,408                                                           16
1      X(J)=0.                                                                17
       IF (III.EQ.0) KKGO=0                                                   18
       III=1                                                                  19
       IDATPT=0                                                               20
       CALL CONOUT (1)                                                        21
       P6DSAV=1.                                                              22
       AM6DSV=1.                                                              23
       ETAASV=1.                                                              24
       FAR7SV=1.                                                              25
       DO 2 I=1,5                                                             26
       XLO(I)=100.                                                            27
2      XHI(I)=100.                                                            28
       CALL ENGBAL                                                            29
       STOP                                                                   30
       END                                                                    31
```

```
$IBFTC ENGBAL  DECK
       SUBROJTINE ENGBAL                                                       1
       COMMON /   ALL/                                                         2
      1WORD  ,IDES  ,JDES  ,KDES  ,MODE  ,INIT  ,IDUMP ,IAMTP ,               3
      2IGASMX,IDBURN,IAFTBN,IDCD  ,IMCD  ,IDSHOC,IMSHOC,NOZFLT,               4
      3ITRYS ,LOOPER,NOMAP ,NUMMAP,MAPEDG,TOLALL,ERR(6)                       5
       COMMON /DESIGN/                                                         6
      1PCNFGJ,PCNCGU,T4GU  ,DUMD1 ,DUMD2 ,DELFG ,DELFN ,DELSFC,               7
      2ZFDS  ,PCNFDS,PRFDS ,ETAFDS,WAFDS ,PRFCF ,ETAFCF,WAFCF ,               8
      3ZCDS  ,PCNCDS,PRCDS ,ETACDS,WACDS ,PRCCF ,ETACCF,WACCF ,               9
      4T4DS  ,WFBDS ,DTCODS,ETABDS,WA3CDS,DPCODS,DTCOCF,ETABCF,              10
      5TFHPDS,CNHPDS,ETHPDS,TFHPCF,CNHPCF,ETHPCF,DHHPCF,T2DS  ,              11
      6TFLPDS,CNLPDS,ETLPDS,TFLPCF,CNLPCF,ETLPCF,DHLPCF,T21DS ,              12
      7T24DS ,WFDDS ,DTDUDS,ETADDS,WA23DS,DPDUDS,DTDUCF,ETADCF,              13
      8T7DS  ,WFADS ,DTAFDS,ETAADS,WG6CDS,DPAFDS,DTAFCF,ETAACF,              14
      9A55   ,A25   ,A6    ,A7    ,A8    ,A9    ,A28   ,A29   ,              15
      $PS55  ,AM55  ,CVDNOZ,CVMNOZ,A8SAV ,A9SAV ,A28SAV,A29SAV              16
```

```
      COMMON / FRONT/                                                    17
     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  ,BLDB  ,         21
     5CNF   ,PRF   ,ETAF  ,WAFC  ,WAF   ,WA3   ,WG4   ,FAR4  ,         22
     6CNC   ,PRC   ,ETAC  ,WACC  ,WAC   ,ETAB  ,DPCOM ,DUMF  ,         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,PCBLDB,PCBLHP,PCBLLP          27
      COMMON /  SIDE/                                                   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 ,ETAD  ,DPDUC ,BYPASS,DUMS3 ,         33
     6TS28  ,PS28  ,V28   ,AM28  ,TS29  ,PS29  ,V29   ,AM29            34
      COMMON /  BACK/                                                   35
     1XT55  ,XP55  ,XH55  ,XS55  ,XT25  ,XP25  ,XH25  ,XS25  ,         36
     2XWFB  ,XWG55 ,XFAR55,XWFD  ,XWG24 ,XFAR24,XXP1  ,DUMB  ,         37
     3T6    ,P6    ,H6    ,S6    ,T7    ,P7    ,H7    ,S7    ,         38
     4T8    ,P8    ,H8    ,S8    ,T9    ,P9    ,H9    ,S9    ,         39
     5WG6   ,WFA   ,WG7   ,FAR7  ,ETAA  ,DPAFT ,V55   ,V25   ,         40
     6PS6   ,V6    ,AM6   ,TS7   ,PS7   ,V7    ,AM7   ,AM25  ,         41
     7TS8   ,PS8   ,V8    ,AM8   ,TS9   ,PS9   ,V9    ,AM9   ,         42
     8VA    ,FRD   ,VJD   ,FGMD  ,VJM   ,FGMM  ,FGPD  ,FGPM  ,         43
     9FGM   ,FGP   ,WFT   ,WGT   ,FART  ,FG    ,FN    ,SFC             44
      COMMON/DUMMYS/DUMMY(100)                                          45
      LOGICAL ERRER,FAN                                                 46
      EQUIVALENCE (FAN,DUMMY(11)),(ISPOOL,DUMMY(6))                    47
      COMMON/ERER/ERRER                                                 48
      DIMENSION VAR(6),DEL(6),ERRB(6),DELVAR(6),EMAT(6,6),VMAT(6),      49
     1AMAT(6)                                                           50
      DATA AWORD/6HENGBAL/                                              51
      DATA VDELTA,VLIM,VCHNGE,NOMISX/                                   52
     1 0.001,0.100,0.850,4/                                             53
      CALL PUTIN                                                        54
      IF (INIT.EQ.1) GO TO 1                                            55
      TFFHP=TFHPDS                                                      56
      TFFLP=TFLPDS                                                      57
1     LOOPER=0                                                          58
      NUMMAP=0                                                          59
      NOMISS=0                                                          60
2     LOOP=0                                                            61
      MISMAT=0                                                          62
      NOMAP=0                                                           63
      IGO=2                                                             64
      DO 3 I=1,6                                                        65
      VMAT(I)=0.                                                        66
      AMAT(I)=0.                                                        67
      DELVAR(I)=0.                                                      68
      DO 3 L=1,6                                                        69
3     EMAT(I,L)=0.                                                      70
4     LOOPER=LOOPER+1                                                   71
      CALL CDFAN                                                        72
      WORD=AWORD                                                        73
      IF (LOOPER.GT.ITRYS) ERRER=.TRUE.                                 74
      IF (LOOPER.GT.ITRYS) GO TO 24                                     75
      IF (NOMAP.GT.0) GO TO 2                                           76
      NUMMAP=0                                                          77
```

```
5     VAR(1)=ZF*100.                                                    78
      IF (MODE.NE.3) VAR(2)=PCNF                                        79
      IF (MODE.EQ.3) VAR(2)=T4/10.                                      80
      VAR(3)=ZC*100.                                                    81
      IF (MODE.NE.1) VAR(4)=PCNC                                        82
      IF (MODE.EQ.1) VAR(4)=T4/10.                                      83
      VAR(5)=TFFHP                                                      84
      VAR(6)=TFFLP                                                      85
      NMAX=6                                                            86
      IF (FAN.OR.ISPOOL.EQ.2) GO TO 6                                   87
      NMAX=3                                                            88
      VAR(3)=TFFLP                                                      89
6     DO 7 I=1,NMAX                                                     90
7     IF (ABS(ERR(I)).GT.TOLALL) GO TO 8                                91
      CALL PERF                                                         92
      CALL ERROR                                                        93
8     IF (LOOP.GT.0) GO TO 10                                           94
      MAPEDG=0                                                          95
      MAPSET=0                                                          96
      DO 9 I=1,NMAX                                                     97
      ERRB(I)=ERR(I)                                                    98
9     DEL(I)=VDELTA*VAR(I)                                              99
      GO TO 13                                                         100
10    IF (MISMAT.GT.0) GO TO 27                                        101
      IF (MAPEDG.EQ.0) GO TO 11                                        102
      MAPEDG=0                                                         103
      MAPSET=1                                                         104
      VAR(LOOP)=VAR(LOOP)+2.*DEL(LOOP)                                 105
      GO TO 14                                                         106
11    IF (MAPSET.EQ.0) VAR(LOOP)=VAR(LOOP)+DEL(LOOP)                   107
      IF (MAPSET.EQ.1) VAR(LOOP)=VAR(LOOP)-DEL(LOOP)                   108
      MAPSET=0                                                         109
      DO 12 I=1,NMAX                                                   110
12    EMAT(I,LOOP)=(ERRB(I)-ERR(I))/DEL(LOOP)                          111
13    LOOP=LOOP+1                                                      112
      IF (LOOP.GT.NMAX) GO TO 15                                       113
      VAR(LOOP)=VAR(LOOP)-DEL(LOOP)                                    114
14    ZF=VAR(1)/100.                                                   115
      IF (MODE.NE.3) PCNF=VAR(2)                                       116
      IF (MODE.EQ.3) T4=VAR(2)*10.                                     117
      ZC=VAR(3)/100.                                                   118
      IF (MODE.NE.1) PCNC=VAR(4)                                       119
      IF (MODE.EQ.1) T4=VAR(4)*10.                                     120
      TFFHP=VAR(5)                                                     121
      TFFLP=VAR(6)                                                     122
      IF (ISPOOL.EQ.1) TFFLP=VAR(3)                                    123
      IF (ZF.LT.0.) ZF=0.05                                            124
      IF (ZC.LT.0.) ZC=0.05                                            125
      GO TO (2,4),IGO                                                  126
15    DO 16 I=1,NMAX                                                   127
16    AMAT(I)=-ERRB(I)                                                 128
      DO 18 I=1,NMAX                                                   129
      IZERO=0                                                          130
      DO 17 LOOP=1,NMAX                                                131
17    IF (EMAT(I,LOOP).EQ.0.) IZERO=IZERO+1                            132
      IF (IZERO.LT.NMAX) GO TO 18                                      133
      WRITE (6,30) I                                                   134
      LOOPER=ITRYS+100                                                 135
      GO TO 24                                                         136
18    CONTINUE                                                         137
      DO 20 LOOP=1,NMAX                                                138
      IZERO=0                                                          139
      DO 19 I=1,NMAX                                                   140
```

```
19    IF (EMAT(I,LOOP).EQ.0.) IZERO=IZERO+1                                  141
      IF (IZERO.LT.NMAX) GO TO 20                                            142
      WRITE (6,31) LOOP                                                      143
      LOOPER=ITRYS+100                                                       144
      GO TO 24                                                               145
20    CONTINUE                                                               146
21    CALL MATRIX (EMAT,VMAT,AMAT,NMAX)                                      147
      LBIG=0                                                                 148
      VARBIG=0.0                                                             149
      DO 22 L=1,NMAX                                                         150
      ABSVAR=ABS(VMAT(L))                                                    151
      IF (ABSVAR.LE.VLIM*VAR(L)) GO TO 22                                    152
      IF (ABSVAR.LE.VARBIG) GO TO 22                                         153
      LBIG=L                                                                 154
      VARBIG=ABSVAR                                                          155
22    CONTINUE                                                               156
      VRATIO=1.0                                                             157
      IF (LBIG.GT.0) VRATIO=VLIM*VAR(LBIG)/VARBIG                            158
      ERRAVE=0.0                                                             159
      VMTAVE=0.0                                                             160
      DELAVE=0.0                                                             161
      DO 23 L=1,NMAX                                                         162
      DELVAR(L)=VRATIO*VMAT(L)                                               163
      ERRAVE=ERRAVE+ABS(AMAT(L))                                             164
      VMTAVE=VMTAVE+ABS(VMAT(L))                                             165
      DELAVE=DELAVE+ABS(DELVAR(L))                                           166
23    VAR(L)=VAR(L)+DELVAR(L)                                                167
      ERRAVE=ERRAVE/FLOAT(NMAX)                                              168
      VMTAVE=VMTAVE/FLOAT(NMAX)                                              169
      DELAVE=DELAVE/FLOAT(NMAX)                                              170
      IF (MISMAT.GT.0) GO TO 29                                              171
      IF (NOMISS.EQ.0) MISMAT=1                                              172
      IF (MISMAT.EQ.0) IGO=1                                                 173
24    WRITE (8,32) LOOPER                                                    174
      DO 25 I=1,NMAX                                                         175
25    WRITE (8,33) AMAT(I),(EMAT(I,L),L=1,6),VMAT(I),DELVAR(I),VAR(I)        176
      WRITE (8,34) ERRAVE,VMTAVE,DELAVE                                      177
26    IF (LOOPER.LT.ITRYS) GO TO 14                                          178
      CALL ERROR                                                             179
      RETURN                                                                 180
27    VMTAVX=VMTAVE                                                          181
      DO 28 I=1,NMAX                                                         182
28    AMAT(I)=-ERR(I)                                                        183
      GO TO 21                                                               184
29    WRITE (8,35) AMAT,ERRAVE,DELVAR,DELAVE,VMAT,VMTAVE,VAR                 185
      MISMAT=MISMAT+1                                                        186
      IF (VMTAVE.LT.VCHNGE*VMTAVX) GO TO 26                                  187
      WRITE (8,36)                                                           188
      IF (MISMAT.LT.NOMISX) NOMISS=1                                         189
      MISMAT=0                                                               190
      LOOP=0                                                                 191
      IGO=2                                                                  192
      GO TO 5                                                                193
C                                                                            194
30    FORMAT (4HOROW,I2,16H IS ZERO IN EMAT)                                 195
31    FORMAT (7HOCOLUMN,I2,16H IS ZERO IN EMAT)                              196
32    FORMAT (8H8   ERR8,28X23HERROR MATRIX AFTER LOOP,I4,29X4HVMAT,6X5H     197
     1DELVAR,7X14HVARIABLE$$$$$$)                                            198
33    FORMAT (1H0,F8.4,8X6F10.4,10XF10.4,F11.4,4XF11.4,6H$$$$$$)             199
34    FORMAT (1H0,F8.4,32X14HAVERAGE VALUES,31X,2F11.4,6H$$$$$$)             200
```

```
35    FORMAT (12HO-----  AMAT,7F16.6,6H$$$$$$,/,12H -----DELVAR,7F16.6,6      201
     1H$$$$$$,/,12H -----  VMAT,7F16.6,6H$$$$$$,/,12H -----   VAR,6F16.6      202
     2,6H$$$$$$)                                                              203
36    FORMAT (1HO,50X22HCHANGE TOO SMALL$$$$$$)                                204
      END                                                                      205
```

```
$IBFTC GUESSS  DECK
      FUNCTION GUESS(M,T,TD,P,PD,W,WD,D,DD,VD)                                 1
      IF (M.EQ.0) GUESS=VD*((T/TD)**1.60)*((DD/D)**0.50)                       2
      IF (M.EQ.1) GUESS=VD*((P/PD)**1.80)*((DD/D)**0.33)                       3
      IF (M.EQ.2) GUESS=VD*((W/WD)**0.33)*((DD/D)**1.00)                       4
      IF (M.EQ.3) GUESS=VD*((W/WD)**0.00)*((P/PD)**0.50)                       5
      IF (M.EQ.4) GUESS=VD*((W/WD)**0.00)*((P/PD)**0.50)                       6
      IF (M.EQ.5) GUESS=VD*((T/TD)**1.10)*((DD/D)**0.60)                       7
      IF (M.EQ.6) GUESS=VD*((P/PD)**1.00)*((D/DD)**0.25)                       8
      IF (M.EQ.7) GUESS=VD*((P/PD)**0.62)*((D/DD)**0.31)                       9
      RETURN                                                                  10
      END                                                                     11
```

```
$IBFTC MATRIX  DECK
      SUBROUTINE MATRIX (E,V,A,N)                                              1
      DIMENSION E(6,6),V(6),A(6),PIV(7),T(6,7)                                 2
      NN=N+1                                                                   3
      NM=N-1                                                                   4
      DO 1 I=1,N                                                               5
      T(I,NN)=A(I)                                                             6
      DO 1 J=1,N                                                               7
1     T(I,J)=E(I,J)                                                            8
      DO 7 I=1,N                                                               9
      TEMP=0.                                                                 10
      DO 2 J=I,N                                                              11
      IF (TEMP.GT.ABS(T(J,I))) GO TO 2                                        12
      TEMP=ABS(T(J,I))                                                        13
      IPIV=J                                                                  14
2     CONTINUE                                                                15
      IP1=I+1                                                                 16
      DO 3 J=IP1,NN                                                           17
3'    PIV(J)=T(IPIV,J)/T(IPIV,I)                                              18
      IFROM=N                                                                 19
      ITO=N                                                                   20
4     IF (IFROM.EQ.IPIV) GO TO 6                                              21
      RM=-T(IFROM,I)                                                          22
      DO 5 J=IP1,NN                                                           23
5     T(ITO,J)=T(IFROM,J)+RM*PIV(J)                                           24
      ITO=ITO-1                                                               25
6     IFROM=IFROM-1                                                           26
      IF (IFROM.GE.I) GO TO 4                                                 27
      DO 7 J=IP1,NN                                                           28
7     T(I,J)=PIV(J)                                                           29
      DO 8 I=1,NM                                                             30
      J=NN-I                                                                  31
      K=N-I                                                                   32
      DO 8 L=J,N                                                              33
```

```
8       T(K,NN)=T(K,NN)-T(K,L)*T(L,NN)                                    34
        DO 9 I=1,N                                                        35
9       V(I)=T(I,NN)                                                      36
        RETURN                                                            37
        END                                                               38



$IBFTC PUTIN   DECK
        SUBROUTINE PUTIN                                                   1
        COMMON /POINT/IDATPT                                               2
        COMMON /   ALL/                                                    3
       1WORD  ,IDES  ,JDES  ,KDES  ,MODE  ,INIT  ,IDUMP ,IAMTP ,          4
       2IGASMX,IDBURN,IAFTBN,IDCD  ,IMCD  ,IDSHOC,IMSHOC,NOZFLT,           5
       3ITRYS ,LOOPER,NOMAP ,NUMMAP,MAPEDG,TOLALL,ERR(6)                   6
        COMMON /DESIGN/                                                    7
       1PCNFGJ,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 ,WFDDS ,DTDUDS,ETADDS,WA23DS,DPDUDS,DTDUCF,ETADCF,          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 ,A28SAV,A29SAV          17
        COMMON / FRONT/                                                    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  ,WAFC  ,WAF   ,WA3   ,WG4   ,FAR4  ,          23
       6CNC   ,PRC   ,ETAC  ,WACC  ,WAC   ,ETAB  ,DPCOM ,DUMF  ,          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 /  SIDE/                                                    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
        COMMON /  BACK/                                                    36
       1XT55  ,XP55  ,XH55  ,XS55  ,XT25  ,XP25  ,XH25  ,XS25  ,          37
       2XWFB  ,XWG55 ,XFAR55,XWFD  ,XWG24 ,XFAR24,XXP1  ,DUMB  ,          38
       3T6    ,P6    ,H6    ,S6    ,T7    ,P7    ,H7    ,S7    ,          39
       4T8    ,P8    ,H8    ,S8    ,T9    ,P9    ,H9    ,S9    ,          40
       5WG6   ,WFA   ,WG7   ,FAR7  ,ETAA  ,DPAFT ,V55   ,V25   ,          41
       6PS6   ,V6    ,AM6   ,TS7   ,PS7   ,V7    ,AM7   ,AM25  ,          42
       7TS8   ,PS8   ,V8    ,AM8   ,TS9   ,PS9   ,V9    ,AM9   ,          43
       8VA    ,FRD   ,VJD   ,FGMD  ,VJM   ,FGMM  ,FGPD  ,FGPM  ,          44
       9FGM   ,FGP   ,WFT   ,WGT   ,FART  ,FG    ,FN    ,SFC             45
        COMMON/DUMMYS/DUMMY(100)                                           46
        COMMON/LOOPPR/KKGO,PRFNEW,PRCNEW                                   47
        DIMENSION XSAVE(308),XFILL(1)                                      48
        EQUIVALENCE (XFILL,WORD)                                           49
        LOGICAL ERRER                                                      50
        COMMON/ERER/ERRER                                                  51
```

```
C *** ITITLE=1  WILL READ IN TITLE                                          52
C *** MODE  =0  FOR CONSTANT T4                                            53
C *** MODE  =1  FOR CONSTANT PCNC                                          54
C *** MODE  =2  FOR CONSTANT WFB                                           55
C***  MODE=3  FOR  CONSTANT PCNF                                           56
C *** INIT  =1  WILL NOT INITIALIZE POINT                                   57
C *** IDUMP =1  WILL DUMP LOOPING WRITE-OUTS IF ERROR OCCURS                58
C *** IDUMP =2  WILL DUMP LOOPING WRITE-OUTS AFTER EVERY POINT              59
C *** IAMTP =0  WILL USE INPUT AM AND MIL SPEC ETAR                         60
C *** IAMTP =1  WILL USE INPUT AM AND INPUT ETAR                            61
C *** IAMTP =2  WILL USE T2 AS T1=T1+T2 AND STANDARD P1                     62
C *** IAMTP =3  WILL USE P2 AND STANDARD T1                                 63
C *** IAMTP =4  WILL USE T2 AND P2                                          64
C *** IAMTP =5 WILL USE RAM2 FOR SPECIAL RECOVERY                           65
C *** IGASMX=-1 SEPERATE FLOW, INPUT AM6                                    66
C *** IGASMX=0  SEPARATE FLOW, A6=A55                                       67
C *** IGASMX=1  WILL MIX DUCT AND MAIN STREAMS, A6=A25+A55                  68
C *** IGASMX=2 WILL MIX DUCT AND MAIN STREAMS, INPUT AM6                    69
C *** IDBURN=1  FOR DUCT BURNING, INPUT T24                                 70
C *** IDBURN=2  FOR DUCT BURNING, INPUT WFD                                 71
C *** IAFTBN=1  FOR AFTERBURNING, INPUT T7                                  72
C *** IAFTBN=2  FOR AFTERBURNING, INPUT WFA                                 73
C *** IDCD  =1  DUCT NOZZLE WILL BE C-D                                     74
C *** IMCD  =1  MAIN NOZZLE WILL BE C-D                                     75
C *** NOZFLT=1  FOR FLOATING MAIN NOZZLE                                    76
C *** NOZFLT=2  FOR FLOATING DUCT NOZZLE                                    77
C *** NOZFLT=3  FOR FLOATING MAIN AND DUCT NOZZLES                          78
C *** ITRYS =N  NUMBER OF PASSES THRU ENGINE BEFORE QUITTING                79
      DIMENSION ITABLE(400)                                                80
      DATA (ITABLE(I),I=1,3)/0,400,0/                                      81
1     CALL ZERO                                                            82
      IF (K<GO.EQ.1) GO TO 5                                               83
      IDES=0                                                               84
      CALL INPUT (5,6,1,WORD,ITABLE)                                       85
      IF (ERRER.AND.IAFTBN.GT.0) GO TO 1                                   86
      ERRER=.FALSE.                                                        87
C     TABLE IS REFERENCED TO COMMON/ALL/FIRST ENTRY                        88
      IF (IDES.EQ.0) GO TO 7                                               89
      IF (K<GO.NE.2) GO TO 3                                               90
      DO 2 I=1,308                                                         91
2     XFILL(I)=XSAVE(I)                                                    92
      CALL INPUT (5,6,1,WORD,ITABLE)                                       93
3     CONTINUE                                                             94
C     SAVE INPUT IN CASE OF LOOP ON PRESSURE RATIOS                        95
      DO 4 I=1,308                                                         96
4     XSAVE(I)=XFILL(I)                                                    97
      GO TO 7                                                              98
5     DO 6 I=1,308                                                         99
6     XFILL(I)=XSAVE(I)                                                   100
      WRITE (6,8) PRFDS,PRFNEW,PRCDS,PRCNEW                               101
      PRCDS=PRCNEW                                                        102
      PRFDS=PRFNEW                                                        103
7     CONTINUE                                                            104
      KKGO=2                                                              105
      IF (IAFTBN.GT.0.OR.IDBURN.GT.0) INIT=1                              106
      IF (NOZFLT.GT.0) INIT=1                                             107
      IF (MODE.EQ.0) WRITE (8,9) IDES,AM,ALTP,T4,T24,T7                   108
      IF (MODE.EQ.1) WRITE (8,10) IDES,AM,ALTP,PCNC,T24,T7                109
      IF (MODE.EQ.2) WRITE (8,11) IDES,AM,ALTP,WFB,T24,T7                 110
      CALL COINLT                                                         111
      RETURN                                                              112
C                                                                         113
```

```
C                                                                       114
C                                                                       115
8      FORMAT (18HOCHANGE PRFDS FROM,F9.3,4H  TO,F9.3,16H  AND PRCDS FRDM  116
     1,F10.3,4H  TO,F10.3)                                              117
9      FORMAT (1HO,7H  IDES=,I3,10X7H    AM=,F7.3,6X7H  ALTP=,F7.0,6X7H   118
     1  T4=,F8.2,5X7H   T24=,F8.2,5X7H    T7=,F8.2,6H$$$$$$)             119
10     FORMAT (1HO,7H  IDES=,I3,10X7H    AM=,F7.3,6X7H  ALTP=,F7.0,6X7H   120
     1PCNC=,F8.3,5X7H   T24=,F8.2,5X7H    T7=,F8.2,6H$$$$$$)             121
11     FORMAT (1HO,7H  IDES=,I3,10X7H    AM=,F7.3,6X7H  ALTP=,F7.0,6X7H   122
     1 WFB=,F8.4,5X7H   T24=,F8.2,5X7H    T7=,F8.2,6H$$$$$$)             123
       END                                                              124
```

```
$IBFTC ZERO    DECK
       SUBROUTINE ZERO                                                   1
       COMMON /   ALL/                                                   2
      1WORD  ,IDES  ,JDES  ,KDES  ,MODE  ,INIT  ,IDUMP ,IAMTP ,         3
      2IGASMX,IDBURN,IAFTBN,IDCD  ,IMCD  ,IDSHOC,IMSHOC,NOZFLT,         4
      3ITRYS ,LOOPER,NOMAP ,NUMMAP,MAPEDG,TOLALL,ERR(6)                 5
       COMMON/DESIGN/QXQ(80)                                            6
       COMMON / FRONT/                                                  7
      1T1    ,P1    ,H1    ,S1    ,T2    ,P2    ,H2    ,S2    ,       8
      2T21   ,P21   ,H21   ,S21   ,T3    ,P3    ,H3    ,S3    ,       9
      3T4    ,P4    ,H4    ,S4    ,T5    ,P5    ,H5    ,S5    ,      10
      4T55   ,P55   ,H55   ,S55   ,BLF   ,BLC   ,BLDU  ,BLOB  ,      11
      5CNF   ,PRF   ,ETAF  ,WAFC  ,WAF   ,WA3   ,WG4   ,FAR4  ,      12
      6CNC   ,PRC   ,ETAC  ,WACC  ,WAC   ,ETAB  ,DPCOM ,DUMF  ,      13
      7CNHP  ,ETATHP,DHTCHP,DHTC  ,BLHP  ,WG5   ,FAR5  ,CS    ,      14
      8CNLP  ,ETATLP,DHTCLP,DHTF  ,BLLP  ,WG55  ,FAR55 ,HPEXT ,      15
      9AM    ,ALTP  ,ETAR  ,ZF    ,PCNF  ,ZC    ,PCNC  ,WFB   ,      16
      $TFFHP ,TFFLP ,PCBLF ,PCBLC ,PCBLDU,PCBLOB,PCBLHP,PCBLLP         17
       COMMON /  SIDE/                                                  18
      1XP1   ,XWAF  ,XWAC  ,XBLF  ,XBLDU ,XH3   ,DUMS1 ,DUMS2 ,      19
      2XT21  ,XP21  ,XH21  ,XS21  ,T23   ,P23   ,H23   ,S23   ,      20
      3T24   ,P24   ,H24   ,S24   ,T25   ,P25   ,H25   ,S25   ,      21
      4T28   ,P28   ,H28   ,S28   ,T29   ,P29   ,H29   ,S29   ,      22
      5WAD   ,WFD   ,WG24  ,FAR24 ,ETAD  ,DPDUC ,BYPASS,DUMS3 ,      23
      6TS28  ,PS28  ,V28   ,AM28  ,TS29  ,PS29  ,V29   ,AM29          24
       COMMON /  BACK/                                                  25
      1XT55  ,XP55  ,XH55  ,XS55  ,XT25  ,XP25  ,XH25  ,XS25  ,      26
      2XWFB  ,XWG55 ,XFAR55,XWFD  ,XWG24 ,XFAR24,XXP1  ,DUMB  ,      27
      3T6    ,P6    ,H6    ,S6    ,T7    ,P7    ,H7    ,S7    ,      28
      4T8    ,P8    ,H8    ,S8    ,T9    ,P9    ,H9    ,S9    ,      29
      5WG6   ,WFA   ,WG7   ,FAR7  ,ETAA  ,DPAFT ,V55   ,V25   ,      30
      6PS6   ,V6    ,AM6   ,TS7   ,PS7   ,V7    ,AM7   ,AM25  ,      31
      7TS8   ,PS8   ,V8    ,AM8   ,TS9   ,PS9   ,V9    ,AM9   ,      32
      8VA    ,FRD   ,VJD   ,FGMD  ,VJM   ,FGMM  ,FGPD  ,FGPM  ,      33
      9FGM   ,FGP   ,WFT   ,WGT   ,FART  ,FG    ,FN    ,SFC           34
       COMMON/DUMMYS/DUMMY(100)                                         35
       DIMENSION Z1(63),Z2(48),Z3(72)                                   36
       EQUIVALENCE (Z1,T1),(Z2,XP1),(Z3,XT55)                           37
       IDES=0                                                           38
       JDES=0                                                           39
       INIT=0                                                           40
       IDBURN=0                                                         41
       IAFTBN=0                                                         42
       IDSHOC=3                                                         43
       IMSHOC=3                                                         44
       T2Q=T2                                                           45
```

```
      P2Q=P2                                                              45
      T4Q=T4                                                              47
      DO 1 I=1,63                                                         48
1     Z1(I)=0.                                                            49
      DO 2 I=1,48                                                         50
2     Z2(I)=0.                                                            51
      DO 3 I=1,72                                                         52
3     Z3(I)=0.                                                            53
      T2=T2Q                                                              54
      P2=P2Q                                                              55
      T4=T4Q                                                              56
      CALL SYG (1)                                                        57
      RETURN                                                              58
      END                                                                 59
```

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$IBFTC COINLT  DECK
      SUBROUTINE COINLT                                                    1
      COMMON /   ALL/                                                      2
     1WORD  ,IDES  ,JDES  ,KDES  ,MODE  ,INIT  ,IDUMP ,IAMTP ,            3
     2IGASMK,IDBURN,IAFTBN,IDCD  ,IMCD  ,IDSHOC,IMSHOC,NOZFLT,            4
     3ITRYS ,LOOPER,NOMAP ,NUMMAP,MAPEDG,TOLALL,ERR(6)                    5
      COMMON /DESIGN/                                                      6
     1PCNFGJ,PCNCGU,T4GU  ,DUMD1 ,DUMD2 ,DELFG ,DELFN ,DELSFC,            7
     2ZFDS  ,PCNFDS,PRFDS ,ETAFDS,WAFDS ,PRFCF ,ETAFCF,WAFCF ,            8
     3ZCDS  ,PCNCDS,PRCDS ,ETACDS,WACDS ,PRCCF ,ETACCF,WACCF ,            9
     4T4DS  ,WFBDS ,DTCODS,ETABDS,WA3CDS,DPCODS,DTCOCF,ETABCF,           10
     5TFHPDS,CNHPDS,ETHPDS,TFHPCF,CNHPCF,ETHPCF,DHHPCF,T2DS  ,           11
     6TFLPDS,CNLPDS,ETLPDS,TFLPCF,CNLPCF,ETLPCF,DHLPCF,T21DS ,           12
     7T24DS ,WFDDS ,DTDUDS,ETADDS,WA23DS,DPDUDS,DTDUCF,ETADCF,           13
     8T7DS  ,WFADS ,DTAFDS,ETAADS,WG6CDS,DPAFDS,DTAFCF,ETAACF,           14
     9A55   ,A25   ,A6    ,A7    ,A8    ,A9    ,A28   ,A29   ,           15
     $PS55  ,AM55  ,CVDNOZ,CVMNOZ,A8SAV ,A9SAV ,A28SAV,A29SAV           16
      COMMON / FRONT/                                                      17
     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  ,WAFC  ,WAF   ,WA3   ,WG4   ,FAR4  ,           22
     6CNC   ,PRC   ,ETAC  ,WACC  ,WAC   ,ETAB  ,DPCOM ,DUMF  ,           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,PCBLDB,PCBLHP,PCBLLP           27
      COMMON/SIDE/ZYX(48)/BACK/YZX(72)                                     28
      COMMON/DUMMYS/DUMMY(100)                                             29
      DATA AWORD/6HCOINLT/                                                 30
      WORD=AWORD                                                           31
      AJ=778.26                                                            32
      G=32.174049                                                          33
      ALT=ALTP*2.0855531E+07/(2.0855531E+07-ALTP)                          34
      CALL ATMOS (ALT,T1,XX1,XX2,XX3,P1,CS,XX4,IIER)                       35
      IF (IAMTP.EQ.2) T1=T1+T2                                             36
      IF (IAMTP.EQ.5) CALL RAM2 (AM,ETAR)                                  37
      IF (IAMTP.NE.1.AND.IAMTP.NE.5) CALL RAM (AM,ETAR)                    38
      FAR=0.0                                                              39
      CALL PROCOM (FAR,T1,CS,XX2,XX3,R1,PHI1,H1)                           40
      S1=PHI1-R1*ALOG(P1)                                                  41
      H2=H1+(AM*CS)**2/(2.*AJ*G)                                           42
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      P2T=1.                                                                43
      DO 1 I=1,10                                                           44
      CALL THERMO (P2T,H2,T2T,S2T,AW,0,0.0,1)                               45
      IF (ABS(S2T-S1).LE.0.0001*S1) GO TO 2                                 46
1     P2T=P1*EXP((AW/1.986375)*((S2T-S1)+(1.986375/AW)*ALOG(P2T/P1)))       47
      CALL ERROR                                                            48
      RETURN                                                                49
2     IF (IAMTP.EQ.3.OR.IAMTP.EQ.4) ETAR=P2/P2T                             50
      P2=ETAR*P2T                                                           51
      IF (IAMTP.NE.4) CALL THERMO (P2,H2,T2,S2,XX5,0,0.0,1)                 52
      IF (IAMTP.EQ.4) CALL THERMO (P2,H2,T2,S2,XX5,0,0.0,0)                 53
      IF (INIT.EQ.1) GO TO 5                                                54
      IF (IDES.EQ.1) GO TO 3                                                55
      IF (MODE.EQ.3) GO TO 4                                                56
      PCNF=GUESS(MODE,T4,T4DS,PCNC,PCNCDS,WFB,WFBDS,T2,T2DS,PCNFDS)         57
      PCNFGJ=PCNF                                                           58
      GO TO 4                                                               59
3     PCNF=PCNFDS                                                           60
      PCNFGJ=PCNF                                                           61
      T2DS=T2                                                               62
4     ZF=ZFDS                                                               63
5     RETURN                                                                64
      END                                                                   65
```

```
$IBFTC ATMOS   DECK
      SUBROUTINE ATMOS (ZFT,TM,SIGMA,RHO,THETA,DELTA,CA,AMU,K)               1
C   THIS IS A SUBROUTINE TO COMPUTE CERTAIN ELEMENTS OF THE 1962            2
C   U.S. STANDARD ATMOSPHERE UP TO 90 KILOMETERS.                           3
C    CALLING SEQUENCE...                                                    4
C                                                                           5
C    CALL ATMOS (ZFT, TM, SIGMA, RHO, THETA, DELTA, CA, AMU, K)             6
C         ZFT   =   GEOMETRIC ALTITUDE (FEET)                              7
C         TM    =   MOLECULAR SCALE TEMPERATURE (DEGREES RANKINE)           8
C         SIGMA =   RATIO OF DENSITY TO THAT AT SEA LEVEL                   9
C         RHO   =   DENSITY (LB-SEC**2-FT**(-4)   OR   SLUGS-FT**3)       10
C         THETA =   RATIO OF TEMPERATURE TO THAT AT SEA LEVEL              11
C         DELTA =   RATIO OF PRESSURE TO THAT AT SEA LEVEL                 12
C         CA    =   SPEED OF SOUND (FT/SEC)                                13
C         AMU   =   VISCOSITY COEFFICIENT (LB-SEC/FT**2)                   14
C                                                                          15
C         K = 1 NORMAL                                                     16
C           = 2 ALTITUDE LESS THAN -5000 METERS OR GREATER THAN 90 KM      17
C           = 3 FLOATING POINT OVERFLOW                                    18
C                                                                          19
C   ALL DATA AND FUNDAMENTAL CONSTANTS ARE IN THE METRIC SYSTEM AS         20
C   THESE QUANTITIES ARE DEFINED AS EXACT IN THIS SYSTEM.                  21
C                                                                          22
C   THE RADIUS OF THE EARTH (REFT59) IS THE VALUE ASSOCIATED WITH THE      23
C   1959 ARDC ATMOSPHERE SO THAT PROGRAMS CURRENTLY USING THE LIBRARY      24
C   ROUTINE WILL NOT REQUIRE ALTERATION TO USE THIS ROUTINE.               25
      DIMENSION HB(10),TMB(10),DELTAB(10),ALM(10)                          26
      DATA(HB(I),   TMB(I),   DELTAB(I),    ALM(I),I=1,10)/                27
     1   -5.0,      320.65,   1.75363E 00,   -6.5,                         28
     2    0.0,      288.15,   1.00000E 00,   -6.5,                         29
     3   11.0,      216.65,   2.23361E-01,    0.0,                         30
     4   20.0,      216.65,   5.40328E-02,    1.0,                         31
     5   32.0,      228.65,   8.56663E-03,    2.8,                         32
     6   47.0,      270.65,   1.09455E-03,    0.0,                         33
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     7   52.0,      270.65,    5.82289E-04,    -2.0,                          34
     8   61.0,      252.65,    1.79718E-04,    -4.0,                          35
     9   79.0,      180.65,    1.0241 E-05,     0.0,                          36
     $   88.743,    180.65,    1.6223 E-06,     0.0/                          37
      DATA  REFT59/2.0855531E 07/, GZ    /9.80665/,                           38
     1      AMZ   /28.9644      /, RSTAR /8.31432/,                           39
     2      FTTOKM/3.048E-04    /, S     /110.4  /,                           40
     3      AMUZ  /1.2024E-05   /, CAZ   /1116.45/,                          41
     4      RHOZ  /0.076474     /, GZENG /32.1741/                           42
C  CONVERT GEOMETRIC ALTITUDE TO GEOPOTENTIAL ALTITUDE                        43
      HFT=(REFT59/(REFT59+ZFT))*ZFT                                           44
C  CONVERT HFT AND ZFT TO KILOMETERS                                         45
      Z=FTTOKM*ZFT                                                            46
      H=FTTOKM*HFT                                                            47
      K=1                                                                     48
      TMZ=TMB(2)                                                              49
      IF (H.LT.-5.0.OR.Z.GT.90.0) GO TO 7                                     50
      DO 1 M=1,10                                                             51
      IF (H-HB(M)) 2,3,1                                                      52
1     CONTINUE                                                                53
      GO TO 7                                                                 54
2     M=M-1                                                                   55
3     DELH=H-HB(M)                                                            56
      IF (ALM(M).EQ.0.0) GO TO 4                                              57
      TMK=TMB(M)+ALM(M)*DELH                                                  58
C  GRADIENT IS NON ZERO, PAGE 10, EQUATION I.2.10-(3)                        59
      DELTA=DELTAB(M)*((TMB(M)/TMK)**(GZ*AMZ/(RSTAR*ALM(M))))                 60
      GO TO 5                                                                 61
4     TMK=TMB(M)                                                              62
C  GRADIENT IS ZERO, PAGE 10, EQUATION I.2.10-(4)                            63
      DELTA=DELTAB(M)*EXP(-GZ*AMZ*DELH/(RSTAR*TMB(M)))                        64
5     THETA=TMK/TMZ                                                           65
      SIGMA=DELTA/THETA                                                       66
      ALPHA=SQRT(THETA**3)*((TMZ+S)/(TMK+S))                                  67
C  CONVERSION TO ENGLISH UNITS                                               68
      TM=1.8*TMK                                                              69
      RHO=RHOZ*SIGMA/GZENG                                                    70
      CA=CAZ*SQRT(THETA)                                                      71
      AMU=AMUZ*ALPHA/GZENG                                                    72
      CALL OVERFL (J)                                                         73
      GO TO (6,8),J                                                           74
6     K=K+2                                                                   75
      GO TO 8                                                                 76
7     K=2                                                                     77
8     RETURN                                                                  78
      END                                                                     79
```

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

```
$IBFTC RAMTWO  DECK
      SUBROUTINE RAM2 (AM,ETAR)                                          1
      DIMENSION PRINLT(15),FMN(15)                                       2
      DIMENSION Y(3),X(3)                                                3
      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/     4
      DATA PRINLT/.9,.932,.95,.961,.968,.97,.9701,.97,.9681,.958,.94,    5
     1.9181,.858,.8201,.75/                                              6
      M=0                                                                7
      DO 1 J=1,15                                                        8
1     IF (AM.GE.FMN(J)) M=J-1                                            9
      IF (M.EQ.0) M=1                                                   10
      IF (M.GE.14) M=13                                                 11
      DO 2 I=1,3                                                        12
      MM=M-1+I                                                          13
      X(I)=FMN(MM)                                                      14
2     Y(I)=PRINLT(MM)                                                   15
      CALL PARABO (X,Y,AM,ETAR)                                         16
      RETURN                                                            17
      END                                                               18
```

```
$IBFTC COFAN   DECK
      SUBROUTINE COFAN                                                   1
      COMMON /   ALL/                                                    2
     1WORD  ,IDES  ,JDES  ,KDES  ,MODE  ,INIT  ,IDUMP ,IAMTP ,          3
     2IGASMK,IDBURN,IAFTBN,IDCD  ,IMCD  ,IDSHOC,IMSHOC,NOZFLT,          4
     3ITRYS ,LOOPER,NOMAP ,NUMMAP,MAPEDG,TOLALL,ERR(6)                  5
      COMMON /DESIGN/                                                    6
     1PCNFGJ,PCNCGU,T4GU  ,DUMD1 ,DUMD2 ,DELFG ,DELFN ,DELSFC,          7
     2ZFDS  ,PCNFDS,PRFDS ,ETAFDS,WAFDS ,PRFCF ,ETAFCF,WAFCF ,          8
     3ZCDS  ,PCNCDS,PRCDS ,ETACDS,WACDS ,PRCCF ,ETACCF,WACCF ,          9
     4T4DS  ,WFBDS ,DTCODS,ETABDS,WA3CDS,DPCODS,DTCOCF,ETABCF,         10
     5TFHPDS,CNHPDS,ETHPDS,TFHPCF,CNHPCF,ETHPCF,DHHPCF,T2DS  ,         11
     6TFLPDS,CNLPDS,ETLPDS,TFLPCF,CNLPCF,ETLPCF,DHLPCF,T21DS ,         12
     7T24DS ,WFDDS ,DTDUDS,ETADDS,WA23DS,DPDUDS,DTDUCF,ETADCF,         13
     8T7DS  ,WFADS ,DTAFDS,ETAADS,WG6CDS,DPAFDS,DTAFCF,ETAACF,         14
     9A55   ,A25   ,A6    ,A7    ,A8    ,A9    ,A28   ,A29   ,         15
     $PS55  ,AM55  ,CVDNOZ,CVMNOZ,A8SAV ,A9SAV ,A28SAV,A29SAV          16
      COMMON / FRONT/                                                   17
     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  ,WAFC  ,WAF   ,WA3   ,WG4   ,FAR4  ,         22
     6CNC   ,PRC   ,ETAC  ,WACC  ,WAC   ,ETAB  ,DPCOM ,DUMF  ,         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/SIDE/ZYX(48)/BACK/YZX(72)                                  28
      COMMON/DUMMYS/DUMMY(100)                                          29
      COMMON /  FAN/CNX(15),PRX(15,15),WACX(15,15),ETAX(15,15),         30
     1NCN,NPT(15)                                                       31
      DIMENSION WLH(2)                                                  32
      DATA AWORD,WLH/6H COFAN,6H (LO) ,6H (HI) /                        33
      WORD=AWORD                                                        34
      THETA=SQRT(T2/518.668)                                            35
      IF (IDES.EQ.1) THETAD=THETA                                       36
```

```
      CNF=PCNF*THETAD/(100.*THETA)                                          37
      IF (IDES.EQ.1) WAFDS=WAFC*P2/THETA                                    38
      IF (ZF.LT.0.) ZF=0.                                                   39
      IF (ZF.GT.1.) ZF=1.                                                   40
      CNFS=CNF                                                              41
      CALL SEARCH (ZF,CNF,PRF,WAFC,ETAF,CNX(1),NCN,PRX(1,1),WACX(1,1),ET    42
     1AX(1,1),NPT(1),15,15,IGO)                                             43
      IF ((CNF-CNFS).GT.0.0005*CNF) MAPEDG=1                                44
      IF (IGO.EQ.1.OR.IGO.EQ.2) WRITE (8,11) CNFS,WLH(IGO)                  45
      WAF=WAFC*P2/THETA                                                     46
      IF (IDES.NE.1) GO TO 1                                                47
      PRFCF=(PRFDS-1.)/(PRF-1.)                                             48
      ETAFCF=ETAFDS/ETAF                                                    49
      WAFCF=WAFDS/WAF                                                       50
      WRITE (6,12) PRFCF,ETAFCF,WAFCF,T2DS                                  51
1     PRF=PRFCF*(PRF-1.)+1.                                                 52
      ETAF=ETAFCF*ETAF                                                      53
      WAF=WAFCF*WAF                                                         54
      WAFC=WAFCF*WAFC                                                       55
      PCNF=100.*THETA*CNF/THETAD                                            56
      DUMD1=PCNF                                                            57
      CALL THCOMP (PRF,ETAF,T2,H2,S2,P2,T21,H21,S21,P21)                    58
      IF (PCBLF.GT.0.) BLF=PCBLF*WAF                                        59
      IF (JDES.EQ.1) GO TO 8                                                60
      JDES=1                                                                61
      IF (INIT.EQ.1) GO TO 7                                                62
      IF (IDES.EQ.1) GO TO 5                                                63
      IF (MODE.NE.2) GO TO 2                                                64
      T4=GUESS(3,Y1,Y2,PCNF,PCNFDS,WFB,WFBDS,Y7,Y8,T4DS)                    65
      PCNC=GUESS(4,Y1,Y2,PCNF,PCNFDS,WFB,WFBDS,Y7,Y8,PCNCDS)                66
      GO TO 6                                                               67
2     IF (MODE.EQ.1) GO TO 4                                                68
      IF (MODE.EQ.0) GO TO 3                                                69
      T4=GUESS(7,Y1,Y2,PCNF,PCNFDS,Y5,Y6,T2,T2DS,T4DS)                      70
3     PCNC=GUESS(5,T4,T4DS,Y3,Y4,Y5,Y6,T21,T21DS,PCNCDS)                    71
      GO TO 6                                                               72
4     T4=GUESS(6,Y1,Y2,PCNC,PCNCDS,Y5,Y6,T21,T21DS,T4DS)                    73
      GO TO 5                                                               74
5     PCNC=PCNCDS                                                           75
      T4=T4DS                                                               76
      WFB=WFBDS                                                             77
      T21DS=T21                                                             78
6     ZC=ZCDS                                                               79
      PCNCGU=PCNC                                                           80
      T4GU=T4                                                               81
7     INIT=0                                                                82
8     IF (MODE.NE.3) GO TO 9                                                83
      IF (ABS(CNF-CNFS).LE.0.001*CNFS) GO TO 10                             84
      WRITE (8,13) CNFS,CNF                                                 85
      CALL ERROR                                                            86
9     PCNF=100.*THETA*CNF/THETAD                                            87
10    CALL DOCOMP                                                           88
      RETURN                                                                89
C                                                                           90
C                                                                           91
11    FORMAT (19H0* * *  CNF OFF MAP,F10.4,2XA6,11H* * *$$$$$$)             92
12    FORMAT (11HOFAN DESIGN,13X8H  PRFCF=,E15.8,8H ETAFCF=,E15.8,8H  WA    93
     1FCF=,E15.8,8H   T2DS=,E15.8)                                          94
13    FORMAT (10HOCNF WAS= ,E15.8,11H  AND NOW= ,E15.8,24H  CHECK PCNF I    95
     1NPUT$$$$$$)                                                          96
      END                                                                   97
```

```
$IBFTC COCOMP  DECK
      SUBROUTINE COCOMP                                                      1
      COMMON /   ALL/                                                        2
     1WORD  ,IDES  ,JDES  ,KDES  ,MODE  ,INIT  ,IDUMP ,IAMTP ,              3
     2IGASMK,IDBURN,IAFTBN,IDCD  ,IMCD  ,IDSHOC,IMSHOC,NOZFLT,              4
     3ITRYS ,LOOPER,NOMAP ,NUMMAP,MAPEDG,TOLALL,ERR(6)                      5
      COMMON /DESIGN/                                                        6
     1PCNFGJ,PCNCGU,T4GU  ,DUMD1 ,DUMD2 ,DELFG ,DELFN ,DELSFC,              7
     2ZFDS  ,PCNFDS,PRFDS ,ETAFDS,WAFDS ,PRFCF ,ETAFCF,WAFCF ,              8
     3ZCDS  ,PCNCDS,PRCDS ,ETACDS,WACDS ,PRCCF ,ETACCF,WACCF ,              9
     4T4DS  ,WFBDS ,DTCODS,ETABDS,WA3CDS,DPCODS,DTCOCF,ETABCF,             10
     5TFHPDS,CNHPDS,ETHPDS,TFHPCF,CNHPCF,ETHPCF,DHHPCF,T2DS  ,             11
     6TFLPDS,CNLPDS,ETLPDS,TFLPCF,CNLPCF,ETLPCF,DHLPCF,T21DS ,             12
     7T24DS ,WFDDS ,DTDUDS,ETADDS,WA23DS,DPDUDS,DTDUCF,ETADCF,             13
     8T7DS  ,WFADS ,DTAFDS,ETAADS,WG6CDS,DPAFDS,DTAFCF,ETAACF,             14
     9A55   ,A25   ,A6    ,A7    ,A8    ,A9    ,A28   ,A29   ,             15
     $PS55  ,AM55  ,CVDNOZ,CVMNOZ,A8SAV ,A9SAV ,A28SAV,A29SAV              16
      COMMON / FRONT/                                                       17
     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  ,WAFC  ,WAF   ,WA3   ,WG4   ,FAR4  ,             22
     6CNC   ,PRC   ,ETAC  ,WACC  ,WAC   ,ETAB  ,DPCOM ,DUMF  ,             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,PCBLDB,PCBLHP,PCBLLP               27
      COMMON/SIDE/ZYX(48)/BACK/YZX(72)                                      28
      COMMON/DUMMYS/DUMMY(100)                                              29
      LOGICAL ERRER,FAN                                                     30
      EQUIVALENCE (FAN,DUMMY(11)),(ISPOOL,DUMMY(6))                        31
      COMMON / COMP/CNX(15),PRX(15,15),WACX(15,15),ETAX(15,15),             32
     1NCN,NPT(15)                                                           33
      DIMENSION WLH(2)                                                      34
      DATA AWORD,WLH/6HCOCOMP,6H (LO) ,6H (HI) /                            35
      WORD=AWORD                                                            36
      THETA=SQRT(T21/518.668)                                               37
      IF (IDES.EQ.1) THETAD=THETA                                           38
      CNC=PCNC*THETAD/(100.*THETA)                                          39
      IF (.NOT.FAN) WACC=(WAF-BLF)*THETA/P21                                40
      IF (IDES.EQ.1) WACDS=WACC*P21/THETA                                   41
      IF (ZC.LT.0.) ZC=0.                                                   42
      IF (ZC.GT.1.) ZC=1.                                                   43
      CNCS=CNC                                                              44
      IF (ISPOOL.EQ.1) GO TO 1                                              45
      CALL SEARCH (ZC,CNC,PRC,WACC,ETAC,CNX(1),NCN,PRX(1,1),WACX(1,1),ET    45
     1AX(1,1),NPT(1),15,15,IGO)                                             47
      GO TO 2                                                               48
1     PRC=1.                                                                49
      ETAC=1.                                                               50
      CNC=1.                                                                51
      PRCCF=1.                                                              52
2     CONTINUE                                                              53
      IF (MODE.EQ.1) GO TO 3                                                54
      IF ((CNC-CNCS).GT.0.0005*CNC) MAPEDG=1                                55
3     IF (IGO.EQ.1.OR.IGO.EQ.2) WRITE (8,7) CNCS,WLH(IGO)                   56
      WAC=WACC*P21/THETA                                                    57
      IF (IDES.NE.1) GO TO 4                                                58
      IF (ISPOOL.EQ.2) PRCCF=(PRCDS-1.)/(PRC-1.)                            59
      ETACCF=ETACDS/ETAC                                                    60
      IF (ISPOOL.EQ.1) ETACCF=1.0                                           61
```

```
      WACCF=WACDS/WAC                                                    62
      WRITE (6,8) PRCCF,ETACCF,WACCF,T21DS                               63
4     PRC=PRCCF*(PRC-1.)+1.                                              64
      ETAC=ETACCF*ETAC                                                   65
      WAC=WACCF*WAC                                                      66
      WACC=WACCF*WACC                                                    67
      IF (.NOT.FAN) ERR(5)=(WAF-WAC-BLF)/WAC                             68
      CALL THCOMP (PRC,ETAC,T21,H21,S21,P21,T3,H3,S3,P3)                 69
      IF (PCBLC.GT.0.) BLC=PCBLC*WAC                                     70
      WA3=WAC-BLC                                                        71
      BLDU=PCBLDU*BLC                                                    72
      BLOB=PCBLOB*BLC                                                    73
      BLHP=PCBLHP*BLC                                                    74
      BLLP=PCBLLP*BLC                                                    75
      IF (MODE.NE.1) GO TO 5                                             76
      IF (ABS(CNC-CNCS).LE.0.001*CNCS) GO TO 6                           77
      WRITE (8,9) CNCS,CNC                                               78
      CALL ERROR                                                         79
5     PCNC=100.*THETA*CNC/THETAD                                         80
6     CALL COCOMB                                                        81
      RETURN                                                             82
C                                                                        83
C                                                                        84
7     FORMAT (19HO* * *  CNC OFF MAP,F10.4,2XA6,11H* * *$$$$$$)          85
8     FORMAT (18HOCOMPRESSOR DESIGN,6X8H  PRCCF=,E15.8,8H ETACCF=,E15.8, 86
     18H  WACCF=,E15.8,8H  T21DS=,E15.8)                                 87
9     FORMAT (10HOCNC WAS= ,E15.8,11H  AND NOW= ,E15.8,24H  CHECK PCNC I 88
     1NPUT$$$$$$)                                                        89
      END                                                                90
```

```
$IBFTC COCOMB  DECK
      SUBROUTINE COCOMB                                                   1
      COMMON /   ALL/                                                     2
     1WORD  ,IDES  ,JDES  ,KDES  ,MODE  ,INIT  ,IDUMP ,IAMTP ,           3
     2IGASMX,IDBURN,IAFTBN,IDCD  ,IMCD  ,IDSHOC,IMSHOC,NOZFLT,           4
     3ITRYS ,LOOPER,NOMAP ,NUMMAP,MAPEDG,TOLALL,ERR(6)                   5
      COMMON /DESIGN/                                                     6
     1PCNFGU,PCNCGU,T4GU  ,DUMD1 ,DUMD2 ,DELFG ,DELFN ,DELSFC,           7
     2ZFDS  ,PCNFDS,PRFDS ,ETAFDS,WAFDS ,PRFCF ,ETAFCF,WAFCF ,           8
     3ZCDS  ,PCNCDS,PRCDS ,ETACDS,WACDS ,PRCCF ,ETACCF,WACCF ,           9
     4T4DS  ,WFBDS ,DTCODS,ETABDS,WA3CDS,DPCODS,DTCOCF,ETABCF,          10
     5TFHPDS,CNHPDS,ETHPDS,TFHPCF,CNHPCF,ETHPCF,DHHPCF,T2DS  ,          11
     6TFLPDS,CNLPDS,ETLPDS,TFLPCF,CNLPCF,ETLPCF,DHLPCF,T21DS ,          12
     7T24DS ,WFDDS ,DTDUDS,ETADDS,WA23DS,DPDUDS,DTDUCF,ETADCF,          13
     8T7DS  ,WFADS ,DTAFDS,ETAADS,WG6CDS,DPAFDS,DTAFCF,ETAACF,          14
     9A55   ,A25   ,A6    ,A7    ,A8    ,A9    ,A28   ,A29   ,          15
     $PS55  ,AM55  ,CVDNOZ,CVMNOZ,A8SAV ,A9SAV ,A28SAV,A29SAV          16
      COMMON / FRONT/                                                    17
     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  ,WAFC  ,WAF   ,WA3   ,WG4   ,FAR4  ,          22
     6CNC   ,PRC   ,ETAC  ,WACC  ,WAC   ,ETAB  ,DPCOM ,DUMF  ,          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
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```
      $TFFHP ,TFFLP ,PCBLF ,PCBLC ,PCBLDU,PCBLOB,PCBLHP,PCBLLP                  27
       COMMON/SIDE/ZYX(48)/BACK/YZX(72)                                        28
       COMMON/DUMMYS/DIMMY(100)                                                29
       LOGICAL ERRER,FAN                                                       30
       EQUIVALENCE (FAN,DIMMY(11)),(ISPOOL,DIMMY(6))                           31
       COMMON / COMB/PSI(15),DELT(15,15),ETA(15,15),NPS,NPT(15)                32
       DIMENSION Q(9),DUMBO(15,15)                                             33
       DATA AWORD/6HCOCOMB/                                                    34
       WORD=AWORD                                                              35
       Q(2)=0.                                                                 36
       Q(3)=0.                                                                 37
       P3PSI=14.696*P3                                                         38
       WA3C=WA3*SQRT(T3)/P3PSI                                                 39
       IF (IDES.EQ.1) WA3CDS=WA3C                                              40
       DPCOM=DPCODS*(WA3C/WA3CDS)                                              41
       IF (DPCOM.GT.1.) DPCOM=1.                                               42
       P4=P3*(1.-DPCOM)                                                        43
1      IF (T4.GT.4000.) T4=4000.                                               44
       IF (T4.GE.1000.) GO TO 2                                                45
       T4=1000.                                                                46
       IF (MODE.EQ.1) MAPEDG=1                                                 47
2      DTCO=T4-T3                                                              48
       IF (IDES.NE.1) GO TO 3                                                  49
       DTCODS=DTCO                                                             50
       DTCOCF=DTCODS/DTCO                                                      51
3      DTCO=DTCOCF*DTCO                                                        52
       P3PSIN=P3PSI                                                            53
       CALL SEARCH (-1.,P3PSIN,DTCO,ETAB,DUMMY,PSI(1),NPS,DELT(1,1),ETA(1      54
      1,1),DUMBO(1,1),NPT(1),15,15,IGO)                                        55
       IF (IGO.EQ.7) CALL ERROR                                                56
       IF (IDES.NE.1) GO TO 4                                                  57
       ETABCF=ETABDS/ETAB                                                      58
4      ETAB=ETABCF*ETAB                                                        59
       HV=((((((-.4594317E-19*T4)-.2034116E-15)*T4+.2783643E-11)*T4+.2051      60
      1501E-07)*T4-.2453116E-03)*T4-.9433296E-01)*T4+.1845537E+05              61
       CALL THERMO (P4,HA,T4,XX1,XX2,0,0.0,0)                                  62
       FAR4=(HA-H3)/(HV*ETAB)                                                  63
       IF (FAR4.LT.0.) FAR4=0.                                                 64
       WFBX=FAR4*WA3                                                           65
       IF (MODE.NE.2) GO TO 7                                                  66
       ERRW=(WFB-WFBX)/WFB                                                     67
       DIR=SQRT(WFB/WFBX)                                                      68
       CALL AFQUIR (Q(1),T4,ERRW,0.,20.,0.0001,DIR,T4T,IGO)                    69
       GO TO (5,8,6),IGO                                                       70
5      T4=T4T                                                                  71
       GO TO 1                                                                 72
6      CALL ERROR                                                              73
7      WFB=WFBX                                                                74
8      CALL THERMO (P4,H4,T4,S4,XX2,1,FAR4,0)                                  75
       WG4=WFB+WA3                                                             76
       IF (IDES.EQ.1) WRITE (6,10) WA3CDS,ETABCF,DTCOCF                        77
       IF (ISPOOL.EQ.1) GO TO 9                                                78
       CALL COMPTB                                                             79
       RETURN                                                                  80
9      FAR5=FAR4                                                               81
       T5=T4                                                                   82
       WG5=WG4                                                                 83
       S5=S4                                                                   84
       H5=H4                                                                   85
       P5=P4                                                                   86
       ETATP=1.                                                                87
       CNHP=1.                                                                 88
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      DHHPCF=1.                                                              89
      ETHPCF=1.                                                              90
      TFHPCF=1.                                                              91
      THHCAL=0.                                                              92
      DHTCHP=0.                                                              93
      DHTC=0.                                                                94
      CALL COLPTB                                                            95
      RETURN                                                                 96
C                                                                            97
10    FORMAT (17HOCOMBUSTER DESIGN,7X8H WA3CDS=,E15.8,8H ETABCF=,E15.8,8     98
     1H DTCOCF=,E15.8)                                                       99
      END                                                                   100
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$IBFTC COHPTB  DECK
      SUBROUTINE COHPTB                                                      1
      COMMON /   ALL/                                                        2
     1WORD  ,IDES  ,JDES  ,KDES  ,MODE  ,INIT  ,IDUMP ,IAMTP ,              3
     2IGASMX,IDBURN,IAFTBN,IDCD  ,IMCD  ,IDSHOC,IMSHOC,NOZFLT,              4
     3ITRYS ,LOOPER,NOMAP ,NUMMAP,MAPEDG,TOLALL,ERR(6)                      5
      COMMON /DESIGN/                                                        6
     1PCNFGJ,PCNCGU,T4GU  ,DUMD1 ,DUMD2 ,DELFG ,DELFN ,DELSFC,              7
     2ZFDS  ,PCNFDS,PRFDS ,ETAFDS,WAFDS ,PRFCF ,ETAFCF,WAFCF ,              8
     3ZCDS  ,PCNCDS,PRCDS ,ETACDS,WACDS ,PRCCF ,ETACCF,WACCF ,              9
     4T4DS  ,WFBDS ,DTCODS,ETABDS,WA3CDS,DPCODS,DTCOCF,ETABCF,             10
     5TFHPDS,CNHPDS,ETHPDS,TFHPCF,CNHPCF,ETHPCF,DHHPCF,T2DS  ,             11
     6TFLPDS,CNLPDS,ETLPDS,TFLPCF,CNLPCF,ETLPCF,DHLPCF,T21DS ,             12
     7T24DS ,WFDDS ,DTDUDS,ETADDS,WA23DS,DPDUDS,DTDUCF,ETADCF,             13
     8T7DS  ,WFADS ,DTAFDS,ETAADS,WG6CDS,DPAFDS,DTAFCF,ETAACF,             14
     9A55   ,A25   ,A6    ,A7    ,A8    ,A9    ,A28   ,A29   ,             15
     $PS55  ,AM55  ,CVDNOZ,CVMNOZ,A8SAV ,A9SAV ,A28SAV,A29SAV              16
      COMMON / FRONT/                                                       17
     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  ,WAFC  ,WAF   ,WA3   ,WG4   ,FAR4  ,             22
     6CNC   ,PRC   ,ETAC  ,WACC  ,WAC   ,ETAB  ,DPCOM ,DUMF  ,             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/SIDE/QXQ(48)/BACK/QWQ(72)                                      28
      COMMON/DUMMYS/DUMMY(100)                                              29
      EQUIVALENCE(TFFACT,DUMMY(12)),(CNACT,DUMMY(13)),(DHCACT,DUMMY(14))    30
      COMMON/TERBHI/DHHISV,TFHISV,CNHISV,ETHISV,DHHPDS                      31
      COMMON /HTURB/TFFX(15),CNX(15,15),DHTCX(15,15),ETATX(15,15),          32
     1NTFFS,NPTTFF(15)                                                      33
      DATA AWORD,WLO,WHI/6HCOHPTB,6H (LO) ,6H (HI) /                        34
      WORD=AWORD                                                            35
      IF (IDES.EQ.0) GO TO 1                                                36
      CNHPCF=CNHPDS*SQRT(T4)/PCNC                                           37
1     CNHP=CNHPCF*PCNC/SQRT(T4)                                             38
      CNHPS=CNHP                                                            39
      TFFHPS=TFFHP                                                          40
      CALL SEARCH (-1.,TFFHP,CNHP,DHTCHP,ETATHP,TFFX(1),NTFFS,CNX(1,1),D    41
     1HTCX(1,1),ETATX(1,1),NPTTFF(1),15,15,IGO)                             42
      IF (IGO.EQ.1.OR.IGO.EQ.11.OR.IGO.EQ.21) WRITE (8,8) TFFHPS,WLO        43
      IF (IGO.EQ.2.OR.IGO.EQ.12.OR.IGO.EQ.22) WRITE (8,8) TFFHPS,WHI        44
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      IF (IGO.EQ.10.OR.IGO.EQ.11.OR.IGO.EQ.12) WRITE (8,9) CNHPS,WLO          45
      IF (IGO.EQ.20.OR.IGO.EQ.21.OR.IGO.EQ.22) WRITE (8,9) CNHPS,WHI          46
      IF (IGO.NE.7) GO TO 2                                                   47
      CALL ERROR                                                              48
      RETURN                                                                  49
2     MAPGO=0                                                                 50
      IF (ABS(TFFHPS-TFFHP).LE.0.001*TFFHPS) GO TO 3                          51
      MAPGO=1                                                                 52
      IF (ABS(CNHPS-CNHP).GT.0.001*CNHPS) MAPGO=3                             53
      GO TO 4                                                                 54
3     IF (ABS(CNHPS-CNHP).GT.0.001*CNHPS) MAPGO=2                             55
4     IF (MAPGO.GT.0) CALL MAPBAC (1,MAPGO,TFFHPS,TFFHP,CNHPS,CNHP,PCNC,     55
     1T4,MODE,NOMAP,NUMMAP)                                                   57
      IF (NOMAP.GT.0) RETURN                                                  58
      TFHCAL=WG4*SQRT(T4)/(14.696*P4)                                         59
      BTUEXT=0.706705*HPEXT                                                   60
      DHTCC=(BTUEXT+WAC*(H3-H21))/(WG4*T4)                                    61
      IF (IDES.EQ.0) GO TO 5                                                  62
      TFHPCF=TFHPDS/TFHCAL                                                    63
      DHHPCF=DHTCC/DHTCHP                                                     64
      ETHPCF=ETHPDS/ETATHP                                                    65
      WRITE (6,10) CNHPCF,TFHPCF,ETHPCF,DHHPCF                                66
5     TFHCAL=TFHPCF*TFHCAL                                                    67
      DHTCHP=DHHPCF*DHTCHP                                                    68
      ETATHP=ETHPCF*ETATHP                                                    69
      DHTC=DHTCC*T4                                                           70
      TFFACT=TFHCAL/TFHPCF                                                    71
      CNACT=CNHP/CNHPCF                                                       72
      DHCACT=DHTCHP/DHHPCF                                                    73
      ERR(1)=(TFHCAL-TFFHP)/TFHCAL                                            74
      ERR(2)=(DHTCC-DHTCHP)/DHTCC                                             75
      CALL THTURB (DHTC,ETATHP,FAR4,H4,S4,P4,T5,H5,S5,P5)                     76
      IF (BLHP.LE.0.) GO TO 6                                                 77
      FAR5=WFB/(WA3+BLHP)                                                     78
      WG5=WG4+BLHP                                                            79
      H5=(BLHP*H3+WG4*H5)/WG5                                                 80
      CALL THERMO (P5,H5,T5,S5,XX2,1,FAR5,1)                                  81
      GO TO 7                                                                 82
6     FAR5=FAR4                                                               83
      WG5=WG4                                                                 84
7     CALL COLPTB                                                             85
      RETURN                                                                  86
C                                                                             87
C                                                                             88
8     FORMAT (19HO*****TFFHP OFF MAP,F10.4,2XA6,11H*****$$$$$$)              89
9     FORMAT (19HO***** CNHP OFF MAP,F10.4,2XA6,11H*****$$$$$$)              90
10    FORMAT (20HOH.P. TURBINE DESIGN,5X7HCNHPCF=,E15.8,8H TFHPCF=,E15.8      91
     1,8H ETHPCF=,E15.8,8H DHHPCF=,E15.8)                                     92
      END                                                                     93
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$IBFTC COLPTB  DECK
      SUBROUTINE COLPTB                                                       1
      COMMON /   ALL/                                                         2
     1WORD  ,IDES  ,JDES  ,KDES  ,MODE  ,INIT  ,IDUMP ,IAMTP ,               3
     2IGASMX,IDBURN,IAFTBN,IDCD  ,IMCD  ,IDSHOC,IMSHOC,NOZFLT,               4
     3ITRYS ,LOOPER,NOMAP ,NUMMAP,MAPEDG,TOLALL,ERR(6)                        5
      COMMON /DESIGN/                                                         6
     1PCNFGJ,PCNCGU,T4GU  ,DUMD1 ,DUMD2 ,DELFG ,DELFN ,DELSFC,                7
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     2ZFDS   ,PCNFDS,PRFDS ,ETAFDS,WAFDS ,PRFCF ,ETAFCF,WAFCF ,                  8
     3ZCDS   ,PCNCDS,PRCDS ,ETACDS,WACDS ,PRCCF ,ETACCF,WACCF ,                  9
     4T4DS   ,WFBDS ,DTCODS,ETABDS,WA3CDS,DPCODS,DTCOCF,ETABCF,                 10
     5TFHPDS,CNHPDS,ETHPDS,TFHPCF,CNHPCF,ETHPCF,DHHPCF,T2DS   ,                 11
     6TFLPDS,CNLPDS,ETLPDS,TFLPCF,CNLPCF,ETLPCF,DHLPCF,T21DS ,                  12
     7T24DS ,WFDDS ,DTDUDS,ETADDS,WA23DS,DPDUDS,DTDUCF,ETADCF,                  13
     8T7DS   ,WFADS ,DTAFDS,ETAADS,WG6CDS,DPAFDS,DTAFCF,ETAACF,                 14
     9A55    ,A25   ,A6    ,A7    ,A8    ,A9    ,A28   ,A29   ,                 15
     $PS55   ,AM55  ,CVDNOZ,CVMNOZ,A8SAV ,A9SAV ,A28SAV,A29SAV                  16
      COMMON / FRONT/                                                           17
     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  ,WAFC  ,WAF   ,WA3   ,WG4   ,FAR4  ,                22
     6CNC    ,PRC   ,ETAC  ,WACC  ,WAC   ,ETAB  ,DPCOM ,DUMF  ,                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/SIDE/QXQ(48)/BACK/QWQ(72)                                          28
      COMMON/DUMMYS/DUMMY(100)                                                  29
      EQUIVALENCE(TFFACT,DUMMY(15)),(CNACT,DUMMY(16)),(DHCACT,DUMMY(17))        30
      LOGICAL ERRER,FAN                                                         31
      EQUIVALENCE (FAN,DUMMY(11)),(ISPOOL,DUMMY(6))                             32
      COMMON/TERBLO/DHLOSV,TFLOSV,CNLOSV,ETLOSV,DHLPDS                          33
      COMMON /LTURB/TFFX(15),CNX(15,15),DHTCX(15,15),ETATX(15,15),              34
     1NTFFS,NPTTFF(15)                                                          35
      DATA AWORD,WLO,WHI/6HCOLPTB,6H (LO) ,6H (HI) /                            36
      WORD=AWORD                                                                37
      IF (IDES.EQ.0) GO TO 1                                                    38
      CNLPCF=CNLPDS*SQRT(T5)/PCNF                                               39
1     CNLP=CNLPCF*PCNF/SQRT(T5)                                                 40
      CNLPS=CNLP                                                                41
      TFFLPS=TFFLP                                                              42
      CALL SEARCH (-1.,TFFLP,CNLP,DHTCLP,ETATLP,TFFX(1),NTFFS,CNX(1,1),D        43
     1HTCX(1,1),ETATX(1,1),NPTTFF(1),15,15,IGO)                                 44
      IF (IGO.EQ.1.OR.IGO.EQ.11.OR.IGO.EQ.21) WRITE (8,10) TFFLPS,WLO           45
      IF (IGO.EQ.2.OR.IGO.EQ.12.OR.IGO.EQ.22) WRITE (8,10) TFFLPS,WHI           46
      IF (IGO.EQ.10.OR.IGO.EQ.11.OR.IGO.EQ.12) WRITE (8,11) CNLPS,WLO           47
      IF (IGO.EQ.20.OR.IGO.EQ.21.OR.IGO.EQ.22) WRITE (8,11) CNLPS,WHI           48
      IF (IGO.NE.7) GO TO 2                                                     49
      CALL ERROR                                                                50
      RETURN                                                                    51
2     MAPGO=0                                                                   52
      IF (ABS(TFFLPS-TFFLP).LE.0.001*TFFLPS) GO TO 3                            53
      MAPGO=1                                                                   54
      IF (ABS(CNLPS-CNLP).GT.0.001*CNLPS) MAPGO=3                               55
      GO TO 4                                                                   56
3     IF (ABS(CNLPS-CNLP).GT.0.001*CNLPS) MAPGO=2                               57
4     IF (MAPGO.GT.0) CALL MAPBAC (2,MAPGO,TFFLPS,TFFLP,CNLPS,CNLP,PCNF,        58
     1T4,MODE,NOMAP,NUMMAP)                                                     59
      IF (NOMAP.GT.0) RETURN                                                    60
      TFLCAL=WG5*SQRT(T5)/(14.696*P5)                                           61
      DHTCF=WAF*(H21-H2)/(WG5*T5)                                               62
      IF (ISPOOL.EQ.2) GO TO 5                                                  63
      BTUEXT=0.706705*HPEXT                                                     64
      DHTCF=(BTUEXT+WAF*(H21-H2))/(WG5*T5)                                      65
5     CONTINUE                                                                  66
      IF (IDES.EQ.0) GO TO 6                                                    67
      TFLPCF=TFLPDS/TFLCAL                                                      68
      DHLPCF=DHTCF/DHTCLP                                                       69
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      ETLPCF=ETLPDS/ETATLP                                                    70
      WRITE (6,12) CNLPCF,TFLPCF,ETLPCF,DHLPCF                                71
6     TFLCAL=TFLPCF*TFLCAL                                                    72
      DHTCLP=DHLPCF*DHTCLP                                                    73
      ETATLP=ETLPCF*ETATLP                                                    74
      DHTF=DHTCF*T5                                                           75
      TFFACT=TFLCAL/TFLPCF                                                    76
      CNACT=CNLP/CNLPCF                                                       77
      DHCACT=DHTCLP/DHLPCF                                                    78
      I1=3                                                                    79
      I2=4                                                                    80
      IF (ISPOOL.NE.1) GO TO 7                                                81
      I1=1                                                                    82
      I2=2                                                                    83
7     ERR(I1)=(TFLCAL-TFFLP)/TFLCAL                                           84
      ERR(I2)=(DHTCF-DHTCLP)/DHTCF                                            85
      CALL THTURB (DHTF,ETATLP,FAR5,H5,S5,P5,T55,H55,S55,P55)                 86
      IF (BLLP.LE.0.) GO TO 8                                                 87
      FAR55=WFB/(WA3+BLHP+BLLP)                                               88
      WG55=WG5+BLLP                                                           89
      H55=(BLLP*H3+WG5*H55)/WG55                                              90
      CALL THERMO (P55,H55,T55,S55,XX2,1,FAR55,1)                             91
      GO TO 9                                                                 92
8     FAR55=FAR5                                                              93
      WG55=WG5                                                                94
9     CALL FRTOSD                                                             95
      RETURN                                                                  96
C                                                                             97
C                                                                             98
10    FORMAT (19H0*****TFFLP OFF MAP,F10.4,2XA6,11H*****$$$$$$)              99
11    FORMAT (19H0***** CNLP OFF MAP,F10.4,2XA6,11H*****$$$$$$)             100
12    FORMAT (20HOL.P. TURBINE DESIGN,5X7HCNLPCF=,E15.8,8H TFLPCF=,E15.8     101
     1,8H ETLPCF=,E15.8,8H DHLPCF=,E15.8)                                    102
      END                                                                    103
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$IBFTC CODUCT  DECK
      SUBROUTINE CODUCT                                                       1
      COMMON /   ALL/                                                         2
     1WORD  ,IDES  ,JDES  ,KDES  ,MODE  ,INIT  ,IDUMP ,IAMTP ,               3
     2IGASMX,IDBURN,IAFTBN,IDCD  ,IMCD  ,IDSHOC,IMSHOC,NOZFLT,               4
     3ITRYS ,LOOPER,NOMAP ,NUMMAP,MAPEDG,TOLALL,ERR(6)                       5
      COMMON /DESIGN/                                                         6
     1PCNFGJ,PCNCGU,T4GU  ,DUMD1 ,DUMD2 ,DELFG ,DELFN ,DELSFC,               7
     2ZFDS  ,PCNFDS,PRFDS ,ETAFDS,WAFDS ,PRFCF ,ETAFCF,WAFCF ,               8
     3ZCDS  ,PCNCDS,PRCDS ,ETACDS,WACDS ,PRCCF ,ETACCF,WACCF ,               9
     4T4DS  ,WFBDS ,DTCODS,ETABDS,WA3CDS,DPCODS,DTCOCF,ETABCF,              10
     5TFHPDS,CNHPDS,ETHPDS,TFHPCF,CNHPCF,ETHPCF,DHHPCF,T2DS  ,              11
     6TFLPDS,CNLPDS,ETLPDS,TFLPCF,CNLPCF,ETLPCF,DHLPCF,T21DS ,              12
     7T24DS ,WFDDS ,DTDUDS,ETADDS,WA23DS,DPDUDS,DTDUCF,ETADCF,              13
     8T7DS  ,WFADS ,DTAFDS,ETAADS,WG6CDS,DPAFDS,DTAFCF,ETAACF,              14
     9A55   ,A25   ,A6    ,A7    ,A8    ,A9    ,A28   ,A29   ,              15
     $PS55  ,AM55  ,CVDNOZ,CVMNOZ,A8SAV ,A9SAV ,A28SAV,A29SAV              15
      COMMON/FRONT/XX(80)                                                    17
      COMMON /  SIDE/                                                        18
     1P1    ,WAF   ,WAC   ,BLF   ,BLDU  ,H3    ,DUMS1 ,DUMS2 ,              19
     2T21   ,P21   ,H21   ,S21   ,T23   ,P23   ,H23   ,S23   ,              20
     3T24   ,P24   ,H24   ,S24   ,T25   ,P25   ,H25   ,S25   ,              21
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     4T28   ,P28   ,H28   ,S28   ,T29   ,P29   ,H29   ,S29   ,                  22
     5WAD   ,WFD   ,WG24  ,FAR24 ,ETAD  ,DPDUC ,BYPASS,DUMS3 ,                  23
     6TS28  ,PS28  ,V28   ,AM28  ,TS29  ,PS29  ,V29   ,AM29                     24
      COMMON/BACK/ZZ(72)                                                        25
      COMMON/DUMMYS/DUMMY(100)                                                  26
      EQUIVALENCE(A24,DUMMY(4)),(AM23,DUMMY(5))                                 27
      EQUIVALENCE (AM25,ZZ(48))                                                 28
      DIMENSION Q(9)                                                            29
      DATA AWORD1,AWORD2/6HCODUCT,6HDNOZZL/                                     30
      WORD=AWORD1                                                               31
      Q(2)=0.                                                                   32
      Q(3)=0.                                                                   33
      AJ=778.26                                                                 34
      CAPSF=2116.2170                                                           35
      GOGO=0.0                                                                  36
      G=32.174049                                                               37
      WAX=WAF-WAC-BLF                                                           38
      WAD=WAX+BLDU                                                              39
      P23=P21                                                                   40
C***  DRY LOSS                                                                  41
      H23=(BLDU*H3+WAX*H21)/WAD                                                 42
      CALL THERMO (P23,H23,T23,S23,XX2,1,0.0,1)                                 43
      WA23C=WAD*SQRT(T23)/P23                                                   44
      IF (IDES.EQ.1) WA23DS=WA23C                                               45
      BYPASS=(WAF-WAC)/WAC                                                      46
      DPDUC=DPDUDS*(WA23C/WA23DS)                                               47
      IF (DPDUC.GT.1.) DPDUC=1.0                                                48
      P24=P23*(1.-DPDUC)                                                        49
      CALL PROCOM (0.,T23,XX1,XX2,XX3,XX4,PHI23,XX6)                            50
      IF (IGASMX.GT.0) IDBURN=0                                                 51
      AM24=AM23                                                                 52
      TS24=T23*0.875                                                            53
1     DO 2 I=1,15                                                               54
      CALL PROCOM (0.,TS24,CS24,AK24,CP24,REX24,PHIS24,HS24)                    55
      V24=AM24*CS24                                                             56
      HSCAL=H23-V24**2/(2.*G*AJ)                                                57
      DELHS=HSCAL-HS24                                                          58
      IF (ABS(DELHS).LE.0.001*HSCAL) GO TO 3                                    59
2     TS24=TS24+DELHS/CP24                                                      60
      GO TO 10                                                                  61
3     C1=P24*SQRT(G/(T23*AJ))*CAPSF                                             62
      IF (IDES.NE.1) GO TO 4                                                    63
      IF (GOGO.GT.0.) GO TO 4                                                   64
      ASTOA=((AK24+1.)/2.)**((AK24+1.)/(2.*(AK24-1.)))*AM24*(1.+(((AK24-        65
     11.)/2.)*AM24**2))**((AK24+1.)/(2.*(AK24-1.)))                             66
      EQWCR=SQRT(G*AK24/REX24/AJ)/(SQRT(518.69)/2116.2)*(2.0/(AK24+1.))*        67
     1*((AK24+1.)/2./(AK24-1.))                                                 68
      WA23CC=WA23C/SQRT(518.69)                                                 69
      A24=1./ASTOA*WA23CC/EQWCR                                                 70
      GOGO=1.0                                                                  71
4     WQA=WAD/A24                                                               72
      WQAT=C1*SQRT(AK24/REX24)*AM24/(1.+(AK24-1.)*AM24**2/2.)**((AK24+1.        73
     1)/(2.*(AK24-1.)))                                                         74
      DIR=WQA/WQAT                                                              75
      EW=(WQA-WQAT)/WQA                                                         76
      CALL AFQUIR (Q(1),AM24,EW,0.,30.,0.001,DIR,AM24T,IGO)                     77
      GO TO (5,6,10),IGO                                                        78
5     AM24=AM24T                                                                79
      IF (AM24.GT.1.0) AM24=0.5                                                 80
      GO TO 1                                                                   81
6     PS24=P24/EXP((PHI23-PHIS24)/REX24)                                        82
      IF (IDBURN.GT.0) GO TO 7                                                  83
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C***  NON-DUCT BURNING                                                    84
      T24=T23                                                            85
      WFD=0.                                                             86
      FAR24=0                                                            87
      GO TO 16                                                           88
7     IF (IDBURN.EQ.2) T24=T23+2000.                                     89
8     IF (T24.GT.4000.) T24=4000.                                        90
      IF (T24.LT.T23) T24=T23                                            91
C***  DUCT BURNING                                                       92
      RHO42=CAPSF*PS24/(AJ*REX24*TS24)                                   93
      PS42=PS24                                                          94
      V42=V24                                                            95
      Q(2)=0.                                                            96
      Q(3)=0.                                                            97
C *** IF DESIRED, ENTER CALCULATIONS FOR ETAD HERE                       98
      HV=((((((-.4594317E-19*T24)-.2034116E-15)*T24+.2783643E-11)*T24+.2 99
     1051501E-07)*T24-.2453116E-03)*T24-.9433296E-01)*T24+.1845537E+05   100
      CALL THERMO (P24,HA,T24,XX1,XX2,0,0.0,0)                           101
      FAR24=(HA-H23)/(HV*ETAD)                                           102
      IF (FAR24.LT.0.) FAR24=0.                                          103
      WFDX=FAR24*WAD                                                     104
      IF (IDBURN.NE.2) GO TO 11                                          105
      ERRW=(WFD-WFDX)/WFD                                                106
      DIR=SQRT(WFD/WFDX)                                                 107
      CALL AFQUIR (Q(1),T24,ERRW,0.,20.,0.0001,DIR,T24T,IGO)             108
      GO TO (9,12,10),IGO                                                109
9     T24=T24T                                                           110
      GO TO 8                                                            111
10    CALL ERROR                                                         112
11    WFD=WFDX                                                           113
12    CONTINUE                                                           114
C***  MOMENTUM LOSS                                                      115
      WG24=WFD+WAD                                                       116
      CALL PROCOM (FAR24,T24,XX1,XX2,XX3,REX24,PHI24,H24)                117
      RHO24=CAPSF*P24/(AJ*REX24*T24)                                     118
      V24=WG24/(RHO24*A24)                                               119
      Q(2)=0.                                                            120
      Q(3)=0.                                                            121
      PS24=PS42-0.01                                                     122
13    RHO24=WG24/(V24*A24)                                               123
      HS24=H24-V24**2/(2.*G*AJ)                                          124
      CALL THERMO (1.0,HS24,TS24,PHIS24,XX2,1,FAR24,1)                   125
      IF (TS24.GE.301.) GO TO 14                                         126
      CALL THERMO (1.0,HS24,400.,PHIS24,XX2,1,FAR24,1)                   127
      V24=SQRT(2.*G*AJ*(H24-HS24))                                       128
      GO TO 13                                                           129
14    PS24=RHO24*AJ*REX24*TS24/CAPSF                                     130
      PS24A=PS42+(RHO42*V42**2-RHO24*V24**2)/(G*CAPSF)                   131
      DIR=SQRT(ABS(PS24/PS24A))                                          132
      EP=(PS24-PS24A)/PS24                                               133
      CALL AFQUIR (Q(1),V24,EP,0.,50.,0.001,DIR,V24T,IGO)                134
      V24=V24T                                                           135
      IF (V24.LT.25.) V24=25.                                            136
      GO TO (13,15,10),IGO                                               137
15    P24=PS24*EXP((PHI24-PHIS24)/REX24)                                 138
      CALL PROCOM (FAR24,TS24,CS24,XX2,XX3,XX4,XX5,XX6)                  139
      AM24=V24*CS24                                                      140
16    CALL THERMO (P24,H24,T24,S24,XXI,1,FAR24,0)                        141
      WG24=WFD+WAD                                                       142
      T25=T24                                                            143
      P25=P24                                                            144
      H25=H24                                                            145
```

```
      S25=S24                                                                146
      AM25=AM24                                                              147
      IF (IGASMX.GT.0) GO TO 20                                              148
      WORD=AWORD2                                                            149
      A28SAV=A28                                                             150
      A29SAV=A29                                                             151
      NOZD=0                                                                 152
      IDNOZ=0                                                                153
      IF (NOZFLT.EQ.2.OR.NOZFLT.EQ.3) NOZD=1                                 154
      IF (IDES.EQ.1.OR.IDBURN.GT.0.OR.NOZD.EQ.1) IDNOZ=1                     155
      IF (IDBURN.EQ.1.OR.NOZFLT.EQ.2.OR.NOZFLT.EQ.3) IDCD=1                  156
      IF (IDBURN.EQ.0.AND.NOZFLT.EQ.0) IDCD=0                                157
      IF (IDCD.EQ.1) GO TO 17                                                158
      CALL CONVRG (T25,H25,P25,S25,FAR24,WG24,P1,IDNOZ,A28,P25R,T28,H28,     159
     1P28,S28,TS28,PS28,V28,AM28,ICON)                                       160
      GO TO (18,18,18,10),ICON                                               161
17    CALL CONDIV (T25,H25,P25,S25,FAR24,WG24,P1,IDNOZ,A28,A29,P25R,T28,     162
     1H28,P28,S28,T29,H29,P29,S29,TS28,TS29,PS28,PS29,V28,V29,AM28,AM29,     163
     2ICON)                                                                  164
      IDSHOC=ICON                                                            165
      GO TO (19,19,19,10),ICON                                               166
18    T29=T28                                                                167
      H29=H28                                                                168
      P29=P28                                                                169
      S29=S28                                                                170
      TS29=TS28                                                              171
      PS29=PS28                                                              172
      V29=V28                                                                173
      AM29=AM28                                                              174
      A29=A28                                                                175
      IDSHOC=ICON+3                                                          176
19    ERR(5)=(P25R-P25)/P25R                                                 177
      IF (IDNOZ.EQ.1) WRITE (6,21) A28,AM28,A29,AM29                         178
20    CALL FASTBK                                                            179
      RETURN                                                                 180
C                                                                            181
C                                                                            182
21    FORMAT (19HODUCT NOZZLE DESIGN,5X8H    A28=,E15.8,8H   AM28=,E15.8     183
     1,8H    A29=,E15.8,8H   AM29=,E15.8)                                    184
      END                                                                    185
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```
$IBFTC COM1X   DECK
      SUBROUTINE COMIX                                                        1
      COMMON /   ALL/                                                         2
     1WORD  ,IDES  ,JDES  ,KDES  ,MODE  ,INIT  ,IDUMP ,IAMTP ,               3
     2IGASMX,IDBURN,IAFTBN,IDCD  ,IMCD  ,IDSHOC,IMSHOC,NOZFLT,               4
     3ITRYS ,LOOPER,NOMAP ,NUMMAP,MAPEDG,TOLALL,ERR(6)                       5
      COMMON /DESIGN/                                                         6
     1PCNFGJ,PCNCGU,T4GU  ,DUMD1 ,DUMD2 ,DELFG ,DELFN ,DELSFC,               7
     2ZFDS  ,PCNFDS,PRFDS ,ETAFDS,WAFDS ,PRFCF ,ETAFCF,WAFCF ,               8
     3ZCDS  ,PCNCDS,PRCDS ,ETACDS,WACDS ,PRCCF ,ETACCF,WACCF ,               9
     4T4DS  ,WFBDS ,DTCODS,ETABDS,WA3CDS,DPCODS,DTCOCF,ETABCF,              10
     5TFHPDS,CNHPDS,ETHPDS,TFHPCF,CNHPCF,ETHPCF,DHHPCF,T2DS  ,              11
     6TFLPDS,CNLPDS,ETLPDS,TFLPCF,CNLPCF,ETLPCF,DHLPCF,T21DS ,              12
     7T24DS ,WFDDS ,DTDUDS,ETADDS,WA23DS,DPDUDS,DTDUCF,ETADCF,              13
     8T7DS  ,WFADS ,DTAFDS,ETAADS,WG6CDS,DPAFDS,DTAFCF,ETAACF,              14
     9A55   ,A25   ,A6    ,A7    ,A8    ,A9    ,A28   ,A29   ,               15
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```
      $PS55  ,AM55  ,CVDNOZ,CVMNOZ,A8SAV ,A9SAV ,A28SAV,A29SAV                16
       COMMON/FRONT/QZQ(80)/SIDE/QWQ(48)                                      17
       COMMON /  BACK/                                                        18
      1T55   ,P55   ,H55   ,S55   ,T25   ,P25   ,H25   ,S25   ,               19
      2WFB   ,WG55  ,FAR55 ,WFD   ,WG24  ,FAR24 ,P1    ,DUMB  ,               20
      3T6    ,P6    ,H6    ,S6    ,T7    ,P7    ,H7    ,S7    ,               21
      4T8    ,P8    ,H8    ,S8    ,T9    ,P9    ,H9    ,S9    ,               22
      5WG6   ,WFA   ,WG7   ,FAR7  ,ETAA  ,DPAFT ,V55   ,V25   ,               23
      6PS6   ,V6    ,AM6   ,TS7   ,PS7   ,V7    ,AM7   ,AM25  ,               24
      7TS8   ,PS8   ,V8    ,AM8   ,TS9   ,PS9   ,V9    ,AM9   ,               25
      8VA    ,FRD   ,VJD   ,FGMD  ,VJM   ,FGMM  ,FGPD  ,FGPM  ,               26
      9FGM   ,FGP   ,WFT   ,WGT   ,FART  ,FG    ,FN    ,SFC                   27
       EQUIVALENCE(ZF,QZQ(68)),(PCNF,QZQ(69))                                 28
       COMMON/DUMMYS/DUMMY(100)                                               29
       COMMON/LOOPPR/KKGO,PRFNEW,PRCNEW                                       30
       DATA AWORD/6H COMIX/                                                   31
       DIMENSION QQ(9)                                                        32
       WORD=AWORD                                                             33
       AJ=778.26                                                              34
       CAPSF=2116.2170                                                        35
       G=32.174049                                                            36
       CALL PROCOM (FAR55,T55,XX1,XX2,XX3,XX4,PHI55,XX5)                      37
       CALL PROCOM (FAR24,T25,XX1,XX2,XX3,XX4,PHI25,XX5)                      38
       IF (IDES.EQ.0) GO TO 12                                                39
C *** CALCULATE A55 AND A25 WITH PS25=PS55                                    40
       IF (PS55.EQ.0.) GO TO 3                                                41
       TS55=T55*(PS55/P55)**0.286                                             42
       DO 1 I=1,15                                                            43
       CALL PROCOM (FAR55,TS55,CS55,AK55,CP55,REX55,PHIS55,HS55)              44
       PHIS=PHI55-REX55*ALOG(P55/PS55)                                        45
       DELPHI=PHIS-PHIS55                                                     46
       IF (ABS(DELPHI).LE.0.0001*PHIS) GO TO 6                                47
1      TS55=TS55*EXP(4.0*DELPHI)                                              48
2      CALL ERROR                                                             49
       RETURN                                                                 50
3      TS55=0.875*T55                                                         51
       DO 4 I=1,15                                                            52
       CALL PROCOM (FAR55,TS55,CS55,AK55,CP55,REX55,PHIS55,HS55)              53
       V55=AM55*CS55                                                          54
       HSCAL=H55-V55**2/(2.*G*AJ)                                             55
       DELHS=HSCAL-HS55                                                       56
       IF (ABS(DELHS).LE.0.0005*HSCAL) GO TO 5                                57
4      TS55=TS55+DELHS/CP55                                                   58
       GO TO 2                                                                59
5      PS55=P55/EXP((PHI55-PHIS55)/REX55)                                     60
       IF (PS55.GT.P25.AND.IDES.EQ.1.AND.IGASMX.GT.0) GO TO 47                61
6      IF (H55.GT.HS55) GO TO 7                                               62
       WRITE (8,48) P55,PS55,T55,TS55,H55,HS55                                63
       CALL ERROR                                                             64
7      V55=SQRT(2.*G*AJ*(H55-HS55))                                           65
       RHO=CAPSF*PS55/(AJ*REX55*TS55)                                         66
       A55=W355/(RHO*V55)                                                     67
       AM55=V55/CS55                                                          68
       IF (IGASMX.GT.0) GO TO 8                                               69
       WRITE (6,49) A55,AM55                                                  70
       IF (IGASMX.EQ.-1) GO TO 35                                             71
       IF (IGASMX.EQ.0) GO TO 43                                              72
8      PS25=PS55                                                              73
       TS25=T25*(PS25/P25)**0.286                                             74
       DO 9 I=1,15                                                            75
       CALL PROCOM (FAR24,TS25,CS25,AK25,CP25,REX25,PHIS25,HS25)              76
       PHIS=PHI25-REX25*ALOG(P25/PS25)                                        77
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      GQ(2)=0.                                                          141
      GQ(3)=0.                                                          142
      AM25=0.25                                                         143
      TS25=0.875*T25                                                    144
23    DO 24 I=1,15                                                      145
      CALL PROCOM (FAR24,TS25,CS25,AK25,CP25,REX25,PHIS25,HS25)         146
      V25=AM25*CS25                                                     147
      HSCAL=H25-V25**2/(2.*G*AJ)                                        148
      DELHS=HSCAL-HS25                                                  149
      IF (ABS(DELHS).LE.0.0005*HSCAL) GO TO 25                          150
24    TS25=TS25+DELHS/CP25                                              151
      GO TO 2                                                           152
25    WQAT=C1*SQRT(AK25/REX25)*AM25/(1.+(AK25-1.)*AM25**2/2.)**((AK25+1.  153
     1)/(2.*(AK25-1.)))                                                 154
      AMX=AM25                                                          155
      IGOGO=1                                                           156
      GO TO 16                                                          157
26    PS25=P25/EXP((PHI25-PHIS25)/REX25)                                158
27    WG6=WG24+WG55                                                     159
      ERR(5)=(PS25-PS55)/PS25                                           160
      WF6=WFD+WFB                                                       161
      FAR6=WF6/(WG6-WF6)                                                162
      H6=(WG24*H25+WG55*H55)/WG6                                        163
      CALL THERMO (1.,H6,T6,PHI6,AMX,1,FAR6,1)                          164
      C1=PS55*A55*(1.+AK55*AM55**2)+PS25*A25*(1.+AK25*AM25**2)          165
      TS6=0.833*T6                                                      166
      DO 32 I=1,15                                                      167
      CALL PROCOM (FAR6,TS6,CS6,AK6,CP6,REX6,PHIS6,HS6)                 168
      C2=WG6*SQRT(AJ*REX6*T6/(AK6*G))                                   169
      C3=C2/(CAPSF*C1)                                                  170
      C4=(AK6-1.)/2.-(C3*AK6)**2                                        171
      C5=1.-2.*AK6*C3**2                                                172
      C6=C5**2+4.*C4*C3**2                                              173
      IF (C6) 28,29,30                                                  174
28    CALL ERROR                                                        175
      RETURN                                                            176
29    AM62G=-C5/(2.*C4)                                                 177
      GO TO 31                                                          178
30    AM62G=(SQRT(C6)-C5)/(2.*C4)                                       179
31    IF (AM62G.LE.0.) GO TO 28                                         180
      AM6G=SQRT(AM62G)                                                  181
      V6=AM6G*CS6                                                       182
      HSCAL=H6-V6**2/(2.*G*AJ)                                          183
      DELHS=HSCAL-HS6                                                   184
      IF (ABS(DELHS).LE.0.0005*HSCAL) GO TO 33                          185
32    TS6=TS6+DELHS/CP6                                                 186
      GO TO 28                                                          187
33    IF (IGASMX.GT.0) GO TO 34                                         188
34    A6G=A25+A55                                                       189
      C7=SQRT(1.+(AK6-1.)*AM62G/2.)                                     190
      PS6=C2/(CAPSF*A6G*AM6G*C7)                                        191
      P6=PS6*EXP((PHI6-PHIS6)/REX6)                                     192
      CALL THERMO (P6,H6,T6,S6,XX1,1,FAR6,0)                            193
      S6AVE=(WG24*S25+WG55*S55)/WG6                                     194
      IF (S6.GE.S6AVE) GO TO 35                                         195
      S6=S6AVE                                                          196
      P6=EXP(AMX*(PHI6-S6)/1.986375)                                    197
35    IF (IGASMX.EQ.1) GO TO 45                                         198
      IF (IGASMX.EQ.-1) GO TO 36                                        199
      IF (IGASMX.EQ.2) GO TO 37                                         200
36    T6=T55                                                            201
      P6=P55                                                            202
      H6=H55                                                            203
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      S6=S55                                                            204
      WG6=WG55                                                          205
      PS6=PS55                                                          206
      FAR6=FAR55                                                        207
      AK6=AK55                                                          208
37    IF (IDES.EQ.0) GO TO 40                                           209
C***  CALCULATES A6 AS A FUNCTION OF INPUT AM6                          210
      TS6=T5/(1.0+(((AK6-1.0)/2.0)*AM6**2))                             211
      DO 38 JJ=1,15                                                     212
      AK6P=AK6                                                          213
      CALL PROCOM (FAR6,TS6,CS6,AK6,CP6,REX6,PHIS6,HS6)                 214
      V6=AM6*CS6                                                        215
      DELAK6=AK6P-AK6                                                   216
      IF (ABS(DELAK6).LE.0.0005*AK6) GO TO 39                           217
38    TS6=T5/(1.0+(((AK6-1.0)/2.0)*AM6**2))                             218
      GO TO 28                                                          219
39    PS6=P5/((1.0+(((AK6-1.0)/2.0)*AM6**2))**(AK6/(AK6-1.0)))          220
      AM6ABD=AM6                                                        221
      RHO=CAPSF*PS6/(AJ*REX6*TS6)                                       222
      A6=WG6/(RHO*V6)                                                   223
      WRITE (6,54) A6                                                   224
      GO TO 46                                                          225
C     CALCULATES M6=F(A6DESIGN)                                         226
40    TS6P=T6/(1.0+(((AK6-1.0)/2.0)*AM6ABD**2))                         227
      DO 41 I=1,15                                                      228
      CALL PROCOM (FAR6,TS6P,CS6,AK6,CP6,REX6,PHIS6,HS6)                229
      PS6P=PS6*(TS6P/TS6)**(AK6/(AK6-1.0))                              230
      RHO6=CAPSF*PS6P/(AJ*REX6*TS6P)                                    231
      V6=SQRT(2.*G*AJ*(H6-HS6))                                         232
      IF ((H5-HS6).LT.0.0) GO TO 44                                     233
      A6P=WG6/(RHO6*V6)                                                 234
      DELA6=A6P-A6                                                      235
      V6=WG6/(RHO6*A6)                                                  236
      AM6=V6/CS6                                                        237
      AM62=AM6**2                                                       238
      IF (ABS(DELA6).LE.00.002*A6) GO TO 42                             239
41    TS6P=T5/(1.0+(((AK6-1.0)/2.0)*AM62))                              240
      GO TO 28                                                          241
42    TS6=TS6P                                                          242
      PS6=PS6P                                                          243
      GO TO 46                                                          244
43    T6=T55                                                            245
      P6=P55                                                            246
      H6=H55                                                            247
      S6=S55                                                            248
      WG6=WG55                                                          249
      PS6=PS55                                                          250
      V6=V55                                                            251
      AM6=AM55                                                          252
      IF (IGASMX.EQ.0) A6=A55                                           253
      GO TO 46                                                          254
44    WRITE (6,55) H6,HS6                                               255
      GO TO 28                                                          256
45    AM62=AM62G                                                        257
      AM6=AM6G                                                          258
      A6=A25+A55                                                        259
46    CALL CDAFBN                                                       260
      RETURN                                                            261
47    KKGO=1                                                            262
      OPRDS=PRFDS*PRCDS                                                 263
      PRFNEW=PRFDS*PS55/P25*1.02                                        264
      PRCNEW=OPRDS/PRFNEW                                               265
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      CALL ENGBAL                                                          265
      RETURN                                                               267
C                                                                          268
C                                                                          269
48    FORMAT (22HOSQRT OF H55-HS55 NEG ,6E15.6,6H$$$$$$)                   270
49    FORMAT (20HOTURBINE AREA DESIGN,6X6H  A55=,E15.8,8H   AM55=,E15.8)   271
50    FORMAT (22HOSQRT OF H25-HS25 NEG ,6E15.6,6H$$$$$$)                   272
51    FORMAT (25HOTURBINE/DUCT AREA DESIGN,7H   A55=,E15.8,8H   AM55=,E1   273
     15.8,8H    A25=,E15.8,8H   AM25=,E15.8)                              274
52    FORMAT (12HOCOMIX PCNF=,F7.4,4H AM=,F8.6,5H P55=,F9.5,6H PS55=,F9.   275
     15,5H P25=,F9.5,6H PS25=,F9.5,6H$$$$$$)                              276
53    FORMAT (10HOCOMIX ZF=,F8.5,4H AM=,F8.6,5H P55=,F9.5,6H PS55=,F9.5,   277
     15H P25=,F9.5,6H PS25=,F9.5,6H$$$$$$)                                278
54    FORMAT (3X,27HAFTERBURNER DESIGN AREA A6 F8.3)                       279
55    FORMAT (3X,18HNEG.HS6 FACTOR H6 F9.4,3X,4HHS6 F9.4)                  280
      END                                                                  281
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$IBFTC COAFBN  DECK
      SUBROUTINE COAFBN                                                     1
      COMMON /   ALL/                                                       2
     1WORD  ,IDES  ,JDES  ,KDES  ,MODE  ,INIT  ,IDUMP ,IAMTP ,             3
     2IGASMX,IDBURN,IAFTBN,IDCD  ,IMCD  ,IDSHOC,IMSHOC,NOZFLT,              4
     3ITRYS ,LOOPER,NOMAP ,NUMMAP,MAPEDG,TOLALL,ERR(6)                      5
      COMMON /DESIGN/                                                       6
     1PCNFGJ,PCNCGU,T4GU  ,DUMD1 ,DUMD2 ,DELFG ,DELFN ,DELSFC,              7
     2ZFDS  ,PCNFDS,PRFDS ,ETAFDS,WAFDS ,PRFCF ,ETAFCF,WAFCF ,              8
     3ZCDS  ,PCNCDS,PRCDS ,ETACDS,WACDS ,PRCCF ,ETACCF,WACCF ,              9
     4T4DS  ,WFBDS ,DTCODS,ETABDS,WA3CDS,DPCODS,DTCOCF,ETABCF,             10
     5TFHPDS,CNHPDS,ETHPDS,TFHPCF,CNHPCF,ETHPCF,DHHPCF,T2DS  ,             11
     6TFLPDS,CNLPDS,ETLPDS,TFLPCF,CNLPCF,ETLPCF,DHLPCF,T21DS ,             12
     7T24DS ,WFDDS ,DTDUDS,ETADDS,WA23DS,DPDUDS,DTDUCF,ETADCF,             13
     8T7DS  ,WFADS ,DTAFDS,ETAADS,WG6CDS,DPAFDS,DTAFCF,ETAACF,             14
     9A55   ,A25   ,A6    ,A7    ,A8    ,A9    ,A28   ,A29   ,             15
     $PS55  ,AM55  ,CVDNOZ,CVMNOZ,A8SAV ,A9SAV ,A28SAV,A29SAV              16
      COMMON/FRONT/QXQ(80)/SIDE/QYQ(48)                                     17
      COMMON /  BACK/                                                       18
     1T55   ,P55   ,H55   ,S55   ,T25   ,P25   ,H25   ,S25   ,             19
     2WF8   ,WG55  ,FAR55 ,WFD   ,WG24  ,FAR24 ,P1    ,DUMB  ,             20
     3T6    ,P6    ,H6    ,S6    ,T7    ,P7    ,H7    ,S7    ,             21
     4T8    ,P8    ,H8    ,S8    ,T9    ,P9    ,H9    ,S9    ,             22
     5WG6   ,WFA   ,WG7   ,FAR7  ,ETAA  ,DPAFT ,V55   ,V25   ,             23
     6PS6   ,V6    ,AM6   ,TS7   ,PS7   ,V7    ,AM7   ,AM25  ,             24
     7TS8   ,PS8   ,V8    ,AM8   ,TS9   ,PS9   ,V9    ,AM9   ,             25
     8VA    ,FRD   ,VJD   ,FGMD  ,VJM   ,FGMM  ,FGPD  ,FGPM  ,             26
     9FGM   ,FGP   ,WFT   ,WGT   ,FART  ,FG    ,FN    ,SFC                 27
      COMMON/DUMMYS/DUMMY(100)                                              28
      EQUIVALENCE (P6DSAV,DUMMY(7)),(AM6DSV,DUMMY(8)),(ETAASV,DUMMY(9)),    29
     1(FAR7SV,DUMMY(10))                                                    30
      DIMENSION Q(9)                                                        31
      DATA AWORD/6HCOAFBN/                                                  32
      WORD=AWORD                                                            33
      Q(2)=0.                                                               34
      Q(3)=0.                                                               35
      AJ=778.26                                                             36
      CAPSF=2116.2170                                                       37
      G=32.174049                                                           38
C***  P6DS AND AM6DS ARE SET FOR GENERALIZATION OF AFTERBURNER              39
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C***  EFFICIENCY MAP GENERALIZATION                                      40
      IF (IDES.EQ.1) P6DS=P6*14.696                                      41
      IF (IDES.EQ.1) AM6DS=AM6                                           42
      WF6=WFB                                                            43
      IF (IBASMX.GT.0) WF6=WF6+WFD                                       44
      WA6=W36-WF6                                                        45
C *** DRY LOSS                                                           46
      WG6C=W36*SQRT(T6)/P6                                               47
      IF (IDES.EQ.1) WG6CDS=WG6C                                         48
      DPAFT=DPAFDS*(WG6C/WG6CDS)                                         49
      IF (DPAFT.GT.1.) DPAFT=1.                                          50
      P7=P6*(1.-DPAFT)                                                   51
      A7=A6                                                              52
      FAR6=WF6/WA6                                                       53
      CALL PROCOM (FAR6,T6,XX1,XX2,XX3,XX4,PHI6,XX6)                     54
      WQA=W36/A7                                                         55
      C1=P7*SQRT(G/(T6*AJ))*CAPSF                                        56
      AM7=AM6                                                            57
      TS7=0.875*T6                                                       58
1     DO 2 I=1,15                                                        59
      CALL PROCOM (FAR6,TS7,CS7,AK7,CP7,REX7,PHIS7,HS7)                  60
      V7=AM7*CS7                                                         61
      HSCAL=H6-V7**2/(2.*G*AJ)                                           62
      DELHS=HSCAL-HS7                                                    63
      IF (ABS(DELHS).LE.0.0005*HSCAL) GO TO 3                            64
2     TS7=TS7+DELHS/CP7                                                  65
      GO TO 14                                                           66
3     WQAT=C1*SQRT(AK7/REX7)*AM7/(1.+(AK7-1.)*AM7**2/2.)**((AK7+1.)/(2.* 67
     1(AK7-1.)))                                                         68
      DIR=WQA/WQAT                                                       69
      EW=(WQA-WQAT)/WQA                                                  70
      CALL AFQUIR (Q(1),AM7,EW,0.,40.,.001,DIR,AM7T,IGO)                 71
      GO TO (4,5,14),IGO                                                 72
4     AM7=AM7T                                                           73
      IF (AM7.GE.1.0) AM7=0.9                                            74
      GO TO 1                                                            75
5     PS7=P7/EXP((PHI6-PHIS7)/REX7)                                      76
      IF (IAFTBN.GT.0) GO TO 7                                           77
C *** NON-AFTERBURNING                                                   78
6     T7=T6                                                              79
      WFA=0.0                                                            80
      FAR7=FAR6                                                          81
      WG7=W36                                                            82
      IF (IDES.EQ.1.AND.T7DS.NE.0.) GO TO 7                              83
      GO TO 20                                                           84
C *** AFTERBURNING                                                       85
7     IF (IAFTBN.EQ.2) T7=T6+2000.                                       86
      IF (IDES.EQ.1) T7=T7DS                                             87
      IF (T7.LE.T6) GO TO 6                                              88
      RHO65=CAPSF*PS7/(AJ*REX7*TS7)                                      89
      PS65=PS7                                                           90
      V65=V7                                                             91
      Q(2)=0.                                                            92
      Q(3)=0.                                                            93
8     IF (T7.GT.4000.) T7=4000.                                          94
      HV=((((((-.4594317E-19*T7)-.2034116E-15)*T7+.2783643E-11)*T7+.2051 95
     1501E-07)*T4-.2453116E-03)*T4-.9433296E-01)*T4+.1845537E+05         96
      CALL THERMO (P7,HA,T7,XX1,XX2,1,FAR6,0)                            97
C***  TO ALTER DESIGN ABETAA MAP FROM GENERAL TO SPECIFIC MAP             98
      IF (IDES.NE.1) GO TO 9                                             99
      FAR7DS=(HA-H6)/(HV*ETAADS)                                        100
      CALL ETAAB (0.,0.,0.,0.,ETAADS,ETAASV,P6DS,P6DSAV,AM6DS,AM6DSV,IDE 101
     1S,FAR7DS,FAR7SV)                                                  102
```

```
      T7=T6                                                              103
      GO TO 20                                                           104
9     P6GS=P5*14.696                                                     105
      FAR7GS=(HA-H6)/(HV*ETAADS)                                         106
      DO 10 II=1,15                                                      107
      CALL ETAAB (FAR7GS,AM6,P6GS,ETAA,ETAADS,ETAASV,P6DS,P6DSAV,AM6DS,A 108
     1M6DSV,IDES,FAR7DS,FAR7SV)                                          109
      FAR7=(HA-H6)/(HV*ETAA)                                             110
      DELFA7=ABS(FAR7-FAR7GS)                                            111
      IF (DELFA7.LE.0.01*FAR7) GO TO 11                                  112
10    FAR7GS=FAR7                                                        113
11    CONTINUE                                                           114
      IF (FAR7.GT.0.) GO TO 12                                           115
      CALL ERROR                                                         116
12    WFAX=FAR7*WG6                                                      117
      IF (IAFTBN.EQ.1) GO TO 15                                          118
      ERRW=(WFA-WFAX)/WFA                                                119
      DIR=SQRT(WFA/WFAX)                                                 120
      CALL AFQUIR (Q(1),T7,ERRW,0.,30.,.0005,DIR,T7T,IGO)                121
      GO TO (13,16,14),IGO                                               122
13    T7=T7T                                                             123
      GO TO 8                                                            124
14    CALL ERROR                                                         125
15    WFA=WFAX                                                           126
16    FAR7=(WF6+WFA)/WA6                                                 127
      WG7=WG6+WFA                                                        128
C *** MOMENTUM LOSS                                                      129
      CALL PROCOM (FAR7,T7,XX1,XX2,XX3,REX7,PHI7,H7)                     130
      RHO7=CAPSF*P7/(AJ*REX7*T7)                                         131
      V7=WG7/(RHO7*A7)                                                   132
      Q(2)=0.                                                            133
      Q(3)=0.                                                            134
      PS7=PS65-0.01                                                      135
17    RHO7=WG7/(V7*A7)                                                   136
      HS7=H7-V7**2/(2.*G*AJ)                                             137
      CALL THERMO (1.0,HS7,TS7,PHIS7,XX2,1,FAR7,1)                       138
      IF (TS7.GE.301.) GO TO 18                                          139
      CALL THERMO (1.0,HS7,400.,PHIS7,XX2,1,FAR7,0)                      140
      V7=SQRT(2.*G*AJ*(H7-HS7))                                          141
      GO TO 17                                                           142
18    PS7=RHO7*AJ*REX7*TS7/CAPSF                                         143
      PS7A=PS65+(RHO65*V65**2-RHO7*V7**2)/(G*CAPSF)                      144
      DIR=SQRT(ABS(PS7/PS7A))                                            145
      EP=(PS7-PS7A)/PS7                                                  146
      CALL AFQUIR (Q(1),V7,EP,0.,50.,.001,DIR,V7T,IGO)                   147
      V7=V7T                                                             148
      IF (V7.LT.100.) V7=100.                                            149
      GO TO (17,19,14),IGO                                               150
19    P7=PS7*EXP((PHI7-PHIS7)/REX7)                                      151
      CALL PROCOM (FAR7,TS7,CS7,XX2,XX3,XX4,XX5,XX6)                     152
      AM7=V7/CS7                                                         153
20    CALL THERMO (P7,H7,T7,S7,XX2,1,FAR7,0)                             154
      IF (IDES.EQ.1) WRITE (6,21) WG6CDS                                 155
      CALL COMNOZ                                                        156
      RETURN                                                             157
C                                                                        158
C                                                                        159
C                                                                        160
21    FORMAT (19H0AFTERBURNER DESIGN,5X8H WG6CDS=,E15.8)                 161
      END                                                                162
```

```
$IBFTC FRTOSD  DECK
      SUBROUTINE FRTOSD                                                  1
      COMMON/ALL/XX(28)/DESIGN/YY(80)                                    2
      COMMON / FRONT/                                                    3
     1T1     ,P1     ,H1     ,S1     ,T2     ,P2     ,H2     ,S2     ,  4
     2T21    ,P21    ,H21    ,S21    ,T3     ,P3     ,H3     ,S3     ,  5
     3T4     ,P4     ,H4     ,S4     ,T5     ,P5     ,H5     ,S5     ,  6
     4T55    ,P55    ,H55    ,S55    ,BLF    ,BLC    ,BLDU   ,BLOB   ,  7
     5CNF    ,PRF    ,ETAF   ,WAFC   ,WAF    ,WA3    ,WG4    ,FAR4   ,  8
     6CNC    ,PRC    ,ETAC   ,WACC   ,WAC    ,ETAB   ,DPCOM  ,DUMF   ,  9
     7CNHP   ,ETATHP,DHTCHP,DHTC   ,BLHP   ,WG5    ,FAR5   ,CS     ,  10
     8CNLP   ,ETATLP,DHTCLP,DHTF   ,BLLP   ,WG55   ,FAR55  ,HPEXT  ,  11
     9AM     ,ALTP   ,ETAR   ,ZF     ,PCNF   ,ZC     ,PCNC   ,WFB    ,  12
     $TFFHP  ,TFFLP  ,PCBLF  ,PCBLC  ,PCBLDU,PCBLOB,PCBLHP,PCBLLP       13
      COMMON /  SIDE/                                                    14
     1XP1    ,XWAF   ,XWAC   ,XBLF   ,XBLDU  ,XH3    ,DUMS1  ,DUMS2  ,  15
     2XT21   ,XP21   ,XH21   ,XS21   ,T23    ,P23    ,H23    ,S23    ,  16
     3T24    ,P24    ,H24    ,S24    ,T25    ,P25    ,H25    ,S25    ,  17
     4T28    ,P28    ,H28    ,S28    ,T29    ,P29    ,H29    ,S29    ,  18
     5WAD    ,WFD    ,WG24   ,FAR24  ,ETAD   ,DPDUC  ,BYPASS,DUMS3  ,  19
     6TS28   ,PS28   ,V28    ,AM28   ,TS29   ,PS29   ,V29    ,AM29      20
      COMMON/BACK/ZZ(72)                                                 21
      COMMON/DUMMYS/DUMMY(100)                                           22
      LOGICAL ERRER,FAN                                                  23
      EQUIVALENCE (FAN,DUMMY(11)),(ISPOOL,DUMMY(6))                      24
      XP1=P1                                                             25
      XWAF=WAF                                                           26
      XWAC=WAC                                                           27
      XBLF=BLF                                                           28
      XBLDU=BLDU                                                         29
      XH3=H3                                                             30
      XT21=T21                                                           31
      XP21=P21                                                           32
      XH21=H21                                                           33
      XS21=S21                                                           34
      IF (FAN) CALL CODUCT                                               35
      IF (FAN) RETURN                                                    36
      CALL FASTBK                                                        37
      RETURN                                                             38
      END                                                                39
```

```
$IBFTC FASTBC  DECK
      SUBROUTINE FASTBK                                                  1
      COMMON/ALL/XX(28)/DESIGN/YY(80)                                    2
      COMMON / FRONT/                                                    3
     1T1     ,P1     ,H1     ,S1     ,T2     ,P2     ,H2     ,S2     ,  4
     2T21    ,P21    ,H21    ,S21    ,T3     ,P3     ,H3     ,S3     ,  5
     3T4     ,P4     ,H4     ,S4     ,T5     ,P5     ,H5     ,S5     ,  6
     4T55    ,P55    ,H55    ,S55    ,BLF    ,BLC    ,BLDU   ,BLOB   ,  7
     5CNF    ,PRF    ,ETAF   ,WAFC   ,WAF    ,WA3    ,WG4    ,FAR4   ,  8
     6CNC    ,PRC    ,ETAC   ,WACC   ,WAC    ,ETAB   ,DPCOM  ,DUMF   ,  9
     7CNHP   ,ETATHP,DHTCHP,DHTC   ,BLHP   ,WG5    ,FAR5   ,CS     ,  10
     8CNLP   ,ETATLP,DHTCLP,DHTF   ,BLLP   ,WG55   ,FAR55  ,HPEXT  ,  11
     9AM     ,ALTP   ,ETAR   ,ZF     ,PCNF   ,ZC     ,PCNC   ,WFB    ,  12
     $TFFHP  ,TFFLP  ,PCBLF  ,PCBLC  ,PCBLDU,PCBLOB,PCBLHP,PCBLLP       13
      COMMON /  SIDE/                                                    14
     1XP1    ,XWAF   ,XWAC   ,XBLF   ,XBLDU  ,XH3    ,DUMS1  ,DUMS2  ,  15
     2XT21   ,XP21   ,XH21   ,XS21   ,T23    ,P23    ,H23    ,S23    ,  16
```

```
     3T24   ,P24   ,H24   ,S24   ,T25   ,P25   ,H25   ,S25   ,                17
     4T28   ,P28   ,H28   ,S28   ,T29   ,P29   ,H29   ,S29   ,                18
     5WAD   ,WFD   ,WG24  ,FAR24 ,ETAD  ,DPDUC ,BYPASS,DUMS3 ,                19
     6TS28  ,PS28  ,V28   ,AM28  ,TS29  ,PS29  ,V29   ,AM29                   20
      COMMON /  BACK/                                                        21
     1XT55  ,XP55  ,XH55  ,XS55  ,XT25  ,XP25  ,XH25  ,XS25  ,                22
     2XWF8  ,XWG55 ,XFAR55,XWFD  ,XWG24 ,XFAR24,XXP1  ,DUMB  ,                23
     3T6    ,P6    ,H6    ,S6    ,T7    ,P7    ,H7    ,S7    ,                24
     4T8    ,P8    ,H8    ,S8    ,T9    ,P9    ,H9    ,S9    ,                25
     5WG6   ,WFA   ,WG7   ,FAR7  ,ETAA  ,DPAFT ,V55   ,V25   ,                26
     6PS6   ,V6    ,AM6   ,TS7   ,PS7   ,V7    ,AM7   ,AM25  ,                27
     7TS8   ,PS8   ,V8    ,AM8   ,TS9   ,PS9   ,V9    ,AM9   ,                28
     8VA    ,FRD   ,VJD   ,FGMD  ,VJM   ,FGMM  ,FGPD  ,FGPM  ,                29
     9FGM   ,FGP   ,WFT   ,WGT   ,FART  ,FG    ,FN    ,SFC                   30
      COMMON/DUMMYS/DUMMY(100)                                               31
      LOGICAL ERRER,FAN                                                      32
      EQUIVALENCE (FAN,DUMMY(11)),(ISPOOL,DUMMY(6))                         33
      XT55=T55                                                               34
      XP55=P55                                                               35
      XH55=H55                                                               36
      XS55=S55                                                               37
      IF (FAN) GO TO 1                                                       38
      T25=T21                                                                39
      P25=P21                                                                40
      H25=H21                                                                41
      S25=S21                                                                42
      WG24=WAF-BLF                                                           43
1     XT25=T25                                                               44
      XP25=P25                                                               45
      XH25=H25                                                               46
      XS25=S25                                                               47
      XWFB=WFB                                                               48
      XWG55=WG55                                                             49
      XFAR55=FAR55                                                           50
      XWFD=WFD                                                               51
      XWG24=WG24                                                             52
      XFAR24=FAR24                                                           53
      XXP1=P1                                                                54
      CALL COMIX                                                             55
      RETURN                                                                 56
      END                                                                    57
```

```
$IBFTC COMNOZ  DECK
      SUBROUTINE COMNOZ                                                       1
      COMMON /   ALL/                                                         2
     1WORD  ,IDES  ,JDES  ,KDES  ,MODE  ,INIT  ,IDUMP ,IAMTP ,               3
     2IGASMX,IDBURN,IAFTBN,IDCD  ,IMCD  ,IDSHOC,IMSHOC,NOZFLT,               4
     3ITRYS ,LOOPER,NOMAP ,NUMMAP,MAPEDG,TOLALL,ERR(6)                       5
      COMMON /DESIGN/                                                        6
     1PCNFGJ,PCNCGU,T4GU  ,DUMD1 ,DUMD2 ,DELFG ,DELFN ,DELSFC,               7
     2ZFDS  ,PCNFDS,PRFDS ,ETAFDS,WAFDS ,PRFCF ,ETAFCF,WAFCF ,               8
     3ZCDS  ,PCNCDS,PRCDS ,ETACDS,WACDS ,PRCCF ,ETACCF,WACCF ,               9
     4T4DS  ,WFBDS ,DTCODS,ETABDS,WA3CDS,DPCODS,DTCOCF,ETABCF,              10
     5TFHPDS,CNHPDS,ETHPDS,TFHPCF,CNHPCF,ETHPCF,DHHPCF,T2DS  ,              11
     6TFLPDS,CNLPDS,ETLPDS,TFLPCF,CNLPCF,ETLPCF,DHLPCF,T21DS ,              12
     7T24DS ,WFDDS ,DTDUDS,ETADDS,WA23DS,DPDUDS,DTDUCF,ETADCF,              13
     8T7DS  ,WFADS ,DTAFDS,ETAADS,WG6CDS,DPAFDS,DTAFCF,ETAACF,              14
     9A55   ,A25   ,A6    ,A7    ,A8    ,A9    ,A28   ,A29   ,               15
```

```
      $PS55  ,AM55  ,CVDNOZ,CVMNOZ,A8SAV ,A9SAV ,A28SAV,A29SAV                  16
       COMMON/FRONT/QXQ(80)/SIDE/QYQ(48)                                        17
       EQUIVALENCE(AM,QXQ(65))                                                  18
       COMMON /  BACK/                                                          19
      1T55   ,P55   ,H55   ,S55   ,T25   ,P25   ,H25   ,S25   ,                20
      2WFB   ,WG55  ,FAR55 ,WFD   ,WG24  ,FAR24 ,P1    ,DUMB  ,                21
      3T6    ,P6    ,H6    ,S6    ,T7    ,P7    ,H7    ,S7    ,                22
      4T8    ,P8    ,H8    ,S8    ,T9    ,P9    ,H9    ,S9    ,                23
      5WG6   ,WFA   ,WG7   ,FAR7  ,ETAA  ,DPAFT ,V55   ,V25   ,                24
      6PS6   ,V6    ,AM6   ,TS7   ,PS7   ,V7    ,AM7   ,AM25  ,                25
      7TS8   ,PS8   ,V8    ,AM8   ,TS9   ,PS9   ,V9    ,AM9   ,                26
      8VA    ,FRD   ,VJD   ,FGMD  ,VJM   ,FGMM  ,FGPD  ,FGPM  ,                27
      9FGM   ,FGP   ,WFT   ,WGT   ,FART  ,FG    ,FN    ,SFC                    28
       COMMON/DUMMYS/DUMMY(100)                                                 29
       LOGICAL ERRER,FAN                                                        30
       EQUIVALENCE (FAN,DUMMY(11)),(ISPOOL,DUMMY(6))                           31
       DATA AWORD/6HMNOZZL/                                                     32
       WORD=AWORD                                                               33
       A8SAV=A8                                                                 34
       A9SAV=A9                                                                 35
       NOZM=0                                                                   36
       IMNOZ=0                                                                  37
       IF (NOZFLT.EQ.1.OR.NOZFLT.EQ.3) NOZM=1                                   38
       IF (IDES.EQ.1.OR.IAFTBN.GT.0.OR.NOZM.EQ.1) IMNOZ=1                       39
       IF (IAFTBN.EQ.0.AND.NOZFLT.EQ.0) IMOD=0                                  40
       IF (IAFTBN.EQ.1.OR.NOZFLT.EQ.1.OR.NOZFLT.EQ.3) IMOD=1                    41
       IF (IMOD.EQ.1) GO TO 1                                                   42
       CALL CONVRG (T7,H7,P7,S7,FAR7,WG7,P1,IMNOZ,A8,P7R,T8,H8,P8,S8,TS8,       43
      1PS8,V8,AM8,ICON)                                                         44
       GO TO (3,3,3,2),ICON                                                     45
1      CALL CONDIV (T7,H7,P7,S7,FAR7,WG7,P1,IMNOZ,A8,A9,P7R,T8,H8,P8,S8,T       46
      19,H9,P9,S9,TS8,TS9,PS8,PS9,V8,V9,AM8,AM9,ICON)                           47
       IMSHOC=ICON                                                              48
       GO TO (4,4,4,2),ICON                                                     49
2      CALL ERROR                                                               50
3      T9=T8                                                                    51
       H9=H8                                                                    52
       P9=P8                                                                    53
       S9=S8                                                                    54
       TS9=TS8                                                                  55
       PS9=PS8                                                                  56
       V9=V8                                                                    57
       AM9=AM8                                                                  58
       A9=A8                                                                    59
       IMSHOC=ICON+3                                                            60
4      ERR(6)=(P7R-P7)/P7R                                                      61
       IF (ISPOOL.EQ.1) ERR(3)=ERR(6)                                           62
       IF (IMNOZ.EQ.1) WRITE (6,5) A8,AM8,A9,AM9                                63
       RETURN                                                                   64
C                                                                               65
C                                                                               66
5      FORMAT (14HONOZZLE DESIGN,10X8H      A8=,E15.8,8H     AM8=,E15.8,8H      67
      1     A9=,E15.8,8H     AM9=,E15.8)                                        68
       END                                                                      69
```

```
$IBFTC ERROR   DECK
      SUBROUTINE ERROR                                                          1
      COMMON /   ALL/                                                           2
     1WORD  ,IDES  ,JDES  ,KDES  ,MODE  ,INIT  ,IDUMP ,IAMTP ,                 3
     2IGASMX,IDBURN,IAFTBN,IDCD  ,IMCD  ,IDSHOC,IMSHOC,NOZFLT,                 4
     3ITRYS ,LOOPER,NOMAP ,NUMMAP,MAPEDG,TOLALL,ERR(6)                         5
      COMMON /DESIGN/                                                           6
     1PCNFGJ,PCNCGU,T4GU  ,DUMD1 ,DUMD2 ,DELFG ,DELFN ,DELSFC,                 7
     2ZFDS  ,PCNFDS,PRFDS ,ETAFDS,WAFDS ,PRFCF ,ETAFCF,WAFCF ,                 8
     3ZCDS  ,PCNCDS,PRCDS ,ETACDS,WACDS ,PRCCF ,ETACCF,WACCF ,                 9
     4T4DS  ,WFBDS ,DTCODS,ETABDS,WA3CDS,DPCODS,DTCOCF,ETABCF,                 10
     5TFHPDS,CNHPDS,ETHPDS,TFHPCF,CNHPCF,ETHPCF,DHHPCF,T2DS  ,                 11
     6TFLPDS,CNLPDS,ETLPDS,TFLPCF,CNLPCF,ETLPCF,DHLPCF,T21DS ,                 12
     7T24DS ,WFDDS ,DTDUDS,ETADDS,WA23DS,DPDUDS,DTDUCF,ETADCF,                 13
     8T7DS  ,WFADS ,DTAFDS,ETAADS,WG6CDS,DPAFDS,DTAFCF,ETAACF,                 14
     9A55   ,A25   ,A6    ,A7    ,A8    ,A9    ,A28   ,A29   ,                 15
     $PS55  ,AM55  ,CVDNOZ,CVMNOZ,A8SAV ,A9SAV ,A28SAV,A29SAV                  16
      COMMON / FRONT/                                                           17
     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  ,WAFC  ,WAF   ,WA3   ,WG4   ,FAR4  ,                22
     6CNC   ,PRC   ,ETAC  ,WACC  ,WAC   ,ETAB  ,DPCOM ,DUMF  ,                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  ,WF8   ,                26
     $TFFHP ,TFFLP ,PCBLF ,PCBLC ,PCBLDU,PCBLOB,PCBLHP,PCBLLP                   27
      COMMON /  SIDE/                                                           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 ,ETAD  ,DPDUC ,BYPASS,DUMS3 ,                33
     6TS28  ,PS28  ,V28   ,AM28  ,TS29  ,PS29  ,V29   ,AM29                    34
      COMMON /  BACK/                                                           35
     1XT55  ,XP55  ,XH55  ,XS55  ,XT25  ,XP25  ,XH25  ,XS25  ,                 36
     2XWFB  ,XWG55 ,XFAR55,XWFD  ,XWG24 ,XFAR24,XXP1  ,DUMB  ,                 37
     3T6    ,P6    ,H6    ,S6    ,T7    ,P7    ,H7    ,S7    ,                38
     4T8    ,P8    ,H8    ,S8    ,T9    ,P9    ,H9    ,S9    ,                39
     5WG6   ,WFA   ,WG7   ,FAR7  ,ETAA  ,DPAFT ,V55   ,V25   ,                40
     6PS6   ,V6    ,AM6   ,TS7   ,PS7   ,V7    ,AM7   ,AM25  ,                41
     7TS8   ,PS8   ,V8    ,AM8   ,TS9   ,PS9   ,V9    ,AM9   ,                42
     8VA    ,FRD   ,VJD   ,FGMD  ,VJM   ,FGMM  ,FGPD  ,FGPM  ,                43
     9FGM   ,FGP   ,WFT   ,WGT   ,FART  ,FG    ,FN    ,SFC                    44
      COMMON/DUMMYS/DUMMY(100)                                                  45
      LOGICAL ERRER                                                             45
      COMMON/ERER/ERRER                                                         47
      DIMENSION TRASH1(80),TRASH2(80),TRASH3(48),TRASH4(72)                     48
      EQUIVALENCE (TRASH1,PCNFGU),(TRASH2,T1),(TRASH3,XP1),(TRASH4,XT55)        49
      DATA AWORD/6HCOMMON/                                                      50
      ERRER=.TRUE.                                                              51
      WRITE (6,2) WORD                                                          52
      WORD=AWORD                                                                53
      WRITE (6,3) WORD,ZF,PCNF,ZC,PCNC,T4,MODE                                  54
      WRITE (6,4)                                                               55
      WRITE (6,5) (TRASH1(I),I=1,80)                                            56
      WRITE (6,6)                                                               57
      WRITE (6,5) (TRASH2(I),I=1,80)                                            58
      WRITE (6,4)                                                               59
      WRITE (6,5) (TRASH3(I),I=1,48)                                            60
      WRITE (6,4)                                                               61
```

```
      WRITE (6,5) (TRASH4(I),I=1,72)                                    62
      WRITE (6,4)                                                       63
      WRITE (6,7) LOOPER                                                64
      IF (IDJMP.EQ.0) GO TO 1                                           65
      WRITE (6,6)                                                       66
      CALL SYG (2)                                                      67
1     CALL ENGBAL                                                       68
      RETURN                                                            69
C                                                                       70
C                                                                       71
2     FORMAT (28HOAN ERROR HAS BEEN FOUND IN ,A6)                       72
3     FORMAT (1HO,A6,9X,5E15.6,I4)                                      73
4     FORMAT (2HO )                                                     74
5     FORMAT (1HO,8E15.6)                                               75
6     FORMAT (1H1)                                                      76
7     FORMAT (25HOFAILED TO CONVERGE AFTER,I4,6H LOOPS)                 77
      END                                                               78
```

```
$IBFTC SYGS    DECK
      SUBROUTINE SYG (ICON)                                              1
      DIMENSION WORD(132)                                                2
      DATA ONEDOL/6H$     /                                              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 (1HO,12HERROR IN SYG)                                      39
      END                                                               40
```

```
$IBFTC PERFOR  DECK
      SUBROUTINE PERF                                                    1
      COMMON /   ALL/                                                    2
     1WORD  ,IDES  ,JDES  ,KDES  ,MODE  ,INIT  ,IDUMP ,IAMTP ,          3
     2IGASMX,IDBURN,IAFTBN,IDCD  ,IMCD  ,IDSHOC,IMSHOC,NOZFLT,          4
     3ITRYS ,LOOPER,NOMAP ,NUMMAP,MAPEDG,TOLALL,ERR(6)                  5
      COMMON /DESIGN/                                                    6
     1PCNFGJ,PCNCGU,T4GU  ,DUMD1 ,DUMD2 ,DELFG ,DELFN ,DELSFC,          7
     2ZFDS  ,PCNFDS,PRFDS ,ETAFDS,WAFDS ,PRFCF ,ETAFCF,WAFCF ,          8
     3ZCDS  ,PCNCDS,PRCDS ,ETACDS,WACDS ,PRCCF ,ETACCF,WACCF ,          9
     4T4DS  ,WFBDS ,DTCODS,ETABDS,WA3CDS,DPCODS,DTCOCF,ETABCF,         10
     5TFHPDS,CNHPDS,ETHPDS,TFHPCF,CNHPCF,ETHPCF,DHHPCF,T2DS  ,         11
     6TFLPDS,CNLPDS,ETLPDS,TFLPCF,CNLPCF,ETLPCF,DHLPCF,T21DS ,         12
     7T24DS ,WFDDS ,DTDUDS,ETADDS,WA23DS,DPDUDS,DTDUCF,ETADCF,         13
     8T7DS  ,WFADS ,DTAFDS,ETAADS,WG6CDS,DPAFDS,DTAFCF,ETAACF,         14
     9A55   ,A25   ,A6    ,A7    ,A8    ,A9    ,A28   ,A29   ,         15
     $PS55  ,AM55  ,CVDNOZ,CVMNOZ,A8SAV ,A9SAV ,A28SAV,A29SAV          16
      COMMON / FRONT/                                                   17
     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  ,WAFC  ,WAF   ,WA3   ,WG4   ,FAR4  ,         22
     6CNC   ,PRC   ,ETAC  ,WACC  ,WAC   ,ETAB  ,DPCOM ,DUMF  ,         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 /  SIDE/                                                   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 ,ETAD  ,DPDUC ,BYPASS,DUMS3 ,         33
     6TS28  ,PS28  ,V28   ,AM28  ,TS29  ,PS29  ,V29   ,AM29            34
      COMMON /  BACK/                                                   35
     1XT55  ,XP55  ,XH55  ,XS55  ,XT25  ,XP25  ,XH25  ,XS25  ,         36
     2XWFB  ,XWG55 ,XFAR55,XWFD  ,XWG24 ,XFAR24,XXP1  ,DUMB  ,         37
     3T6    ,P6    ,H6    ,S6    ,T7    ,P7    ,H7    ,S7    ,         38
     4T8    ,P8    ,H8    ,S8    ,T9    ,P9    ,H9    ,S9    ,         39
     5WG6   ,WFA   ,WG7   ,FAR7  ,ETAA  ,DPAFT ,V55   ,V25   ,         40
     6PS6   ,V6    ,AM6   ,TS7   ,PS7   ,V7    ,AM7   ,AM25  ,         41
     7TS8   ,PS8   ,V8    ,AM8   ,TS9   ,PS9   ,V9    ,AM9   ,         42
     8VA    ,FRD   ,VJD   ,FGMD  ,VJM   ,FGMM  ,FGPD  ,FGPM  ,         43
     9FGM   ,FGP   ,WFT   ,WGT   ,FART  ,FG    ,FN    ,SFC             44
      COMMON/DUMMYS/DUMMY(100)                                          45
      LOGICAL ERRER,FAN                                                 46
      EQUIVALENCE (FAN,DUMMY(11)),(ISPOOL,DUMMY(6))                     47
      DATA AWORD/6H  PERF/                                              48
      WORD=AWORD                                                        49
      G=32.174049                                                       50
      CAPSF=2116.2170                                                   51
      WFT=WFB+WFD+WFA                                                   52
      WAT=WAF-BLOB                                                      53
      WGT=WAT+WFT                                                       54
      FART=WFT/WAT                                                      55
      VA=AM*CS                                                          56
      FRD=VA*WAF/G                                                      57
C     TO REMOVE CD NOZ COEFF, CHANGE CALL FRASHD,CUMNOZ EQ.             58
C     ALSO SUB CODUCT REMOVE IF (IDBURN.EQ.1) IDCD=1                    59
C     ALSO SUB COMNOZ REMOVE IF (IAFTBN.EQ.1) IMCD=1                    60
      ARATIO=A9/A8                                                      61
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```
      PTRATO=P8/P1                                                          62
      PRATIO=PS9/P1                                                         63
      CALL PROCOM (FAR7,TS9,CS9,AK9,CP9,REX9,PHIS9,HS9)                     64
      CALL FRASHO (PTRATO,ARATIO,CUMNOZ)                                    65
      CVMNOZ=CUMNOZ                                                         66
      VJM=CVMNOZ*V9                                                         67
      FGMM=VJM*WG7/G                                                        68
      FGPM=CAPSF*(PS9-P1)*A9                                                69
      IF (IGASMX.GT.0.OR..NOT.FAN) GO TO 1                                  70
      PRATIO=PS29/P1                                                        71
      ARATIO=A29/A28                                                        72
      PTRATO=P28/P1                                                         73
      CALL PROCOM (FAR24,TS29,CS9,AK29,CP9,REX9,PHIS9,HS9)                  74
      CALL FRASHO (PTRATO,ARATIO,CUDNOZ)                                    75
      CVDNOZ=CUDNOZ                                                         76
      VJD=CVDNOZ*V29                                                        77
      FGMD=VJD*WG24/G                                                       78
      FGPD=CAPSF*(PS29-P1)*A29                                              79
1     FGM=FGMM+FGMD                                                         80
      FGP=FGPM+FGPD                                                         81
      FG=FGM+FGP                                                            82
      FN=FG-FRD                                                             83
      SFC=3600.*WFT/FN                                                      84
      FG=DELFG*FG                                                           85
      FN=DELFN*FN                                                           86
      SFC=DELSFC*SFC                                                        87
      CALL OUTPUT                                                           88
      CALL ERROR                                                            89
      RETURN                                                                90
      END                                                                   91
```

```
$IBFTC OUTPUT  DECK
      SUBROUTINE OUTPUT                                                      1
      COMMON /   ALL/                                                        2
     1WORD  ,IDES  ,JDES  ,KDES  ,MODE  ,INIT  ,IDUMP ,IAMTP ,              3
     2IGASMX,IDBURN,IAFTBN,IDCD  ,IMCD  ,IDSHOC,IMSHOC,NOZFLT,              4
     3ITRYS ,LOOPER,NOMAP ,NUMMAP,MAPEDG,TOLALL,ARR(6)                      5
      COMMON /DESIGN/                                                        6
     1PCNFGJ,PCNCGU,T4GU  ,DUMD1 ,DUMD2 ,DELFG ,DELFN ,DELSFC,              7
     2ZFDS  ,PCNFDS,PRFDS ,ETAFDS,WAFDS ,PRFCF ,ETAFCF,WAFCF ,              8
     3ZCDS  ,PCNCDS,PRCDS ,ETACDS,WACDS ,PRCCF ,ETACCF,WACCF ,              9
     4T4DS  ,WFBDS ,DTCODS,ETABDS,WA3CDS,DPCODS,DTCOCF,ETABCF,             10
     5TFHPDS,CNHPDS,ETHPDS,TFHPCF,CNHPCF,ETHPCF,DHHPCF,T2DS  ,             11
     6TFLPDS,CNLPDS,ETLPDS,TFLPCF,CNLPCF,ETLPCF,DHLPCF,T21DS ,             12
     7T24DS ,WFDDS ,DTDUDS,ETADDS,WA23DS,DPDUDS,DTDUCF,ETADCF,             13
     8T7DS  ,WFADS ,DTAFDS,ETAADS,WG6CDS,DPAFDS,DTAFCF,ETAACF,             14
     9A55   ,A25   ,A6    ,A7    ,A8    ,A9    ,A28   ,A29   ,             15
     $PS55  ,AM55  ,CVDNOZ,CVMNOZ,A8SAV ,A9SAV ,A28SAV,A29SAV              16
      COMMON / FRONT/                                                       17
     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  ,WAFC  ,WAF   ,WA3   ,WG4   ,FAR4  ,            22
     6CNC   ,PRC   ,ETAC  ,WACC  ,WAC   ,ETAB  ,DPCOM ,DUMF  ,            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 /  SIDE/                                                         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 ,ETAD  ,DPDUC ,BYPASS,DUMS3 ,               33
      6TS28  ,PS28  ,V28   ,AM28  ,TS29  ,PS29  ,V29   ,AM29                   34
       COMMON /  BACK/                                                         35
      1XT55  ,XP55  ,XH55  ,XS55  ,XT25  ,XP25  ,XH25  ,XS25  ,                36
      2XWFB  ,XWG55 ,XFAR55,XWFD  ,XWG24 ,XFAR24,XXP1  ,DUMB  ,                37
      3T6    ,P6    ,H6    ,S6    ,T7    ,P7    ,H7    ,S7    ,                38
      4T8    ,P8    ,H8    ,S8    ,T9    ,P9    ,H9    ,S9    ,                39
      5WG6   ,WFA   ,WG7   ,FAR7  ,ETAA  ,DPAFT ,V55   ,V25   ,                40
      6PS6   ,V6    ,AM6   ,TS7   ,PS7   ,V7    ,AM7   ,AM25  ,                41
      7TS8   ,PS8   ,V8    ,AM8   ,TS9   ,PS9   ,V9    ,AM9   ,                42
      8VA    ,FRD   ,VJD   ,FGMD  ,VJM   ,FGMM  ,FGPD  ,FGPM  ,                43
      9FGM   ,FGP   ,WFT   ,WGT   ,FART  ,FG    ,FN    ,SFC                    44
       COMMON / DUMMYS / DUMMY(100)                                            45
       EQUIVALENCE (T4PBL,DUMMY(2)),(T41,DUMMY(3))                             46
       DIMENSION W(5,4),ANS1(80),ANS2(80),ANS3(48),ANS4(72)                    47
       EQUIVALENCE (ANS1,PCNFGU),(ANS2,T1),(ANS3,XP1),(ANS4,XT55)              48
       DATA AWORD1,AWORD2/6HOUTPUT,6HCOMMON/                                   49
       DATA (W(1,I),I=1,4)/6HSUBSON,6HIC C-D,6H NOZZL,6HE     /                50
       DATA (W(2,I),I=1,4)/6HSHOCK ,6HINSIDE,6H C-D N,6HOZZLE /                51
       DATA (W(3,I),I=1,4)/6HSHOCK ,6HOUTSID,6HE C-D ,6HNOZZLE/                52
       DATA (W(4,I),I=1,4)/6HSUBSON,6HIC CON,6HVERG. ,6HNOZZLE/                53
       DATA (W(5,I),I=1,4)/6HSONIC ,6HCONVER,6HGENT N,6HOZZLE /                54
       WORD=AWORD1                                                             55
       IF (IDBURN.GT.0) GO TO 2                                                56
       IF (IAFTBN.GT.0) GO TO 1                                                57
       WRITE (6,7) WORD,AM,ALTP,T4,ETAR                                        58
       GO TO 3                                                                 59
1      WRITE (6,8) WORD,AM,ALTP,T4,T7,ETAR                                     60
       GO TO 3                                                                 61
2      WRITE (6,9) WORD,AM,ALTP,T4,T24,ETAR                                    62
3      CALL CONOUT (2)                                                         63
       WRITE (6,10) (W(IMSHOC,I),I=1,4),FG,FN,SFC                              64
       IF (IBASMX.GT.0) GO TO 4                                                65
       WRITE (6,11) (W(IDSHOC,I),I=1,4)                                        66
4      WRITE (6,12) LOOPER                                                     67
       IF (IDES.NE.1) GO TO 5                                                  68
       WORD=AWORD2                                                             69
       WRITE (6,13) WORD,ZF,PCNF,ZI,PCNI,ZC,PCNC,T4,MODE                       70
       WRITE (6,14)                                                            71
       WRITE (6,15) (ANS1(I),I=1,80)                                           72
       WRITE (6,14)                                                            73
       WRITE (6,15) (ANS2(I),I=1,80)                                           74
       WRITE (6,14)                                                            75
       WRITE (6,15) (ANS3(I),I=1,48)                                           76
       WRITE (6,14)                                                            77
       WRITE (6,15) (ANS4(I),I=1,72)                                           78
       WRITE (6,16)                                                            79
       IF (IDES.EQ.1) GO TO 6                                                  80
5      CONTINUE                                                                81
       A8=A8SAV                                                                82
       A9=A9SAV                                                                83
       A28=A28SAV                                                              84
       A29=A29SAV                                                              85
       IF (IDUMP.NE.2) GO TO 6                                                 86
       WRITE (6,16)                                                            87
       CALL SYG (2)                                                            88
```

```
6     CALL ENGBAL                                                              89
      RETURN                                                                   90
C                                                                              91
C                                                                              92
C                                                                              93
7     FORMAT (1HB,A6,14X7H     AM=,F7.3,6X7H  ALTP=,F7.0,6X7H     T4=,F8.2      94
     1,25X7H  ETAR=,F7.4)                                                      95
8     FORMAT (1HB,A6,14X7H     AM=,F7.3,6X7H  ALTP=,F7.0,6X7H     T4=,F8.2      96
     1,5X7H    T7=,F8.2,5X7H  ETAR=,F7.4)                                      97
9     FORMAT (1HB,A6,14X7H     AM=,F7.3,6X7H  ALTP=,F7.0,6X7H     T4=,F8.2      98
     1,5X7H   T24=,F8.2,5X7H  ETAR=,F7.4)                                      99
10    FORMAT (6HOMAIN ,4A6,9X3HFG=,F9.2,18X3HFN=,F9.2,18X4HSFC=,F8.5)          100
11    FORMAT (6H DUCT ,4A6)                                                    101
12    FORMAT (16HOCONVERGED AFTER,I4,6H LOOPS,/,1H1)                           102
13    FORMAT (1H ,A6,9X,7E15.6,I4)                                             103
14    FORMAT (1H )                                                             104
15    FORMAT (1H ,8E15.6)                                                      105
16    FORMAT (1H1)                                                             106
      END                                                                      107
```

```
$IBFTC CONOJT  DECK
      SUBROJTINE CONOUT (ICON)                                                  1
      COMMON /   ALL/                                                           2
     1WORD  ,IDES  ,JDES  ,KDES  ,MODE  ,INIT  ,IDUMP ,IAMTP ,                  3
     2IGASMX,IDBURN,IAFTBN,IDCD  ,IMCD  ,IDSHOC,IMSHOC,NOZFLT,                  4
     3ITRYS ,LOOPER,NOMAP ,NUMMAP,MAPEDG,TOLALL,ERR(6)                          5
      COMMON /DESIGN/                                                           6
     1PCNFGJ,PCNCGU,T4GU  ,DUMD1 ,DUMD2 ,DELFG ,DELFN ,DELSFC,                  7
     2ZFDS  ,PCNFDS,PRFDS ,ETAFDS,WAFDS ,PRFCF ,ETAFCF,WAFCF ,                  8
     3ZCDS  ,PCNCDS,PRCDS ,ETACDS,WACDS ,PRCCF ,ETACCF,WACCF ,                  9
     4T4DS  ,WFBDS ,DTCODS,ETABDS,WA3CDS,DPCODS,DTCOCF,ETABCF,                 10
     5TFHPDS,CNHPDS,ETHPDS,TFHPCF,CNHPCF,ETHPCF,DHHPCF,T2DS  ,                 11
     6TFLPDS,CNLPDS,ETLPDS,TFLPCF,CNLPCF,ETLPCF,DHLPCF,T21DS ,                 12
     7T24DS ,WFDDS ,DTDUDS,ETADDS,WA23DS,DPDUDS,DTDUCF,ETADCF,                 13
     8T7DS  ,WFADS ,DTAFDS,ETAADS,WG6CDS,DPAFDS,DTAFCF,ETAACF,                 14
     9A55   ,A25   ,A6    ,A7    ,A8    ,A9    ,A28   ,A29   ,                 15
     $PS55  ,AM55  ,CVDNOZ,CVMNOZ,A8SAV ,A9SAV ,A28SAV,A29SAV                  16
      COMMON / FRONT/                                                           17
     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  ,WAFC  ,WAF   ,WA3   ,WG4   ,FAR4  ,                 22
     6CNC   ,PRC   ,ETAC  ,WACC  ,WAC   ,ETAB  ,DPCOM ,DUMF  ,                 23
     7CNHPM ,ETATHP,DHTCHM,DHTC  ,BLHP  ,WG5   ,FAR5  ,CS    ,                 24
     8CNLPM ,ETATLP,DHTCLM,DHTF  ,BLLP  ,WG55  ,FAR55 ,HPEXT ,                 25
     9AM    ,ALTP  ,ETAR  ,ZF    ,PCNF  ,ZC    ,PCNC  ,WFB   ,                 26
     $TFFHPM,TFFLPM,PCBLF ,PCBLC ,PCBLDU,PCBLOB,PCBLHP,PCBLLP                   27
      COMMON /  SIDE/                                                           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 ,ETAD  ,DPDUC ,BYPASS,DUMS3 ,                 33
     6TS28  ,PS28  ,V28   ,AM28  ,TS29  ,PS29  ,V29   ,AM29                    34
      COMMON /  BACK/                                                           35
     1XT55  ,XP55  ,XH55  ,XS55  ,XT25  ,XP25  ,XH25  ,XS25  ,                 36
```

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2XWFB   ,XWG55 ,XFAR55,XWFD  ,XWG24 ,XFAR24,XXP1  ,DUMB  ,                37
3T6     ,P6    ,H6    ,S6    ,T7    ,P7    ,H7    ,S7    ,                38
4T8     ,P8    ,H8    ,S8    ,T9    ,P9    ,H9    ,S9    ,                39
5WG6    ,WFA   ,WG7   ,FAR7  ,ETAA  ,DPAFT ,V55   ,V25   ,                40
6PS6    ,V6    ,AM6   ,TS7   ,PS7   ,V7    ,AM7   ,AM25  ,                41
7TS8    ,PS8   ,V8    ,AM8   ,TS9   ,PS9   ,V9    ,AM9   ,                42
8VA     ,FRD   ,VJD   ,FGMD  ,VJM   ,FGMM  ,FGPD  ,FGPM  ,                43
9FGM    ,FGP   ,WFT   ,WGT   ,FART  ,FG    ,FN    ,SFC                   44
 COMMON/DUMMYS/DUMMY(100)                                                  45
 EQUIVALENCE (TFFHP,DUMMY(12)),(CNHP,DUMMY(13)),(DHTCHP,DUMMY(14))         46
 EQUIVALENCE (TFFLP,DUMMY(15)),(CNLP,DUMMY(16)),(DHTCLP,DUMMY(17))         47
 DIMENSION PARAM(380),WORDY(380),IOUT(103),AOUT(6),WOUT(6)                 48
 EQUIVALENCE (PARAM,PCNFGU)                                                49
 DATA (WORDY(I),I=1,98)/                                                   50
16HPCNFGU,6HPCNCGU,6HT4GU  ,6HDUMD1 ,6HDUMD2 ,6HDELFG ,6HDELFN ,          51
26HDELSFC,6HZFDS  ,6HPCNFDS,6HPRFDS ,6HETAFDS,6HWAFDS ,6HPRFCF ,          52
36HETAFCF,6HWAFCF ,6HZCDS  ,6HPCNCDS,6HPRCDS ,6HETACDS,6HWACDS ,          53
46HPRCCF ,6HETACCF,6HWACCF ,6HT4DS  ,6HWFBDS ,6HDTCODS,6HETABDS,          54
56HWA3CDS,6HDPCODS,6HDTCOCF,6HETABCF,6HTFHPDS,6HCNHPDS,6HETHPDS,          55
66HTFHPCF,6HCNHPCF,6HETHPCF,6HDHHPCF,6HT2DS  ,6HTFLPDS,6HCNLPDS,          56
76HETLPDS,6HTFLPCF,6HCNLPCF,6HETLPCF,6HDHLPCF,6HT21DS ,6HT24DS ,          57
86HWFDDS ,6HDTDUDS,6HETADDS,6HWA23DS,6HDPDUDS,6HDTDUCF,6HETADCF,          58
96HT7DS  ,6HWFADS ,6HDTAFDS,6HETAADS,6HWG6CDS,6HDPAFDS,6HDTAFCF,          59
$6HETAACF,6HA55   ,6HA25   ,6HA6    ,6HA7    ,6HA8    ,6HA9    ,          60
$6HA28   ,6HA29   ,6HPS55  ,6HAM55  ,6HCVDNOZ,6HCVMNOZ,6HA8SAV ,          61
$6HA9SAV ,6HA28SAV,6HA29SAV,6HT1    ,6HP1    ,6HH1    ,6HS1    ,          62
$6HT2    ,6HP2    ,6HH2    ,6HS2    ,6HT21   ,6HP21   ,6HH21   ,          63
$6HS21   ,6HT3    ,6HP3    ,6HH3    ,6HS3    ,6HT4    ,6HP4    /          64
 DATA (WORDY(I),I=99,189)/                                                 65
16HH4    ,6HS4    ,6HT5    ,6HP5    ,6HH5    ,6HS5    ,6HT55   ,          66
26HP55   ,6HH55   ,6HS55   ,6HBLF   ,6HBLC   ,6HBLDU  ,6HBLOB  ,          67
36HCNF   ,6HPRF   ,6HETAF  ,6HWAFC  ,6HWAF   ,6HWA3   ,6HWG4   ,          68
46HFAR4  ,6HCNC   ,6HPRC   ,6HETAC  ,6HWACC  ,6HWAC   ,6HETAB  ,          69
56HDPCDM ,6HDUMF  ,6HCNHPM ,6HETATHP,6HDHTCHM,6HDHTC  ,6HBLHP  ,          70
66HWG5   ,6HFAR5  ,6HCS    ,6HCNLPM ,6HETATLP,6HDHTCLM,6HDHTF  ,          71
76HBLLP  ,6HWG55  ,6HFAR55 ,6HHPEXT ,6HAM   ,6HALTP  ,6HETAR  ,          72
86HZF    ,6HPCNF  ,6HZC    ,6HPCNC  ,6HWFB   ,6HTFFHPM,6HTFFLPM,          73
96HPCBLF ,6HPCBLC ,6HPCBLDU,6HPCBLOB,6HPCBLHP,6HPCBLLP,6HXP1   ,          74
$6HXWAF  ,6HXWAC  ,6HXBLF  ,6HXBLDU ,6HXH3   ,6HDUMS1 ,6HDUMS2 ,          75
$6HXT21  ,6HXP21  ,6HXH21  ,6HXS21  ,6HT23   ,6HP23   ,6HH23   ,          76
$6HS23   ,6HT24   ,6HP24   ,6HH24   ,6HS24   ,6HT25   ,6HP25   ,          77
$6HH25   ,6HS25   ,6HT28   ,6HP28   ,6HH28   ,6HS28   ,6HT29   /          78
 DATA (WORDY(I),I=190,280)/                                                79
16HP29   ,6HH29   ,6HS29   ,6HWAD   ,6HWFD   ,6HWG24  ,6HFAR24 ,          80
26HETAD  ,6HDPDUC ,6HBYPASS,6HDUMS3 ,6HTS28  ,6HPS28  ,6HV28   ,          81
36HAM23  ,6HTS29  ,6HPS29  ,6HV29   ,6HAM29  ,6HXT55  ,6HXP55  ,          82
46HXH55  ,6HXS55  ,6HXT25  ,6HXP25  ,6HXH25  ,6HXS25  ,6HXWFB  ,          83
56HXWG55 ,6HXFAR55,6HXWFD  ,6HXWG24 ,6HXFAR24,6HXXP1  ,6HDUMB  ,          84
66HT6    ,6HP6    ,6HH6    ,6HS6    ,6HT7    ,6HP7    ,6HH7    ,          85
76HS7    ,6HT8    ,6HP8    ,6HH8    ,6HS8    ,6HT9    ,6HP9    ,          86
86HH9    ,6HS9    ,6HWG6   ,6HWFA   ,6HWG7   ,6HFAR7  ,6HETAA  ,          87
96HDPAFT ,6HV55   ,6HV25   ,6HPS6   ,6HV6    ,6HAM6   ,6HTS7   ,          88
$6HPS7   ,6HV7    ,6HAM7   ,6HAM25  ,6HTS8   ,6HPS8   ,6HV8    ,          89
$6HAM8   ,6HTS9   ,6HPS9   ,6HV9    ,6HAM9   ,6HVA    ,6HFRD   ,          90
$6HVJD   ,6HFGMD  ,6HVJM   ,6HFGMM  ,6HFGPD  ,6HFGPM  ,6HFGM   ,          91
$6HFGP   ,6HWFT   ,6HWGT   ,6HFART  ,6HFG    ,6HFN    ,6HSFC   /          92
 DATA (WORDY(I),I=281,297)/                                                93
111*0.   ,6HTFFHP ,6HCNHP  ,6HDHTCHP,6HTFFLP ,6HCNLP  ,6HDHTCLP/          94
 DATA THEEND,BLANK,LIMIT/ 6HTHEEND,6H      ,297/                           95
 GO TO (1,6),ICON                                                          96
```

```
C *** INPUT SECTION                                                    97
1       DO 4 N=1,103                                                   98
        NUM=N                                                          99
        READ (5,11) AIN,CHANGE                                        100
        IF (AIN.EQ.THEEND) GO TO 5                                    101
        DO 2 J=1,LIMIT                                                102
        JJ=J                                                          103
        IF (AIN.EQ.WORDY(J)) GO TO 3                                  104
2       CONTINUE                                                      105
        WRITE (6,12) AIN                                              106
        GO TO 4                                                       107
3       IOUT(NUM)=JJ                                                  108
        IF (CHANGE.NE.BLANK) WORDY(JJ)=CHANGE                         109
4       CONTINUE                                                      110
        WRITE (6,13)                                                  111
5       NUM=NUM-1                                                     112
        RETURN                                                        113
C *** OUTPUT SECTION                                                  114
6       IF (NUM.EQ.1) GO TO 10                                        115
        N=NUM                                                         116
        J=6                                                           117
        DO 9 I=1,NUM,6                                                118
        IF (N.GT.6) GO TO 7                                           119
        J=N                                                           120
7       N=N-6                                                         121
        DO 8 K=1,J                                                    122
        L=I+K-1                                                       123
        M=IOUT(L)                                                     124
        WOUT(K)=WORDY(M)                                              125
8       AOUT(K)=PARAM(M)                                              126
        WRITE (6,14) (WOUT(K),K=1,J)                                  127
        WRITE (6,15) (AOUT(K),K=1,J)                                  128
        IF (N.LE.0) GO TO 10                                          129
9       CONTINUE                                                      130
10      RETURN                                                        131
C                                                                     132
C                                                                     133
11      FORMAT (A6,6X,A6)                                             134
12      FORMAT (10HOTHE WORD ,A6,26H NOT FOUND IN COMMON ARRAY)       135
13      FORMAT (22HOERROR IN CONOUT INPUT)                            136
14      FORMAT (1H ,25XA6,5(9XA6))                                    137
15      FORMAT (1H ,20X6E15.6)                                        138
        END                                                           139
```

```
$IBFTC THCOMP  DECK
        SUBROUTINE THCOMP (PR,ETA,T,H,S,P,TO,HO,SO,PO)                 1
        PO=P*PR                                                        2
        TP=T*PR**0.28572                                               3
        DO 1 I=1,25                                                    4
        CALL THERMO (PO,HP,TP,SP,X1,0,X2,0)                            5
        DELS=SP-S                                                      6
        IF (ABS(DELS).LE.0.00005*S) GO TO 2                            7
1       TP=TP/EXP(4.*DELS)                                             8
        CALL ERROR                                                     9
2       HO=H+((HP-H)/ETA)                                             10
        CALL THERMO (PO,HO,TO,SO,X1,0,X2,1)                           11
        RETURN                                                        12
        END                                                           13
```

```
$IBFTC PROCOM  DECK
      SUBROUTINE PROCOM (FARX,TEX,CSEX,AKEX,CPEX,REX,PHI,HEX)                  1
      IF (FARX.LE.0.067623) GO TO 1                                            2
      FARX=0.067623                                                            3
1     IF (TEX.GE.300.) GO TO 2                                                 4
      TEX=300.                                                                 5
2     IF (TEX.LE.4000.) GO TO 3                                                6
      TEX=4000.                                                                7
3     IF (FARX.GE.0.0) GO TO 4                                                 8
      FARX=0.0                                                                 9
C     AIR PATH                                                                10
4     CPA=((((((1.0115540E-25*TEX-1.4526770E-21)*TEX+7.6215767E-18)*TEX-      11
     11.5128259E-14)*TEX-6.7178376E-12)*TEX+6.5519486E-08)*TEX-5.1536879      12
     2E-05)*TEX+2.5020051E-01                                                 13
      HEA=(((((((1.2644425E-26*TEX-2.0752522E-22)*TEX+1.2702630E-18)*TEX      14
     1-3.0256518E-15)*TEX-1.6794594E-12)*TEX+2.1839826E-08)*TEX-2.576844      15
     20E-05)*TEX+2.5020051E-01)*TEX-1.7558886E+00                             16
      SEA=+2.5020051E-01*ALOG(TEX)+((((((1.4450767E-26*TEX-2.4211288E-22       17
     1)*TEX+1.5243153E-18)*TEX-3.7820648E-15)*TEX-2.2392790E-12)*TEX+3.2      18
     2759743E-08)*TEX-5.1576879E-05)*TEX+4.5432300E-02                        19
      IF (FARX.LE.0.0) GO TO 5                                                 20
C     FUEL/AIR PATH                                                           21
      CPF=((((((7.2678710E-25*TEX-1.3335668E-20)*TEX+1.0212913E-16)*TEX-       22
     14.2051104E-13)*TEX+9.9686793E-10)*TEX-1.3771901E-06)*TEX+1.2258630      23
     2E-03)*TEX+7.3816638E-02                                                 24
      HEF=(((((((9.0848388E-26*TEX-1.9050949E-21)*TEX+1.7021525E-17)*TEX       25
     1-8.4102208E-14)*TEX+2.4921698E-10)*TEX-4.5906332E-07)*TEX+6.129315      26
     20E-04)*TEX+7.3816638E-02)*TEX+3.0581530E+01                             27
      SEF=+7.3816638E-02*ALOG(TEX)+((((((1.0382670E-25*TEX-2.2226118E-21       28
     1)*TEX+2.0425826E-17)*TEX-1.0512776E-13)*TEX+3.3228928E-10)*TEX-6.8      29
     2859505E-07)*TEX+1.2258630E-03)*TEX+6.483398E-01                         30
5     CPEX=(CPA+FARX*CPF)/(1.+FARX)                                           31
      HEX=(HEA+FARX*HEF)/(1.+FARX)                                            32
      PHI=(SEA+FARX*SEF)/(1.+FARX)                                            33
      AMW=28.97-.946186*FARX                                                  34
      REX=1.986375/AMW                                                        35
      AKEX=CPEX/(CPEX-REX)                                                    36
      CSEX=SQRT(AKEX*REX*TEX*25031.37)                                        37
      RETURN                                                                  38
      END                                                                     39
```

```
$IBFTC SERCH   DECK
      SUBROUTINE SEARCH (P,A,B,C,D,AX,NA,BX,CX,DX,NO,NAM,NOM,NCODE)            1
      DIMENSION AX(NAM),BX(NAM,NOM),CX(NAM,NOM),DX(NAM,NOM),NO(NAM),Q(9)       2
C *** NEEDS SUBROUTINE AFQUIR                                                  3
C *** AX AND BX MUST BE STORED LO TO HI                                        4
C *** P=INPUT PROPORTION BETWEEN 0.0 AND 1.0                                   5
C     IF NOT INPUT, P MUST EQUAL -1.                                           6
C *** NCODE=00   OK                                                            7
C     NCODE=01   A LO                                                          8
C     NCODE=02   A HI                                                          9
C     NCODE=07   ERROR                                                        10
C     NCODE=10   B LO                                                         11
C     NCODE=20   B HI                                                         12
      NCODE=0                                                                 13
      C=0.                                                                    14
      D=0.                                                                    15
```

```
C *** FIND A                                                                    16
      DO 1 I=1,NA                                                               17
      IH=I                                                                      18
      IF (A.LT.AX(I)) GO TO 2                                                   19
1     CONTINUE                                                                  20
      IF (A.GT.AX(IH)) NCODE=2                                                  21
      A=AX(IH)                                                                  22
      GO TO 3                                                                   23
2     IF (IH.GT.1) GO TO 3                                                      24
      NCODE=1                                                                   25
      IH=2                                                                      26
      A=AX(1)                                                                   27
3     IL=IH-1                                                                   28
      LIMH=ND(IH)                                                               29
      LIML=ND(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
      B=BH                                                                      43
5     PP=0.5                                                                    44
      Q(2)=0.                                                                   45
      Q(3)=0.                                                                   46
6     BH=PP*(BX(IH,LIMH)-BX(IH,1))+BX(IH,1)                                     47
      BL=PP*(BX(IL,LIML)-BX(IL,1))+BX(IL,1)                                     48
      DO 7 J=2,LIMH                                                             49
      JH=J                                                                      50
      IF (BH.LT.BX(IH,J)) GO TO 8                                               51
7     CONTINUE                                                                  52
8     JL=JH-1                                                                   53
      DO 9 K=2,LIML                                                             54
      KH=K                                                                      55
      IF (BL.LT.BX(IL,K)) GO TO 10                                              56
9     CONTINUE                                                                  57
10    KL=KH-1                                                                   58
      PR=(BX(IH,JL)-BH)/(BX(IH,JH)-BX(IH,JL))                                   59
      CH=CX(IH,JL)-PR*(CX(IH,JH)-CX(IH,JL))                                     60
      DH=DX(IH,JL)-PR*(DX(IH,JH)-DX(IH,JL))                                     61
      PR=(BX(IL,KL)-BL)/(BX(IL,KH)-BX(IL,KL))                                   62
      CL=CX(IL,KL)-PR*(CX(IL,KH)-CX(IL,KL))                                     63
      DL=DX(IL,KL)-PR*(DX(IL,KH)-DX(IL,KL))                                     64
      BT=BL+PRM*(BH-BL)                                                         65
      CT=CL+PRM*(CH-CL)                                                         66
      DT=DL+PRM*(DH-DL)                                                         67
      IF (P.GE.0.) GO TO 13                                                     68
      DIR=SQRT(B/BT)                                                            69
      ERR=(B-BT)/B                                                              70
      CALL AFQUIR (Q(1),PP,ERR,0.,25.,0.001,DIR,PT,ICON)                        71
      GO TO (11,13,12),ICON                                                     72
11    PP=PT                                                                     73
      IF (PP.LT.0.) PP=0.                                                       74
      IF (PP.GT.1.) PP=1.                                                       75
      GO TO 6                                                                   76
12    NCODE=7                                                                   77
```

```
13      B=BT                                                                    78
        C=CT                                                                    79
        D=DT                                                                    80
        RETURN                                                                  81
        END                                                                     82



$IBFTC MAPBAK  DECK
        SUBROUTINE MAPBAC (MAP,MAPGO,TFFS,TFF,CNS,CN,PCN,T,MODE,IGO,NUM)         1
        DATA WH,WL,WT,WS/6H H.P. ,6H L.P. ,6H TFF  ,6HSPEED /                    2
        IF (NUMH.GT.0) GO TO 1                                                   3
        NUMH=0                                                                   4
        NUML=0                                                                   5
1       IGO=MAPGO+3*(MAP-1)                                                      6
        GO TO (2,3,5,6,7,9),IGO                                                  7
C *** HIGH PRESSURE TURBINE                                                      8
2       TFF=TFF+0.1*(TFF-TFFS)                                                   9
        WRITE (8,10) WH,WT,TFFS,TFF                                             10
        RETURN                                                                  11
3       CN=CN+0.05*(CN-CNS)                                                     12
        IF (MODE.NE.1) PCN=PCN*(CN/CNS)                                         13
        IF (MODE.EQ.1) T=T*(CNS/CN)**2                                          14
        WRITE (8,10) WH,WS,CNS,CN                                               15
        IF (NUMH.GT.2) GO TO 4                                                  16
        NUM=1                                                                   17
        NUMH=NUMH+1                                                             18
        RETURN                                                                  19
4       DELCN=CN-CNS                                                            20
        IF (DELCN.GE.0.) RETURN                                                 21
        TFF=TFF*(1.+DELCN/CN)                                                   22
        WRITE (8,11) WH,WT,TFFS,TFF                                             23
        RETURN                                                                  24
5       TFF=TFF+0.1*(TFF-TFFS)                                                  25
        WRITE (8,10) WH,WT,TFFS,TFF                                             26
        GO TO 3                                                                 27
C *** LOW PRESSURE TURBINE                                                      28
6       TFF=TFF+0.1*(TFF-TFFS)                                                  29
        WRITE (8,10) WL,WT,TFFS,TFF                                             30
        RETURN                                                                  31
7       CN=CN+0.05*(CN-CNS)                                                     32
        IF (MODE.NE.3) PCN=PCN*(CN/CNS)                                         33
        IF (MODE.EQ.3) T=T*(CNS/CN)                                             34
        WRITE (8,10) WL,WS,CNS,CN                                               35
        IF (NUML.GT.2) GO TO 8                                                  36
        NUM=1                                                                   37
        NUML=NUML+1                                                             38
        RETURN                                                                  39
8       DELCN=CN-CNS                                                            40
        IF (DELCN.GE.0.) RETURN                                                 41
        TFF=TFF*(1.+DELCN/CN)                                                   42
        WRITE (8,11) WL,WT,TFFS,TFF                                             43
        RETURN                                                                  44
9       TFF=TFF+0.1*(TFF-TFFS)                                                  45
        WRITE (8,10) WL,WT,TFFS,TFF                                             46
        GO TO 7                                                                 47
C                                                                               48
C                                                                               49
10      FORMAT (1HO,A6,12HTURBINE MAP ,A6,4HWAS=,E13.6,10H  AND NOW=,E13.6      50
     1,6H$$$$$$)                                                                51
```

```
11    FORMAT (1HO,A6,A6,22HWAS ALSO CHANGED FROM ,E13.6,5H  TO ,E13.6,6H      52
     1$$$$$$)                                                                 53
      END                                                                     54



$IBFTC CONVRG  DECK
      SUBROUTINE CONVRG (TI,HI,PI,SI,FAR,WG,PA,IDES,AO,PR,TO,HO,PO,SO,TS      1
     10,PSO,VO,AMO,ICON)                                                      2
C     ICON=1      SUBSONIC, COMPARE PI WITH PR                               3
C     ICON=2      SONIC, COMPARE PI WITH PR                                  4
C     ICON=4      ERROR                                                      5
      AJ=778.26                                                              6
      CAPSF=2116.217                                                         7
      G=32.174049                                                            8
      CALL PROCOM (FAR,TI,XX1,XX2,XX3,XX4,PHII,XX6)                          9
C *** SONIC CALCULATIONS                                                     10
      J=0                                                                    11
      TSS=0.833*TI                                                           12
1     J=J+1                                                                  13
      CALL PROCOM (FAR,TSS,CSS,AKS,CP,REXS,PHISS,HSS)                        14
      HSCAL=HI-CSS**2/(2.*G*AJ)                                              15
      DELHS=HSCAL-HSS                                                        16
      IF (ABS(DELHS)-0.0005*HSCAL) 4,4,2                                     17
2     TSS=TSS+DELHS/CP                                                       18
      IF (J-15) 1,1,3                                                        19
3     ICON=4                                                                 20
      RETURN                                                                 21
4     IF (IDES) 12,12,5                                                      22
C *** ISENTROPIC EXPANSION CALCULATIONS                                      23
5     J=0                                                                    24
      TSI=TI*(PA/PI)**0.286                                                  25
6     J=J+1                                                                  26
      CALL THERMO (PA,HSI,TSI,SSI,XX1,1,FAR,0)                               27
      IF (ABS(SSI-SI)-0.0001*SI) 8,8,7                                       28
7     TSI=TSI/EXP(4.*(SSI-SI))                                               29
      IF (J-30) 6,6,3                                                        30
8     VIS=SQRT(2.*G*AJ*(HI-HSI))                                             31
      IF (VIS-CSS) 9,11,11                                                   32
C *** SUBSONIC DESIGN, CALCULATE AO                                          33
9     VO=VIS                                                                 34
      TSO=TSI                                                                35
      PSO=PA                                                                 36
      CALL PROCOM (FAR,TSO,CSO,XX2,XX3,REX,PHISO,HSO)                        37
      RHO=CAPSF*PSO/(AJ*REX*TSO)                                             38
      AO=WG/(RHO*VO)                                                         39
      AMO=VO/CSO                                                             40
      PR=PI                                                                  41
      ICON=1                                                                 42
10    TO=TI                                                                  43
      HO=HI                                                                  44
      PO=PI                                                                  45
      SO=SI                                                                  46
      RETURN                                                                 47
C *** SONIC DESIGN, CALCULATE AO                                             48
11    VO=CSS                                                                 49
      TSO=TSS                                                                50
      PSO=PI*(TSO/TI)**(AKS/(AKS-1.))                                        51
      RHO=CAPSF*PSO/(AJ*REXS*TSO)                                            52
      AO=WG/(RHO*VO)                                                         53
```

```
      AMO=1.0                                                          54
      PR=PI                                                            55
      ICON=2                                                           56
      GO TO 10                                                         57
C *** NON-DESIGN, CALCULATE CRITICAL CONDITIONS                        58
12    VO=CSS                                                           59
      TSO=TSS                                                          60
      PSO=PA                                                           61
      RHO=CAPSF*PSO/(AJ*REXS*TSO)                                      62
      AOCRIT=WG/(RHO*VO)                                               63
      AMO=1.0                                                          64
      PR=PSO*(TI/TSO)**(AKS/(AKS-1.))                                  65
      IF (AO-AOCRIT) 13,13,14                                          66
C *** NON-DESIGN, CRITICAL AND SUPERCRITICAL CONDITIONS                67
13    PSO=PSO*AOCRIT/AO                                                68
      PR=PR*AOCRIT/AO                                                  69
      ICON=2                                                           70
      GO TO 10                                                         71
C *** NON-DESIGN, SUBSONIC CALCULATIONS                                72
14    PSO=PA                                                           73
      J=0                                                              74
      TSO=0.833*TSO                                                    75
15    J=J+1                                                            76
      CALL PROCOM (FAR,TSO,CSO,AKO,CP,REX,PHISO,HSO)                   77
      RHO=CAPSF*PSO/(AJ*REX*TSO)                                       78
      VO=WG/(RHO*AO)                                                   79
      HSCAL=HI-VO**2/(2.*G*AJ)                                         80
      DELHS=HSCAL-HSO                                                  81
      IF (ABS(DELHS)-0.0005*HSCAL) 17,17,16                            82
16    TSO=TSO+DELHS/CP                                                 83
      IF (J-15) 15,15,3                                                84
17    AMO=VO/CSO                                                       85
      PR=PSO*(TI/TSO)**(AKO/(AKO-1.))                                  86
      ICON=1                                                           87
      GO TO 10                                                         88
      END                                                              89
```

```
$IBFTC CONDIV  DECK
      SUBROUTINE CONDIV (TI,HI,PI,SI,FAR,WG,PA,IDES,AT,AO,PIR,TT,HT,PT,S     1
     1T,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
      DIMENSION Q(9)                                                         7
      Q(2)=0.                                                                8
      Q(3)=0.                                                                9
      AJ=778.26                                                             10
      CAPSF=2116.2170                                                       11
      G=32.174049                                                           12
      CALL PROCOM (FAR,TI,XX1,XX2,XX3,XX4,PHII,XX6)                         13
C *** SONIC CALCULATIONS                                                    14
      J=0                                                                   15
      TSS=0.833*TI                                                          16
1     J=J+1                                                                 17
      CALL PROCOM (FAR,TSS,CSS,AK,CP,REXS,PHISS,HSS)                        18
      HSCAL=HI-CSS**2/(2.*G*AJ)                                             19
```

```
      DELHS=HSCAL-HSS                                                    20
      IF (ABS(DELHS)-0.0005*HSCAL) 4,4,2                                 21
2     TSS=TSS+DELHS/CP                                                   22
      IF (J-15) 1,1,3                                                    23
3     ICON=4                                                             24
      RETURN                                                             25
4     IF (IDES) 11,11,5                                                  26
C *** SONIC DESIGN, CALCULATE AT                                         27
5     VT=CSS                                                             28
      TST=TSS                                                            29
      PST=PI*(TST/TI)**(AK/(AK-1.))                                      30
      RHO=CAPSF*PST/(AJ*REXS*TST)                                        31
      AT=WG/(RHO*VT)                                                     32
      AMT=1.0                                                            33
C *** IDEAL EXPANSION DESIGN, CALCULATE AO                               34
      PSO=PA                                                             35
      J=0                                                                36
      TSO=TI*(PSO/PI)**.286                                              37
6     J=J+1                                                              38
      CALL PROCOM (FAR,TSO,CSO,AK,CP,REX,PHISO,HSO)                      39
      PHICAL=PHII-REX*ALOG(PI/PSO)                                       40
      DELPHI=PHICAL-PHISO                                                41
      IF (ABS(DELPHI)-0.0001*PHICAL) 8,8,7                               42
7     TSO=TSO*EXP(4.*DELPHI)                                             43
      IF (J-15) 6,6,3                                                    44
8     VO=SQRT(2.*G*AJ*(HI-HSO))                                          45
      AMO=VO/CSO                                                         46
      AO=(AT/AMO)*(2.*(1.+(AK-1.)*AMO**2/2.)/(AK+1.))**((AK+1.)/(2.*(AK- 47
     1 1.)))                                                             48
      PIR=PI                                                             49
      ICON=3                                                             50
9     TO=TI                                                              51
      HO=HI                                                              52
      PO=PI                                                              53
      SO=SI                                                              54
10    TT=TI                                                              55
      HT=HI                                                              56
      PT=PI                                                              57
      ST=SI                                                              58
      RETURN                                                             59
C *** ASSUME SONIC THROAT AND ISENTROPIC EXPANSION TO AO                  60
11    VT=CSS                                                             61
      AMT=1.0                                                            62
      TST=TSS                                                            63
      RHO=WG/(AT*VT)                                                     64
      PST=RHO*AJ*REXS*TST/CAPSF                                          65
      PIR=PST*(TI/TST)**(AK/(AK-1.))                                     66
      IF (PST-PA) 12,27,27                                               67
12    TSO=0.95*TI                                                        68
      MAM=0                                                              69
13    CALL PROCOM (FAR,TSO,CSO,AK,CP,REX,PHISO,HSO)                      70
      AMO=SQRT(2.*((TI/TSO)-1.)/(AK-1.))                                 71
      AOCAL=(AT/AMO)*(2.*(1.+(AK-1.)*AMO**2/2.)/(AK+1.))**((AK+1.)/(2.*( 72
     1AK-1.)))                                                           73
      EA=(AO-AOCAL)/AO                                                   74
      DIR=SQRT(AO/AOCAL)                                                 75
      CALL AFQUIR (Q(1),TSO,EA,0.,100.,0.0001,DIR,TSOT,JCON)             76
      GO TO (14,18,3),JCON                                               77
14    TSO=TSOT                                                           78
      IF (TSO-TI) 15,13,16                                               79
15    TSC=2.*TI/(AK+1.)                                                  80
      IF (TSO.GT.TSC) GO TO 17                                           81
```

```
16    TSO=0.98*TI                                                          82
      GO TO 13                                                             83
17    IF (Q(2).LT.30.0.OR.AMO.LT.0.95.OR.MAM.EQ.1) GO TO 13                84
      TSO=2.*TI/(2.+0.98*(AK-1.))                                          85
      MAM=1                                                                86
      GO TO 13                                                             87
18    PSO=PIR*(TSO/TI)**(AK/(AK-1.))                                       88
      IF (PSO-PA) 20,19,27                                                 89
C *** CRITICAL FLOW, ISENTROPIC EXPANSION TO PA                            90
19    VO=AMO*CSO                                                           91
      ICON=1                                                               92
      GO TO 9                                                              93
C *** SUBSONIC FLOW                                                        94
20    PSO=PA                                                               95
      Q(2)=0.                                                              96
      Q(3)=0.                                                              97
      J=0                                                                  98
      TSO=0.833*TI                                                         99
21    J=J+1                                                               100
      CALL PROCOM (FAR,TSO,CSO,AK,CP,REX,PHISO,HSO)                       101
      RHO=CAPSF*PSO/(AJ*REX*TSO)                                          102
      VO=WG/(RHO*AO)                                                      103
      HSCAL=HI-VO**2/(2.*G*AJ)                                            104
      DELHS=HSCAL-HSO                                                     105
      IF (ABS(DELHS)-0.0005*HSCAL) 23,23,22                               106
22    TSO=TSO+DELHS/CP                                                    107
      IF (J-15) 21,21,3                                                   108
23    AMO=VO/CSO                                                          109
      PIR=PSO*(TI/TSO)**(AK/(AK-1.))                                      110
      TST=TSO                                                             111
24    CALL PROCOM (FAR,TST,CST,AK,CP,REX,PHIST,HST)                       112
      PST=PIR*(TST/TI)**(AK/(AK-1.))                                      113
      RHO=PST*CAPSF/(AJ*REX*TST)                                          114
      VT=WG/(RHO*AT)                                                      115
      HSCAL=HI-VT**2/(2.*G*AJ)                                            116
      EH=(HSCAL-HST)/HSCAL                                                117
      DIR=1.+(HSCAL-HST)/(CP*TST)                                         118
      CALL AFQUIR (Q(1),TST,EH,0.,20.,0.0005,DIR,TSTT,JCON)               119
      GO TO (25,26,3),JCON                                                120
25    TST=TSTT                                                            121
      GO TO 24                                                            122
26    AMT=VT/CST                                                          123
      ICON=1                                                              124
      GO TO 9                                                             125
C *** SUPERCRITICAL FLOW, ISENTROPIC EXPANSION TO PA                       126
27    PSO=PA                                                              127
      J=0                                                                 128
      TSO=TI*(PSO/PIR)**.286                                              129
28    J=J+1                                                               130
      CALL PROCOM (FAR,TSO,CSO,AK,CP,REX,PHISO,HSO)                       131
      PHICAL=PHII-REX*ALOG(PIR/PSO)                                       132
      DELPHI=PHICAL-PHISO                                                 133
      IF (ABS(DELPHI)-0.0001*PHICAL) 30,30,29                             134
29    TSO=TSO*EXP(4.0*DELPHI)                                             135
      IF (J-15) 28,28,3                                                   136
30    VO=SQRT(2.*G*AJ*(HI-HSO))                                           137
      AMO=VO/CSO                                                          138
      AOID=(AT/AMO)*(2.*(1.+(AK-1.)*AMO**2/2.)/(AK+1.))**((AK+1.)/(2.*(A  139
     1K-1.)))                                                             140
      ICON=3                                                              141
      N=0                                                                 142
      IF (AO-AOID) 31,9,32                                                143
```

```
C *** SUPERCRITICAL FLOW, ISENTROPIC EXPANSION TO AO                          144
31    N=1                                                                    145
32    TSO=0.833*TI                                                           146
      J=0                                                                    147
33    J=J+1                                                                  148
      CALL PROCOM (FAR,TSO,CSO,AK,CP,REX,PHISO,HSO)                          149
      AMO=SQRT(2.*((TI/TSO)-1.)/(AK-1.))                                     150
      AOCAL=(AT/AMO)*(2.*(1.+(AK-1.)*AMO**2/2.)/(AK+1.))**((AK+1.)/(2.*(     151
     1AK-1.)))                                                               152
      DELA=AO-AOCAL                                                          153
      IF (ABS(DELA)-0.0001*AO) 35,35,34                                      154
34    TSO=TSO*SQRT(AOCAL/AO)                                                 155
      IF (J-50) 33,33,3                                                      156
35    IF (N) 37,37,36                                                        157
C *** UNDEREXPANDED, SHOCK OUTSIDE NOZZLE                                    158
36    PSO=PIR*(TSO/TI)**(AK/(AK-1.))                                         159
      VO=AMO*CSO                                                             160
      GO TO 9                                                                161
C *** OVEREXPANDED, FIND SHOCK POSITION                                      162
37    PSX=PIR*(TSO/TI)**(AK/(AK-1.))                                         163
      PSY=PSX*(2.*AK*AMO**2/(AK+1.)-(AK-1.)/(AK+1.))                         164
      IF (PA-PSY) 38,39,39                                                   165
C *** OVEREXPANDED, SHOCK OUTSIDE NOZZLE                                     166
38    PSO=PSX                                                                167
      VO=AMO*CSO                                                             168
      GO TO 9                                                                169
C *** OVEREXPANDED, SHOCK INSIDE NOZZLE                                      170
39    PSO=PA                                                                 171
      J=0                                                                    172
      TSO=0.833*TI                                                           173
40    J=J+1                                                                  174
      CALL PROCOM (FAR,TSO,CSO,AK,CP,REX,PHISO,HSO)                          175
      RHO=CAPSF*PSO/(AJ*REX*TSO)                                             176
      VO=WG/(RHO*AO)                                                         177
      HSCAL=HI-VO**2/(2.*G*AJ)                                               178
      DELHS=HSCAL-HSO                                                        179
      IF (ABS(DELHS)-0.0005*HSCAL) 42,42,41                                  180
41    TSO=TSO+DELHS/CP                                                       181
      IF (J-15) 40,40,3                                                      182
42    AMO=VO/CSO                                                             183
      TO=TI                                                                  184
      HO=HI                                                                  185
      PO=PSO*(TO/TSO)**(AK/(AK-1.))                                          186
      SO=PHII-REX*ALOG(PO)                                                   187
      ICON=2                                                                 188
      GO TO 10                                                               189
      END                                                                    190
```

```
$IBFTC THTERB  DECK
      SUBROUTINE THTURB (DH,ETA,FAR,H,S,P,TO,HO,SO,PO)                        1
      HO=H-DH                                                                 2
      HOP=H-DH/ETA                                                            3
      PT=P/2.                                                                 4
      DO 1 I=1,25                                                             5
      CALL THERMO (PT,HOP,TT,ST,AMWT,1,FAR,1)                                 6
      DELS=ST-S                                                               7
      IF (ABS(DELS).LE.0.00005*S) GO TO 2                                     8
```

```
1       PT=P*EXP(DELS*AMWT/1.986375+ALOG(PT/P))                          9
        CALL ERROR                                                       10
2       PO=PT                                                            11
        CALL THERMO (PO,HO,TO,SO,X1,1,FAR,1)                             12
        RETURN                                                           13
        END                                                              14
```

```
$IBFTC THERMO  DECK
        SUBROUTINE THERMO (PX,HX,TX,SX,AMX,L,FAR,K)                       1
        FX=0.                                                             2
        IF (L.EQ.1) FX=FAR                                                3
        IF (K.EQ.1) GO TO 1                                               4
        CALL PROCOM (FX,TX,CS,AK,CP,R,PHI,HX)                             5
        GO TO 3                                                           6
1       TX=4.*HX                                                          7
        DO 2 I=1,15                                                       8
        CALL PROCOM (FX,TX,CS,AK,CP,R,PHI,H)                              9
        DELH=HX-H                                                        10
        IF (ABS(DELH).LE.0.00001*HX) GO TO 3                             11
2       TX=TX+4.*DELH                                                    12
        WRITE (8,4)                                                      13
3       SX=PHI-R*ALOG(PX)                                                14
        AMX=1.986375/R                                                   15
        RETURN                                                           16
C                                                                        17
C                                                                        18
4       FORMAT (31HONO CONVERGENCE IN THERMO$$$$$$)                      19
        END                                                              20
```

```
$IBFTC AFQUER  DECK
        SUBROUTINE AFQUIR (X,AIND,DEPEND,ANS,AJ,TOL,DIR,ANEW,ICON)        1
        DIMENSION X(9)                                                    2
C X(1)=NAME OF ARRAY TO USE                                               3
C AIND=INDEPENDANT VARIABLE                                               4
C DEPEND= DEPENDANT VARIABLE                                              5
C ANS=ANSWER UPON WHICH TO CONVERGE                                       6
C AJ=MAX NUMBER OF TRYS                                                   7
C TOL=PERCENT TOLERANCE FOR CONVERGENCE                                   8
C DIR=DIRECTION AND PERCENTAGE FOR FIRST GUESS                            9
C ANEW=CALCULATED VALUE OF NEXT TRY AT INDEPENDANT VARIABLE              10
C ICON=CONTROL  =1 GO THRU LOOP AGAIN                                    11
C               =2 YOU HAVE REACHED THE ANSWER                           12
C               =3 COUNTER HAS HIT LIMITS                                13
C X(2)=COUNTER STORAGE                                                   14
C X(3)=CHOOSES METHOD OF CONVERGENCE                                     15
C X(4)=THIRD DEPEND VAR                                                  16
C X(5)=THIRD IND VAR                                                     17
C X(6)=SECOND DEPEND VAR                                                 18
C X(7)=SECOND IND VAR                                                    19
C X(8)=FIRST DEPEND VAR                                                  20
C X(9)=FIRST IND VAR                                                     21
C X(3) MUST BE ZERO UPON FIRST ENTRY TO ROUTINE                          22
        Y=0.                                                             23
        IF (ANS) 1,2,1                                                   24
```

```
1       DEP=DEPEND-ANS                                                          25
        TOLANS=TOL*ANS                                                          26
        GO TO 3                                                                 27
2       DEP=DEPEND                                                              28
        TOLANS=TOL                                                              29
3       IF (ABS(DEP)-TOLANS) 5,5,4                                              30
4       IF (X(2)-AJ) 8,8,7                                                      31
5       ANEW=AIND                                                               32
        X(2)=J.                                                                 33
        ICON=2                                                                  34
        RETURN                                                                  35
6       ANEW=Y                                                                  36
        X(2)=X(2)+1.                                                            37
        ICON=1                                                                  38
        RETURN                                                                  39
7       ANEW=Y                                                                  40
        X(2)=J.                                                                 41
        ICON=3                                                                  42
        RETURN                                                                  43
8       IF (X(3)) 9,9,12                                                        44
C *** FIRST GUESS USING DIR                                                     45
9       X(3)=1.                                                                 46
        X(8)=DEP                                                                47
        X(9)=AIND                                                               48
        IF (AIND) 10,11,10                                                      49
10      Y=DIR*AIND                                                              50
        GO TO 6                                                                 51
11      Y=DIR                                                                   52
        GO TO 6                                                                 53
12      IF (X(3)-1.) 13,13,16                                                   54
C *** LINEAR GUESS                                                              55
13      X(3)=2.                                                                 56
        X(6)=DEP                                                                57
        X(7)=AIND                                                               58
        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(5)-X(4))/(X(7)-X(5))                                               80
        A=(X(3)-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)                                                              132
        GO TO 6                                                                133
        END                                                                    134
```

```
$IBFTC PARABO  DECK
       SUBROUTINE PARABO (X,Y,XD,YANS)                                          1
       DIMENSION X(3),Y(3)                                                      2
       A=((X(1)-X(2))*(Y(1)-Y(3))-(X(1)-X(3))*(Y(1)-Y(2)))/((X(1)-X(2))*(       3
      1X(1)-X(3))*(X(3)-X(2)))                                                  4
       B=((X(1)**2-X(2)**2)*(Y(1)-Y(3))-(X(1)**2-X(3)**2)*(Y(1)-Y(2)))/((       5
      1X(1)-X(2))*(X(1)-X(3))*(X(2)-X(3)))                                      6
```

```
      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
```

```
$IBFTC BLKFAN  DECK
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,
     2  1.02800,  199.800,  0.76648,  1.03840,  166.800,  0.75592,
     3  1.04480,  133.200,  0.72512,  1.04800,   86.400,  0.64152/
      DATA (PR( 2,J),WAC( 2,J),ETA( 2,J),J=1, 7)/
     1  1.00000,  286.800,  0.75592,  1.02000,  270.000,  0.77616,
     2  1.04000,  253.200,  0.79200,  1.05840,  233.400,  0.79728,
     3  1.07520,  209.400,  0.80256,  1.09200,  183.600,  0.77616,
     4  1.10000,  156.600,  0.74008/
      DATA (PR( 3,J),WAC( 3,J),ETA( 3,J),J=1, 7)/
     1  1.00000,  333.600,  0.75064,  1.02560,  322.800,  0.77616,
     2  1.05120,  310.200,  0.80256,  1.08000,  291.600,  0.82808,
     3  1.11600,  259.800,  0.84392,  1.13200,  240.000,  0.82808,
     4  1.14800,  213.600,  0.77616/
      DATA (PR( 4,J),WAC( 4,J),ETA( 4,J),J=1, 7)/
     1  1.00000,  383.400,  0.74536,  1.03680,  376.200,  0.77616,
     2  1.09800,  358.200,  0.82808,  1.12400,  340.200,  0.85448,
     3  1.15000,  313.200,  0.88000,  1.18960,  276.600,  0.82808,
     4  1.19520,  266.400,  0.80784/
      DATA (PR( 5,J),WAC( 5,J),ETA( 5,J),J=1,10)/
     1  1.00000,  439.800,  0.72512,  1.06400,  436.800,  0.77616,
     2  1.11840,  428.400,  0.82808,  1.14800,  420.600,  0.85448,
     3  1.13400,  406.800,  0.88000,  1.20960,  393.600,  0.90112,
     4  1.21760,  388.200,  0.90376,  1.22400,  383.400,  0.90112,
     5  1.24400,  368.400,  0.88000,  1.26720,  342.600,  0.82808/
      DATA (PR( 6,J),WAC( 6,J),ETA( 6,J),J=1,10)/
     1  1.00000,  499.800,  0.68816,  1.10000,  499.800,  0.77616,
     2  1.15000,  493.200,  0.82808,  1.20000,  485.400,  0.85448,
     3  1.22800,  476.400,  0.88000,  1.25520,  466.800,  0.90112,
     4  1.27200,  456.600,  0.91080,  1.28640,  448.200,  0.90112,
     5  1.30240,  433.200,  0.88000,  1.33200,  406.800,  0.82720/
      DATA (PR( 7,J),WAC( 7,J),ETA( 7,J),J=1,10)/
     1  1.00000,  566.400,  0.64152,  1.07600,  566.400,  0.72512,
     2  1.15200,  566.400,  0.77616,  1.21920,  559.800,  0.82808,
     3  1.25000,  553.200,  0.85888,  1.28960,  544.800,  0.88000,
     4  1.33120,  528.600,  0.90112,  1.36160,  509.400,  0.88000,
     5  1.39120,  483.600,  0.82808,  1.40000,  474.000,  0.81752/
      DATA (PR( 8,J),WAC( 8,J),ETA( 8,J),J=1,10)/
     1  1.00000,  633.600,  0.60016,  1.04400,  633.600,  0.64152,
     2  1.13520,  633.600,  0.72512,  1.22080,  633.000,  0.77616,
     3  1.29440,  625.800,  0.82808,  1.34000,  616.800,  0.85888,
     4  1.40000,  600.000,  0.88000,  1.42800,  586.800,  0.85888,
     5  1.44800,  576.600,  0.82808,  1.48000,  553.200,  0.78672/
      DATA (PR( 9,J),WAC( 9,J),ETA( 9,J),J=1,10)/
     1  1.00000,  700.200,  0.56936,  1.10400,  700.200,  0.64152,
     2  1.22000,  700.200,  0.72512,  1.32400,  700.200,  0.77616,
```

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     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  1.55800,   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
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$IBFTC BLKCMP  DECK
C     THIS IS GENERALIZED COMP. MAP FOR UNREALISTIC SUPERSONIC ENGINE           1
      BLOCK DATA                                                               2
      COMMON / COMP/CN(15),PR(15,15),WAC(15,15),ETA(15,15),N,NP(15)            3
      DATA N,NP/10,2*6,2*8,4*10,2*8,5*0/                                       4
      DATA CN/.562,.674,.787,.899,1.,1.034,1.067,1.124,1.236,1.292,5*0./       5
      DATA (PR( 1,J),WAC( 1,J),ETA( 1,J),J=1, 6)/                              6
     1  1.00000,    51.000,   0.59082,   1.84000,    50.200,   0.62178,         7
     2  2.42800,    49.500,   0.64242,   2.86900,    48.800,   0.65274,         8
     3  3.83500,    46.700,   0.67338,   4.54900,    44.500,   0.64242/         9
      DATA (PR( 2,J),WAC( 2,J),ETA( 2,J),J=1, 6)/                             10
     1  1.00000,    59.300,   0.59082,   1.96600,    59.300,   0.64242,        11
     2  3.09300,    58.800,   0.69402,   3.93300,    57.900,   0.72498,        12
     3  4.68900,    56.700,   0.74562,   5.52900,    55.000,   0.72498/        13
      DATA (PR( 3,J),WAC( 3,J),ETA( 3,J),J=1, 8)/                             14
     1  1.00000,    70.000,   0.58566,   1.84000,    70.000,   0.64242,        15
     2  2.63000,    70.000,   0.68370,   3.40800,    69.500,   0.72498,        16
     3  4.52100,    68.800,   0.77744,   5.44500,    67.900,   0.79292,        17
     4  6.31300,    66.400,   0.77744,   6.52300,    65.700,   0.76970/        18
      DATA (PR( 4,J),WAC( 4,J),ETA( 4,J),J=1, 8)/                             19
     1  1.00000,    84.800,   0.58050,   2.00800,    84.800,   0.64242,        20
     2  3.42900,    84.800,   0.72498,   4.60500,    84.800,   0.77744,        21
     3  5.69700,    84.000,   0.80840,   6.61400,    83.300,   0.82904,        22
     4  7.53800,    81.700,   0.80840,   7.95800,    80.500,   0.79292/        23
      DATA (PR( 5,J),WAC( 5,J),ETA( 5,J),J=1,10)/                             24
     1  1.00000,   101.700,   0.57190,   2.51900,   101.700,   0.64242,        25
     2  3.98200,   101.700,   0.72498,   5.27700,   101.700,   0.77744,        26
     3  6.43800,   101.200,   0.80840,   7.20200,   101.000,   0.83936,        27
     4  8.00000,   100.000,   0.86000,   8.56700,    99.500,   0.83936,        28
     5  9.38500,    98.100,   0.80840,   9.59600,    97.400,   0.80582/        29
      DATA (PR( 6,J),WAC( 6,J),ETA( 6,J),J=1,10)/                             30
     1  1.00000,   108.100,   0.57018,   2.85500,   108.100,   0.64242,        31
     2  4.29700,   108.100,   0.72498,   5.61300,   108.100,   0.77744,        32
     3  6.93600,   107.600,   0.80840,   7.62200,   107.100,   0.83936,        33
     4  8.54500,   106.700,   0.86000,   9.13400,   106.000,   0.83936,        34
     5  9.92500,   104.500,   0.80840,  10.21900,   104.000,   0.80410/        35
      DATA (PR( 7,J),WAC( 7,J),ETA( 7,J),J=1,10)/                             36
     1  1.00000,   114.500,   0.55986,   3.26100,   114.500,   0.64242,        37
     2  4.75900,   114.500,   0.72498,   6.11700,   114.500,   0.77744,        38
     3  7.45400,   114.500,   0.80840,   8.30800,   114.300,   0.83936,        39
     4  9.21800,   113.600,   0.84968,   9.63800,   113.300,   0.83936,        40
     5 10.51300,   112.600,   0.80840,  10.99600,   112.400,   0.79808/        41
      DATA (PR( 8,J),WAC( 8,J),ETA( 8,J),J=1,10)/                             42
     1  1.00000,   122.900,   0.53922,   1.68600,   122.900,   0.57018,        43
     2  3.84900,   122.900,   0.64242,   5.46600,   122.900,   0.72498,        44
     3  6.85500,   122.900,   0.77744,   8.37100,   122.900,   0.80840,        45
     4  8.95500,   122.600,   0.82388,   9.88300,   122.100,   0.83936,        46
     5 10.91200,   121.700,   0.80840,  11.81500,   120.700,   0.77744/        47
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      DATA (PR( 9,J),WAC( 9,J),ETA( 9,J),J=1, 8)/                                  48
     1  1.00000,  139.800,  0.47644,  4.35300,  139.800,  0.60114,                 49
     2  7.62200,  139.800,  0.72498, 10.21900,  139.800,  0.77744,                 50
     3 11.05900,  139.800,  0.78260, 11.89900,  139.500,  0.77744,                 51
     4 13.15900,  139.300,  0.72498, 13.65600,  139.000,  0.69918/                 52
      DATA (PR(10,J),WAC(10,J),ETA(10,J),J=1, 8)/                                  53
     1  1.00000,  146.200,  0.46612,  3.76500,  146.200,  0.57018,                 54
     2  6.43100,  146.200,  0.64242,  9.17600,  146.200,  0.72498,                 55
     3 10.21900,  146.200,  0.75078, 11.47900,  146.200,  0.75078,                 56
     4 12.71100,  146.200,  0.72498, 14.41200,  146.200,  0.64242/                 57
      END                                                                          58
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$IBFTC CMBDAT  DECK
      BLOCK DATA                                                                    1
      COMMON / COMB/PSI(15),DELT(15,15),ETA(15,15),N,NP(15)                         2
      DATA N,NP / 15,15*15 /                                                        3
      DATA PSI/4.9116,9.8232,14.735,19.646,24.558,29.470,34.381,                    4
     139.293,44.207,73.674,100.,200.,300.,400.,500./                               5
      DATA DELT/15*200.,15*300.,15*400.,15*500.,15*600.,15*700.,15*800.,            6
     115*900.,15*1000.,15*1100.,15*1200.,15*1300.,15*1400.,15*1500.,                7
     215*1600./                                                                     8
      DATA ETA/                                                                     9
     1.600,.726,.777,.806,.826,.843,.855,.865,7*.870,                              10
     2.758,.825,.858,.875,.888,.898,.906,.912,.914,6*.915,                         11
     3.868,.893,.911,.925,.935,.942,.947,.951,7*.953,                              12
     4.925,.936,.946,.955,.963,.969,.974,.977,.978,6*.979,                         13
     5.960,.966,.972,.977,.982,.985,.990,.992,.993,6*.995,                         14
     6.988,.991,.992,.994,.995,.997,.998,8*.999,                                   15
     78*1.00,7*.999,120*1.00/                                                      16
      END                                                                          17
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$IBFTC HPTDAT  DECK
      BLOCK DATA                                                                    1
      COMMON / HTURB/TFF(15),CN(15,15),DH(15,15),ETA(15,15),N,NP(15)                2
      DATA N,NP/10,9*15,12,5*0/                                                     3
      DATA TFF /   39.670,   42.990,   47.460,   48.610,   49.175,                  4
     1   49.600,   50.000,   50.425,   50.920,   51.575,    5*0./                   5
      DATA (CN( 1,J),DH( 1,J),ETA( 1,J),J=1,15)/                                    6
     1   0.1872,   0.0032,   0.6219,   0.3372,   0.0057,   0.7078,                 7
     2   0.5156,   0.0084,   0.7868,   0.7128,   0.0108,   0.8090,                 8
     3   0.9382,   0.0133,   0.8090,   1.1442,   0.0152,   0.7963,                 9
     4   1.3138,   0.0164,   0.7779,   1.5382,   0.0174,   0.7422,                10
     5   1.7264,   0.0179,   0.7078,   1.9324,   0.0176,   0.7635,                11
     6   2.1500,   0.0167,   0.6068,   2.4058,   0.0144,   0.5309,                12
     7   2.5892,   0.0120,   0.4773,   2.7862,   0.0082,   0.4045,                13
     8   2.9460,   0.0034,   0.3034/                                              14
      DATA (CN( 2,J),DH( 2,J),ETA( 2,J),J=1,15)/                                    15
     1   0.1872,   0.0038,   0.6068,   0.3942,   0.0080,   0.7078,                16
     2   0.5814,   0.0113,   0.8090,   0.7128,   0.0136,   0.8292,                17
     3   0.3442,   0.0156,   0.8363,   0.9804,   0.0176,   0.8393,                18
     4   1.1068,   0.0192,   0.8368,   1.2754,   0.0212,   0.8302,                19
     5   1.4450,   0.0228,   0.8254,   1.7068,   0.0248,   0.8090,                20
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6   1.9596,   0.0260,   0.7696,   2.2706,   0.0261,   0.7078,
7   2.5970,   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   0.5568,   0.0144,   0.8090,   0.8726,   0.0184,   0.8494,
3   1.0696,   0.0216,   0.8543,   1.2382,   0.0240,   0.8515,
4   1.4538,   0.0268,   0.8494,   1.6882,   0.0292,   0.8409,
5   1.9596,   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   2.5450,   0.0496,   0.8520,   2.8706,   0.0540,   0.8494,
7   3.0764,   0.0596,   0.8494,   3.1520,   0.0640,   0.8532,
8   3.1518,   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   0.5196,   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,
4   1.5108,   0.0448,   0.8797,   1.6186,   0.0476,   0.8899,
5   1.7450,   0.0510,   0.8954,   1.8618,   0.0544,   0.9000,
6   1.9558,   0.0576,   0.9010,   2.0000,   0.0600,   0.9000,
7   2.0450,   0.0624,   0.8980,   2.0824,   0.0660,   0.8925,
8   2.1010,   0.0700,   0.8793/
 DATA (CN( 8,J),DH( 8,J),ETA( 8,J),J=1,15)/
1   0.1872,   0.0088,   0.5051,   0.4834,   0.0196,   0.6068,
2   0.7314,   0.0272,   0.7078,   0.8814,   0.0316,   0.7665,
3   1.0226,   0.0356,   0.8090,   1.1442,   0.0392,   0.8292,
4   1.2804,   0.0432,   0.8494,   1.3696,   0.0460,   0.8596,
5   1.4538,   0.0488,   0.8697,   1.5950,   0.0528,   0.8808,
6   1.5746,   0.0560,   0.8848,   1.7450,   0.0596,   0.8848,
7   1.8010,   0.0640,   0.8788,   1.8156,   0.0664,   0.8697,
8   1.8196,   0.0693,   0.8590/
 DATA (CN( 9,J),DH( 9,J),ETA( 9,J),J=1,15)/
1   0.1872,   0.0093,   0.4909,   0.3372,   0.0159,   0.5380,
2   0.5344,   0.0232,   0.6068,   0.6754,   0.0284,   0.6573,
3   0.8068,   0.0330,   0.7078,   0.9196,   0.0368,   0.7463,
4   1.0128,   0.0400,   0.7776,   1.1254,   0.0442,   0.8090,
5   1.2196,   0.0480,   0.8191,   1.3138,   0.0524,   0.8302,
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     6    1.3696,    0.0556,    0.8347,    1.4068,    0.0580,    0.8363,
     7    1.4450,    0.0612,    0.8322,    1.4638,    0.0640,    0.8241,
     8    1.4676,    0.0668,    0.8090/
      DATA (CN(10,J),DH(10,J),ETA(10,J),J=1,12)/
     1    0.1872,    0.0132,    0.4257,    0.2814,    0.0180,    0.4747,
     2    0.3804,    0.0228,    0.5056,    0.4686,    0.0268,    0.5359,
     3    0.5528,    0.0314,    0.5683,    0.6382,    0.0352,    0.5941,
     4    0.5892,    0.0380,    0.6068,    0.7362,    0.0412,    0.6178,
     5    0.7696,    0.0440,    0.6240,    0.8068,    0.0476,    0.6310,
     6    0.8254,    0.0504,    0.6265,    0.8304,    0.0530,    0.6118/
      END
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$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    0.3682,    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    2.0247,    0.0062,    0.6452,    2.2827,    0.0061,    0.6200,
     6    2.4565,    0.0057,    0.6000,    2.6137,    0.0053,    0.5750,
     7    2.8166,    0.0044,    0.5310,    2.9456,    0.0035,    0.5000,
     8    3.3138,    0.0001,    0.3850/
      DATA (CN( 2,J),DH( 2,J),ETA( 2,J),J=1,15)/
     1    0.3682,    0.0026,    0.8000,    0.5518,    0.0039,    0.8100,
     2    0.7919,    0.0054,    0.8200,    1.0672,    0.0069,    0.8300,
     3    1.2882,    0.0080,    0.8300,    1.4446,    0.0087,    0.8290,
     4    1.5937,    0.0096,    0.8100,    1.8954,    0.0101,    0.8000,
     5    2.0619,    0.0104,    0.7850,    2.2273,    0.0107,    0.7600,
     6    2.3747,    0.0108,    0.7450,    2.6229,    0.0106,    0.7000,
     7    2.8720,    0.0101,    0.6800,    3.0555,    0.0094,    0.6450,
     8    3.3138,    0.0077,    0.5900/
      DATA (CN( 3,J),DH( 3,J),ETA( 3,J),J=1,15)/
     1    0.3682,    0.0031,    0.8000,    0.5911,    0.0051,    0.8300,
     2    0.8555,    0.0071,    0.8600,    1.0764,    0.0087,    0.8630,
     3    1.2519,    0.0099,    0.8670,    1.4354,    0.0111,    0.8700,
     4    1.5201,    0.0122,    0.8720,    1.8409,    0.0134,    0.8720,
     5    2.0247,    0.0143,    0.8700,    2.2455,    0.0152,    0.8670,
     6    2.4302,    0.0157,    0.8600,    2.5956,    0.0162,    0.8500,
     7    2.7791,    0.0166,    0.8300,    3.0555,    0.0167,    0.8000,
     8    3.3138,    0.0164,    0.7600/
      DATA (CN( 4,J),DH( 4,J),ETA( 4,J),J=1,15)/
     1    0.3682,    0.0033,    0.7995,    0.4237,    0.0038,    0.8000,
     2    0.5810,    0.0061,    0.8400,    0.8837,    0.0078,    0.8600,
     3    1.1047,    0.0096,    0.8680,    1.2882,    0.0110,    0.8730,
     4    1.5090,    0.0126,    0.8800,    1.7482,    0.0141,    0.8830,
     5    2.0429,    0.0159,    0.8835,    2.2091,    0.0166,    0.8830,
     6    2.3747,    0.0174,    0.8800,    2.6047,    0.0183,    0.8740,
     7    2.8720,    0.0191,    0.8600,    3.1291,    0.0195,    0.8350,
     8    3.3138,    0.0197,    0.8200/
      DATA (CN( 5,J),DH( 5,J),ETA( 5,J),J=1,15)/
     1    0.3682,    0.0036,    0.7750,    0.5065,    0.0049,    0.8000,
     2    0.7365,    0.0071,    0.8480,    0.9754,    0.0092,    0.8600,
     3    1.2882,    0.0119,    0.8750,    1.5647,    0.0141,    0.8900,
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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
 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    0.6529,    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    0.5447,    0.0104,    0.6700,    0.7546,    0.0122,    0.6850,                89
3    0.8555,    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
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```
$IBFTC ETAA3A  DECK
      SUBROJTINE ETAAB (FAR,EM6,P6,ETA,ETAADS,ETAASV,P6DS,P6DSAV,AM6DS,A      1
     1M6DSV,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,.5341,.7317,       6
     2.8293,.9268,1.000,1.0634,1.7/                                            7
      DATA ETABRT/.9400,.9887,1.0193,1.0306,1.0227,.9572,.9377,.9207,          8
     1.9354,.9626,.9773,1.0193,1.0532,1.077,1.0781,1.077,1.0747,1.0668,        9
     21.0573,1.0510,1.0374,1.0192,1.00,.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./                                            15
      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     CONTINJE                                                                 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 (EM5.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 (P5.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 FRATIO  DECK
        SUBROUTINE FRASHO (PRATIO,ARATIO,CF)                             1
        DIMENSION PR(30),AR(10),CFR(30,10),XX(3),YY(3),ZZ(2)             2
        DATA PR/1.0,1.25,1.5,1.75,2.0,2.25,2.5,2.75,3.0,3.25,3.5,3.75,4.0,  3
       14.25,4.5,4.75,5.,5.5,6.,6.5,7.,8.,9.,11.,13.,15.,17.,19.,21.,23./  4
        DATA AR/ 1.0,1.05,1.092,1.228,1.318,1.423,1.8,1.9,1.97,2.15/     5
        DATA (CFR(I,1),I=1,180)/                                         6
       1.971,.975,.978,.980,.981,.980,.9784,.9765,.9742,.9715,           7
       2.9688,.9658,.9632,.960,.957,.9538,.9506,.9445,.938,.932,.927,.918,  8
       3.910,.897,.8855,.875,.867,.859,.8515,.844,                       9
       4.963,.966,.970,.9743,.978,.9805,.982,.9805,.9786,.9762,.974,.9718,  10
       5.9693,.967,.9645,.962,.9595,.954,.949,.944,.9395,.9308,.9238,    11
       6.9117,.901,.892,.884,.8762,.869,.862,                            12
       7.956,.9605,.9638,.967,.970,.9731,.9754,.9775,.9795,.981,.980,.978,  13
       8.9761,.9742,.9723,.9702,.968,.9637,.9594,.9554,.9517,.945,.9387,  14
       9.9276,.9177,.9082,.8998,.891,.883,.8752,                         15
       $.947,.949,.9517,.954,.957,.9601,.9632,.9668,.971,.9737,.976,.9777,  16
       $.978,.9772,.976,.9752,.974,.970,.9655,.9637,.9603,.955,.950,.9403,  17
       $.9317,.9232,.915,.907,.8996,.892,                                18
       $.949,.9502,.9508,.9473,.9438,.941,.939,.940,.950,.956,.9605,.964,  19
       $.967,.968,.9692,.970,.9703,.9698,.9696,.9684,.966,.960,.9444,    20
       $.9438,.9347,.9265,.9193,.9128,.9067,.901,                        21
       $.948,.9485,.9487,.9484,.947,.9435,.936,.9275,.9185,.9155,.9155,  22
       $.929,.941,.9455,.950,.953,.9558,.9591,.9608,.9609,.9601,.957,    23
       $.9531,.9448,.9362,.9279,.9188,.910,.901,.8921/                   24
        DATA (CFR(I,1),I=181,300)/                                       25
       1.808,.815,.8245,.833,.8418,.852,.861,.871,.8811,.892,.903,.9142,  26
       2.924,.935,.9428,.9505,.958,.968,.9748,.9784,.9808,.982,.9816,    27
       3.9778,.974,.9695,.9646,.9598,.9543,.9487,                        28
       4.796,.804,.8121,.82,.8291,.838,.8465,.856,.8654,.8763,.8862,     29
       5.8975,.9085,.922,.930,.939,.946,.9575,.9655,.971,.975,.9783,     30
       6.9792,.977,.974,.970,.9665,.9623,.958,.9538,                     31
       7.792,.7981,.804,.812,.8201,.828,.8357,.846,.8545,.864,.874,      32
       8.8837,.894,.905,.9146,.9247,.933,.95,.9613,.966,.970,.9755,.9768,  33
       9.9782,.9770,.9742,.970,.966,.961,.956,                           34
       $.774,.780,.7871,.794,.801,.8087,.8165,.8247,.833,.841,.850,.8583,  35
       $.868,.878,.887,.8962,.907,.9255,.944,.953,.9592,.966,.9705,.9725,  36
       $.9718,.97,.9685,.9664,.964,.9616/                                37
        Y(X1,X2,X,Y1,Y2)=(Y1-Y2)*(X-X1)/(X1-X2)+Y1                       38
        N=0                                                              39
        DO 1 J=1,30                                                      40
1       IF (PRATIO.GE.PR(J)) N=J-1                                       41
        IF (N.EQ.0) N=1                                                  42
        IF (N.GE.29) N=28                                                43
        M=0                                                              44
        DO 2 K=1,10                                                      45
2       IF (ARATIO.GE.AR(K)) M=K                                         46
        IF (M.EQ.10.OR.M.EQ.0) GO TO 5                                   47
        DO 4 L=1,2                                                       48
        LL=M+L-1                                                         49
        DO 3 I=1,3                                                       50
```

```
      NN=N+I-1                                                          51
      XX(I)=PR(NN)                                                      52
3     YY(I)=CFR(NN,LL)                                                  53
      CALL PARABO (XX,YY,PRATIO,ANS)                                    54
4     ZZ(L)=ANS                                                         55
      CF=Y(AR(M),AR(M+1),ARATIO,ZZ(1),ZZ(2))                            56
      RETURN                                                            57
5     WRITE (6,7) ARATIO,AR(10)                                         58
      DO 6 I=1,3                                                        59
      NN=N+I-1                                                          60
      XX(I)=PR(NN)                                                      61
6     YY(I)=CFR(NN,10)                                                  62
      CALL PARABO (XX,YY,PRATIO,CF)                                     63
      RETURN                                                            64
C                                                                       65
C                                                                       66
7     FORMAT (8HOARATIO=F7.3,4X,26HOUT OF RANGE,USE DATA FOR ,F7.3)     67
      END                                                               68
```

```
$IBFTC INPUT   DECK
      SUBROUTINE INPUT(LUNIT,LOUNIT,ID,D,IT)                             1
      DIMENSION  D(1), IT(1)                                             2
C                                        * DEFINES ARGUMENTS AS ARRAYS     3
C        CONSTRUCTION OF THE TABLE    ITAB                              4
C                                                                       5
C     BIT  STANDARD  RETURN    RETURN    RETURN    RETURN    RETURN     6
C  NUMBER  RETURN    1         2         3         4         5          7
C    0-2             $         A-Z       0-9()     =         OTH        8
C    3-4   DETPC     RI OTH    NLSF                                     9
C    5-6   DER       TINL      OTH PS    CF                            10
C    7-8  0-9.+$)OTH ,*A-Z=    -(*/                                    11
C    9    ,.)A-Z     OTH                                               12
C    9-10 .,         A-Z)      0-9+*     =$                            13
C   10    OTH       $A-Z*)=/                                          14
C   10-11  0-9.,-OTH +*(        $A-Z*     )=/                           15
C   12    0-9 A-Z   OTH                                               16
C   12-13 A-Z       0-9       OTH                                     17
C   13-14  +-       OTH       0-9                                     18
C   15-16  +.       DE-       OTH                                     19
C   17-18  T        F         OTH                                     20
C   19-20  D        E         OTH                                     21
C   21     OTH      .                                                 22
C   21-22  A-Z      OTH                                               23
C   23     *        OTH                                               24
C   24     $        OTH                                               25
C   25     =        OTH                                               26
C   26-27  (        A-Z       OTH                                     27
C   28-29  )        ,         OTH                                     28
C   30     (        OTH                                               29
C   31     )        OTH                                               30
C     ERROR CODE DESIGNATIONS                                         31
C     ROUTINE   TYPE                                                  32
C     10 IXQTI  100 ILLEGAL CHARACTER                                 33
C     20 ITABLI 200 NAME TOO LONG                                     34
C     30 INMBRI 300 TABLE FULL OR BAD                                 35
C     40 INAMEI 400 SCALING ERROR                                     36
C     50 IARITI 500 NAME NOT IN TABLE                                 37
C     60 INAMEN 600 $DATA() INCOMPLETE                                38
```

```
C     70 INPUT  700 FORMULA ILL FORMED                                          39
C               800 FUNCTION UNDEFINED                                          40
C     MCNVRT = TYPE OF LEFT HAND VARIABLE                                       41
C     KCNVRT = TYPE OF CURRENT VARIABLE                                         42
C     ITYPE   MEANING                                                           43
C      1      REAL                                                            44
C      2      INTEGER                                                         45
C      3      DOUBLE PRECISION                                                46
C      4      TYPELESS OR NO CONVERSION                                       47
C      5      SUBROUTINE                                                      48
C      6      FUNCTION                                                        49
C        FORMAT OF TABLE                                                      50
C     1ST WORD   012  3456             7-31                                   51
C                TYPE  NUMBER OF WORDS ADDRESS                                52
C      NEXT 1 TO 15 WORDS   THE NAME, 4 CHARACTERS TO THE WORD                 53
      DIMENSION IFT( 31), IPTAB( 21), ITAB( 65)                               54
      DIMENSION ANAME(15) ,IMAGE(80) ,IMAGE1(81),IPARAM(9)                    55
     .         ,KSTACK(27),NAME(15)  ,RVALUE(2) ,STACK(27)                    56
C                                                                             57
      COMMON                                                                  58
     ./ICOMNI/ VALUE    ,ICOMP    ,IFNTYP   ,IMAGE1   ,IRADIX   ,ISUB        59
     .        ,KCH      ,KCNVRT   ,KCOUNT   ,KDIF     ,KFLD1    ,KFLD2       60
     .        ,LCOMP    ,LCNVRT   ,LEVEL    ,LFRT     ,LOOK                  61
     .        ,MCNVRT   ,MDIF     ,MODALL   ,MSTOR                           62
     .        ,NAME     ,NERROR   ,NONEW    ,NOTARG                        63
     .        ,SMCHR    ,TEST     ,ERMARK                                    64
     ./ICNSTI/ BLANK    ,BLANKS   ,DOLLAR   ,EOS                             65
     .        ,ICOMMA   ,IDOLAR   ,IFT      ,IPTAB    ,ITAB                  66
     .        ,KAM10    ,KBPC     ,KBPW     ,KCPCD    ,KERTYP                67
     .        ,KZERO    ,NOPRNT   ,TAB1                                      68
     ./IPARAM/ ABORT    ,KIUNIT   ,KOUNIT   ,LIMALF   ,LOCK     ,LOCX        69
     .        ,NOLIST   ,NSTDIR   ,TRACE                                     70
     ./ISTAKI/ STACK    ,ISTDIM   ,KSTACK   ,LEVLIM                          71
C                                                                             72
      INTEGER  BLANK    ,BLANKS   ,EOS      ,IDOLAR   ,TAB1     ,TRACE       73
     .,CONTYP  ,STORED                                                        74
      DOUBLE PRECISION STACK, VALUE                                           75
      LOGICAL ABORT                                                           76
C                                 * STOP FOR ERROR                            77
      LOGICAL DOLLAR                                                          78
C                           * TRUE IF A $T,$P, OR $C IS BEING PROCESSED       79
      LOGICAL ERMARK                                                          80
C                                 * .TRUE. IF ANY ERROR HAS OCCURED           81
      LOGICAL LIMALF                                                          82
C                                 * TERMINATE ALF CONSTANTS AT 15 WORDS.      83
      LOGICAL LOCK                                                            84
C                                 * DO NOT STORE ANY INPUT DATA               85
      LOGICAL NOLIST                                                          86
C                                 * DO NOT LIST INPUT CARDS                   87
      LOGICAL NONEW                                                           88
C                                 * DO NOT READ A NEW CARD. SET IN INPJT      89
      LOGICAL MODALL                                                          90
C                                 * .TRUE. RETURN ALL CHARACTERS              91
C                                   .FALSE. DELETE BLANKS AND SKIP FOR E      92
      LOGICAL SHORT                                                           93
C                                 * DO NOT STORE ALPHABETIC AND RADIX CO      94
C                                     DIRECTLY INTO D ARRAY                   95
      LOGICAL SMCHR                                                           96
C                                 * SAME CHARACTER IS TO BE USED OVER BY      97
      LOGICAL TEST                                                            98
C                                 * STORE COMMA AT END OF CARD IF NEEDED      99
C     END          ************************************************          100
```

```
      EQUIVALENCE (STACK,ISTACK), (VALUE,KVALUE,RVALUE),(NAME,ANAME)          101
      EQUIVALENCE (ICOMNI,ISUB),(IMAGE,IMAGE1),(IPARAM,ABORT)                102
       LOGICAL END2                                                          103
C                          * .TRUE. IF A $END CARD HAS ALREADY BEEN FOUND     104
      KIUNIT=LIUNIT                                                         105
      KOUNIT=LOUNIT                                                         106
C     CALL DEBUGX                                                           107
      LIMALF = .TRUE.                                                       108
      DOLLAR = .FALSE.                                                      109
       NOLIST = .FALSE.                                                     110
      END2 = .FALSE.                                                        111
      MODALL = .FALSE.                                                      112
      ERMARK = .FALSE.                                                      113
      LOCK = .FALSE.                                                        114
      KERTYP = 0                                                            115
      IFNTYP = -1                                                           116
      LOCX=1                                                                117
      L=LEVLIM+3                                                            118
      DO 16 I=1,L                                                           119
 16   KSTACK(I)=0                                                           120
      LEVEL=0                                                               121
      LFRT=0                                                                122
      NOTARG = ISTDIM                                                       123
      LCNVRT = 3                                                            124
C                                    * DOUBLE PRECISION, STANDARD           125
      MCNVRT = 1                                                            126
      KDIF = 1                                                              127
      MDIF = 1                                                              128
 1    NONEW = .FALSE.                                                       129
      SMCHR = .TRUE.                                                        130
       CALL ICHAR2($9470,24)                                                131
C                                * ERROR IF $ IS NOT 1ST CHARACTER READ     132
      LDOLAR = KCOUNT                                                       133
C                                     * CARD COLUMN OF LAST DOLLAR SIGN     134
       NONEW=.TRUE.                                                         135
C                                * $DATA MUST BE ON A SINGLE CARD           136
C              D    E  OTH                                                  137
      CALL ICHARI($3,$9470,19)                                              138
C              (   A-Z OTH                                                  139
 4    CALL ICHARI($4,$9470,26)                                              140
       CALL ISUBI                                                           141
      CALL ICHAR2($9470,31)                                                 142
C                                     * ERROR IF NO )                       143
       NONEW=.FALSE.                                                        144
      IT(1)=ISUB                                                            145
C     CALL DEBUG 2 (5HSETNO,IT(1))                                          146
C     CALL DEBUG 2(6HKERSIN,KERSIN)                                         147
      IF (ID.NE. IT(1)) GO TO 99                                            148
C                                   *RETURN BECAUSE WRONG DATA SET          149
      IF (IT(2).LT. 0)GO TO 9370                                            150
C                                        * TABLE FULL OR BAD                151
      GO TO 19                                                              152
 3    IF (END2) GO TO 99                                                    153
      END2 = .TRUE.                                                         154
      NONEW = .FALSE.                                                       155
 5    CALL ICHAR2($1,9)                                                     156
C                               * PASS LETTERS AND ..)                     157
      GO TO 5                                                               158
9470  KERTYP = 470                                                          159
      GO TO 999                                                             160
99    CONTINUE                                                              161
```

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C     CALL DEBUG 2(6HSTATMT,99)                                          162
      KCH = IDOLAR                                                       163
      KCOUNT = LDOLAR                                                    164
C                     *NEXT CALL BEGINS PROCESSING AT THIS CARD COLUMN  165
      IF(ERMARK) IT(1) = -IABS(IT(1))                                    166
C                                       * WARN PROGRAMER OF POSSIBLE ERRO 167
      IF(ERMARK.AND.ABORT)  GO TO789                                     168
      RETURN                                                             169
 789  WRITE(6,787)                                                       170
 787  FORMAT(44H ERROR HAS OCCURED AND ABORT IS .TRUE., STOP)            171
       STOP                                                              172
C     BEGIN TO INPUT THE DATA                                            173
C        STATEMENTS 19 AND 20 ARE THE SWITCHHOUSE                        174
C        CONTROL COMES HERE FOR NEW DIRECTION.                           175
C        LERT = 0 INDICATES THAT THE PREVIOUS TASK WAS COMPLETED.        176
 19   CONTINUE                                                           177
C     CALL DEBUG2(6HSTATMT,19)                                           178
       TEST=.FALSE.                                                      179
       GO TO 21                                                          180
 120  DOLLAR = .FALSE.                                                  181
20    CONTINUE                                                           182
C     CALL DEBUG 2(6HSTATMT,20)                                          183
       TEST=.TRUE.                                                       184
C        ENTRY ICHAR4 LOADS LCOMP WITH TAB NO 10 AND RETURNS ON TAB NO 7 185
C            OTH   ,*A-Z=  -(*/                                          186
 21    CALL ICHAR4($31,    $32,   7,10)                                  187
C NOW WE TEST LCOMP ON EACH OF THE 3 POSSIBLE RETURNS. THIS IS A 12 WAY  188
C             0-9.  +   $    )                                           189
       GO TO  (203,510, 64,430),LCOMP                                    190
C              ,    *  A-Z  =                                           191
 31    GO TO (460,202,530,450),LCOMP                                     192
C              -   (   *   /                                            193
 32    GO TO(520,420,440,441),LCOMP                                      194
64    IF(LERT.NE.0)     GO TO 9770                                       195
      LDOLAR = KCOUNT                                                    196
C                                  * CARD COLUMN OF LAST DOLLAR SIGN     197
      DOLLAR = .TRUE.                                                    198
C     CALL DEBUG 2 (6HSTATMT,64)                                         199
       TEST=.FALSE.                                                      200
      CALL ICHAR4($9170,$9170,3,5)                                       201
C            DE  T   P   C                                               202
       GO TO(99,100,150,630),LCOMP                                       203
100   CALL ITABLI(IT)                                                    204
      IF (KERTYP) 999,120,999                                            205
C                                                                        206
C                                                                        207
C      $PARAMETER                                                        208
C              (    A-Z  OTH                                            209
150   CALL ICHARI($150,$9170,26)                                         210
  151 CALL ICHAR2($152,0)                                                211
C                                 * GET FIRST CHAR OF NAME  ..DON*T BRAN 212
 152  CALL INAMEN                                                        213
      CALL ILOOKI($153,IPTAB)                                            214
9570  KERTYP = 570                                                       215
      GO TO999                                                           216
 153  CALL ICHAR2($9170,29)                                              217
C                                     * ERROR IF NO =                    218
      CALL ICHAR2($9170,10)                                              219
C                                     * GET CHARACTER,SEPERATE PART OF   220
      CALL INMBRI                                                        221
       KCNVRT=IFLD(0,3,IPTAB(LOOK))                                      222
      CALL ICNVTI(3,KCNVRT)                                              223
```

```
C                                    * CONVERT FROM DP TO TYPE OF VARIABLE
       IPT=IFLD(7,25,IPTAB(LOOK))
      IPARAM(IPT) = KVALUE
C              )       ,   OTH
      CALL ICHARI($151,$9170,28)
C     IF(TRACE.GT.0) CALL DEBUGX
C                                        * IF TRACE  TURNED ON PUT ON HEAD
      GO TO 120
C                                    * GO TO SWITCH HOUSE TEST FOR INSERTIO
C
C
C  CONSTANTS = LOGICAL,NUMERIC,ALPHAMERIC,RADIX.
 201  ASSIGN 220 TO CONTYP
C                                        * RADIX
      IFNTYP = -1
      GO TO 210
  202 ASSIGN 230 TO CONTYP
C                                        *  *
      GO TO 210
  203 ASSIGN 250 TO CONTYP
C                                        * NUMERIC,LOGICAL
C
C
C       ALL CONSTANTS          210
 210  LOP = 0
      SHORT =.TRUE.
      MSTOR = 0
C     CALL DEBUG2(6HST CON,210)
      IF(LEVEL.EQ.0)  LEVEL=3
      IF(KSTACK(  LEVEL).EQ.1)  GO TO 9770
C                                              * TWO CONSTANTS IN ROW E.G.
      GO TO CONTYP,(220,230,250)
C
C
C       RADIX CONSTANTS        220
C               (    A-Z  OTH
 220  CALL ICHAR2($9170,30)
      CALL ISUBI
      NAME (2) = 0
 221  CALL ICHAR2($2215,29)
C                                    * ERROR IF NO COMMA AFTER BASE NUMBER
      GO TO 9170
 2215 CALL ICHAR2($9170,12)
C                                    * ERROR IF NO NUMBER
 222  IRADIX = ISUB
      SMCHR = .TRUE.
 223  CALL ISUBI
      MSTOR = MSTOR +1
      NAME(MSTOR) = ISUB
      IF (MSTOR.GE.15)  GO TO 225
C               )     ,    OTH
 224  CALL ICHARI($223,$9170,28)
      IRADIX = 10
      GO TO 240
 225  ASSIGN 224 TO NEXT
      GO TO 241
C
C
C       HOLLERITH CONSTANTS    230
230   MODALL = .TRUE.
      TEST = .FALSE.
      NAME(2) = BLANKS
```

```
231   CALL INAMEN                                                          286
      IF(.NOT.MODALL)GO TO 240                                             287
C                                    *END OF CONSTANT                      288
      IF(LIMALF)   GO TO 265                                               289
C         LONG CONSTANT GOES TO 234                                        290
 234  ASSIGN 231 TO NEXT                                                   291
      GO TO 241                                                            292
C                                                                          293
C                                                                          294
C      STORE ALF + RADIX      240                                         295
 240  ASSIGN 260 TO NEXT                                                   296
      IF (MSTOR-2) 242,2405,241                                            297
 2405 IF (LFRT.EQ.1)  GO TO 242                                            298
      CALL ICHAR2($2406,29)                                                299
      SMCHR = .TRUE.                                                       300
      GO TO 242                                                            301
 2406 SMCHR = .TRUE.                                                       302
 241  SHORT = .FALSE.                                                      303
      IF (LFRT.NE.0)  GO TO 265                                            304
C     CALL DEBUG2(6HST 241,0)                                              305
 242  KVALUE = NAME(1)                                                     306
      RVALUE(2) = ANAME(2)                                                 307
      IF (NOTARG.GT.LEVEL) LCNVRT = 4                                      308
C     CALL DEBUG2(6HST 242,0)                                              309
C     CALL DEBUG2(6HSHORT ,SHORT)                                          310
C     CALL DEBUG2(6HLFRT  ,LFRT)                                           311
 243  IF (SHORT)  GO TO 255                                                312
      DO 245 I= 1,MSTOR                                                    313
      IF (LOCK) GO TO 245                                                  314
      D(LOCX) = ANAME(I)                                                   315
 245  LOCX = LOCX + 1                                                      316
 246  GO TO NEXT, (224,231,260)                                            317
C     SEE NEXT AND MEANING                                                 318
C         250       * ALF OR ) AND RADIX                                   319
C         224       MORE THAN 15 ELEMENTS IN RADIX FIELD                   320
C         231       MORE THAN 15 ELEMENTS IN ALF FIELD                     321
C                                                                          322
C                                                                          323
C      NUMERIC + LOGICAL      250                                          324
 250  TEST = .TRUE.                                                        325
      CALL INMBRI                                                          326
 255  CALL IARITI                                                          327
      LFRT = 1                                                             328
      IF (KERTYP) 999,20,999                                               329
C                                                                          330
C                                                                          331
C      RESET STACK BECAUSE IT WAS NOT USED                                 332
 260  LEVEL = 0                                                            333
      TEST = .TRUE.                                                        334
       CALL ICHAR2($19,29)                                                 335
C                                    * SKIP COMMA                          336
      KERTYP = 171                                                         337
       GO TO 999                                                           338
 265   KERTYP = 270                                                        339
       GO TO 999                                                           340
C                                                                          341
C     TEST EMPTY PARENTHESES                                               342
 400  IF ( (KSTACK(  LEVEL-1)+KSTACK(  LEVEL-2) ).NE.0) GO TO 997          343
C     CALL DEBUG 2(6HSTA (),400)                                           344
C     CALL STACKP                                                          345
C                 *                        PRINT STACK                     346
 401  LEVEL=LEVEL-3                                                        347
```

```
C      EMPTY FUNCTION ARGUMENT IS NOT A CURRENT LEFT SIDE                348
       IF (KSTACK(  LEVEL).LT.6) GO TO 404                               349
 405   VALUE=0.                                                          350
       GO TO 403                                                         351
 404   RVALUE(1)  = D (LOCX)                                             352
       RVALUE(2) = D(LOCX+1)                                             353
       CALL ICNVTI(MCNVRT,3)                                             354
 403   CALL IARITI                                                       355
       GO TO 20                                                          356
C(((((((((((((((((                                                       357
 420   IF (LEVEL.EQ.0) LEVEL=3                                           358
C      CALL DEBUG 2(6HSTAT (,420)                                        359
 422   LOP=0                                                             360
       LFRT = 1                                                          361
       LEVEL=LEVEL+3                                                     362
C      CALL STACKP                                                       363
C                    '                          PRINT STACK             364
       IF (KSTACK(  LEVEL-3)-1) 20, 997, 20                              365
C)))))))))))))))))                                                       366
 430   IF (LEVEL.LT.6) GO TO 997                                         367
C      CALL DEBUG 2(6HSTAT ),430)                                        368
C      CALL STACKP                                                       369
C                    '                          PRINT STACK             370
       LFRT = 1                                                          371
 431   IF (KSTACK(  LEVEL)-1) 400, 432, 997                              372
 432   DO 433 I=1,3                                                      373
        VALUE=STACK(  LEVEL)                                             374
        KSTACK(  LEVEL)=0                                                375
        LEVEL=LEVEL-1                                                    376
 433    CALL IARITI                                                      377
       IF (KERTYP) 999, 20, 999                                          378
C******************(KOP=2)                                               379
 440   KOP=2                                                             380
C      CALL DEBUG 2(6HSTAT *,440)                                        381
       GO TO 445                                                         382
C//////////////////(KOP=3)                                               383
441    KOP = 3                                                           384
C                                                                        385
C      CALL DEBUG 2(6HSTAT /,441)                                        386
 445   IF (LOP.NE.0) GO TO 997                                           387
C      CALL DEBUG 2(6HSTATMT,445)                                        388
C      CALL STACKP                                                       389
C                                      PRINT STACK                       390
       LOP = 1                                                           391
       LFRT = 1                                                          392
       IF (LEVEL.EQ.0) LEVEL=3                                           393
       IF (KSTACK(  LEVEL).NE.1) GO TO 997                               394
 444   VALUE=STACK(  LEVEL)                                              395
       KSTACK(  LEVEL)=0                                                 396
       LEVEL=LEVEL-1                                                     397
       CALL IARITI                                                       398
       IF (KERTYP.NE.0) GO TO 999                                        399
 446   KSTACK(  LEVEL)=KOP                                               400
       LEVEL=LEVEL+1                                                     401
C      CALL STACKP                                                       402
C                                                        PRINT STACK     403
       GO TO 19                                                          404
C===============                                                         405
 450   IF (LEVEL.NE.0) GO TO 997                                         406
C      CALL DEBUG 2(6HSTAT =,450)                                        407
 451   LOP=0                                                             408
       LOCX = LOOK                                                       409
```

```
      MCNVRT = KCNVRT                                                    410
      MDIF = KDIF                                                        411
      LCNVRT = 3                                                         412
C                                    ' DOUBLE PRECISION, STANDARD         413
      LEVEL=3                                                            414
      LFRT=0                                                             415
      KSTACK(  3)=0                                                      416
C     CALL DEBUG2(6HLOCX  ,LOCX)                                         417
C     CALL DEBUG2(6HMCNVRT,MCNVRT)                                       418
      GO TO 19                                                           419
C,,,,,,,,,,,,,,                                                          420
 460  CONTINUE                                                           421
C     CALL DEBUG 2(6HSTAT ,,460)                                         422
C     CALL STACKP                                                        423
C                '                          PRINT STACK                 424
      IF (LEVEL - 3) 461,463, 600                                        425
 461  IF (LEVEL.NE.0) GO TO 997                                          426
 462  LEVEL=3                                                            427
 463   IF(LFRT.EQ.0)GO TO 480                                            428
C                              ' INCREMENT LOCX WITHOUT STORING          429
C         LFRT WILL BE ZERO AFTER $ EXPRESSION OR FOR CONSECUTIVE COMMAS 430
 470  IF (KSTACK(  3).NE.1) GO TO 997                                    431
  471 DO 475  I = 1,2                                                    432
       VALUE=STACK(  LEVEL)                                              433
       KSTACK(  LEVEL)=0                                                 434
       LEVEL=LEVEL-1                                                     435
 475   CALL IARITI                                                       436
      IF (KERTYP.NE.0) GO TO 999                                         437
 476  KSTACK(  1)=0                                                      438
      CALL ICNVTI (LCNVRT,MCNVRT)                                        439
 474  IF(LOCK) GO TO 480                                                 440
      D(LOCX) = RVALUE(1)                                                441
      IF (MCNVRT .EQ. 3) D(LOCX+1) = RVALUE(2)                           442
 480  LOP=0                                                              443
C     CALL STACKP                                                        444
C                '                   PRINT STACK                       445
      LFRT=0                                                             445
      LOCX = LOCX + MDIF                                                 447
      LEVEL=0                                                            448
      LCNVRT = 3                                                         449
C                                    ' DOUBLE PRECISION, STANDARD         450
      GO TO 19                                                           451
C++++++++++++++++++(KOP=4)                                               452
 510  KOP=4                                                              453
C     CALL DEBUG 2(6HSTAT +,510)                                         454
      GO TO 521                                                          455
C------------------(KOP=5)                                               456
 520  KOP=5                                                              457
C     CALL DEBUG 2(6HSTAT -,520)                                         458
 521  IF (LOP.NE.0) GO TO 997                                            459
 522  LOP=1                                                              460
      LFRT = 1                                                           461
      IF (LEVEL.EQ.0) LEVEL=3                                            462
 524  IF (KSTACK(  LEVEL)-1) 525, 526, 997                               463
 525  STACK(  LEVEL)=0. DO                                               464
C     CALL DEBUG 2(6HSTATMT,525)                                         465
 526  DO 528 I=1,2                                                       466
C     CALL DEBUG 2(6HSTATMT,526)                                         467
       VALUE=STACK(  LEVEL)                                              468
       KSTACK(  LEVEL)=0                                                 469
       LEVEL=LEVEL-1                                                     470
```

```
 528   CALL IARITI                                                          471
       IF (KERTYP.NE.0) GO TO 999                                           472
 527   KSTAC<(  LEVEL)=KOP                                                  473
       LEVEL=LEVEL+2                                                        474
       GO TO 19                                                             475
CABCDEFGHIJ<LMNOPQRSTUVWXYZABCDEFGHIJKLMNOPQRSTUVWXYZABCDEFGHIJKLMNOPQRS    475
 530   LOP=0                                                                477
C      CALL DEBUG 2(6HSTAT A,530)                                           478
       IF ( (LEVEL.NE.0).AND.(KSTACK(  LEVEL).EQ.1) ) GO TO 997             479
 535   TEST = .TRUE.                                                        480
       CALL INAMEI($999,D,IT)                                               481
       IF (IFNTYP) 531,621,640                                              482
 531   LFRT = 1                                                             483
       IF(LEVEL.NE.0)GO TO 540                                              484
 532   STACK(  3)=VALUE                                                     485
C      CALL DEBUG 2(6HSTATMT,532)                                           486
       KSTAC<(  3)=1                                                        487
C      CALL STACKP                                                          488
C                    *                    PRINT STACK                     489
       GO TO 20                                                             490
 540   CONTINUE                                                             491
C      CALL DEBUG 2(6HSTATMT,540)                                           492
       CALL IARITI                                                          493
       IF(KERTYP) 999,20,999                                                494
C                                                                           495
C         PROCESS SUBROUTINES AND FUNCTIONS                                 496
C                                                                           497
C      COMMA SEPARATING FUNCTION ARGUMENTS                                  498
 600   IF (KSTACK(  LEVEL-3).LT.6) GO TO 997                                499
C      CALL DEBUG 2(6HSTAT F,600)                                           500
 601   IF (KSTACK(  LEVEL)-1) 602, 603, 997                                 501
 602   STACK(  LEVEL)=0.                                                    502
 603   DO 610 I=1,2                                                         503
       VALUE = STACK(  LEVEL)                                               504
       KSTACK(  LEVEL)=0                                                    505
        LEVEL=LEVEL-1                                                       506
 610    CALL IARITI                                                         507
       IF (KERTYP.NE.0) GO TO 999                                           508
 611   KSTAC<(  LEVEL)=KSTACK(  LEVEL-1)+1                                  509
       LEVEL=LEVEL+3                                                        510
C      CALL STACKP                                                          511
C                    *                         PRINT STACK                512
       GO TO 19                                                             513
C       $CALL                                                               514
 630   DO 631 I = 1,4                                                       515
C       SKIP *ALL* IN $CALL                                                 516
C            OTH   OPERATORS                                                517
       CALL ICHAR2($9170,12)                                                518
 631   CONTINUE                                                             519
       DOLLAR = .FALSE.                                                     520
       TEST = .TRUE.                                                        521
       CALL INAMEI ($999,D,IT)                                              522
       IF (IFNTYP .NE. 1)   GO TO 640                                       523
       KVALUE = -KVALUE                                                     524
C                        * INDICATE THAT NO RESULT IS TO BE STORED FOR SUB  525
C      FUNCTION NAME                                                        526
621    CONTINUE                                                             527
C                                       * FUNCTIONS                         528
C      CALL DEBUG2(6HST FNC,621)                                            529
C      CALL DEBUG2(6HIFNTYP,IFNTYP)                                         530
```

```
C     CALL DEBUG2(6HKVALUE,KVALUE)                                          531
      IFNTYP = -1                                                           532
      IF (LEVEL.EQ.0) LEVEL = 3                                             533
      IF(NOTARG . GT. LEVEL) NOTARG = LEVEL                                 534
      LFRT = 1                                                              535
      STACK(LEVEL)=KVALUE                                                   536
      KSTACK(  LEVEL)=6                                                     537
      LEVEL = LEVEL + 3                                                     538
C     CALL STACKP                                                           539
C                 '                       PRINT STACK                     540
C           (       OTH                                                     541
      CALL ICHAR2($622,30)                                                  542
      GO TO 19                                                              543
C                                  ' IF THERE ARE ARGUMENTS                 544
622   SMCHR = .TRUE.                                                        545
      IF (KVALUE .LT. 0)  LEVEL = LEVEL -3                                  546
      GO TO 405                                                             547
 640  IF (IFNTYP - 2)  9770,201,700                                         548
C     LOCX       THE SUBROUTINE THAT STORES LOCX THE SUBSCRIPT OF  D ARR    549
 700  IF (IFNTYP .NE. 3)   GO TO 9770                                       550
      IFNTYP = -1                                                           551
      IF(LEVEL.NE.0) GO TO 9770                                             552
      LFRT = 0                                                              553
      CALL ICHAR2($9170,30)                                                 554
C                                  ' ERROR IF NO ( AFTER LOCX               555
      ASSIGN 704 TO NEXT                                                    556
C             A-Z  OTH                                                      557
 702  CALL ICHAR2($9170,9)                                                  558
      CALL INAMEI($999,D,IT)                                                559
      IF (IFNTYP .GT. -1) GO TO 9770                                        560
      GO TO NEXT,(704,708)                                                  561
 704  LOOKX = LOOK                                                          562
C             OTH   ,                                                       563
      CALL ICHAR2($706,29)                                                  564
C                                  ' ERROR IF NO COMMA                      565
      GO TO 9170                                                            566
 706  ASSIGN 708 TO NEXT                                                    567
      GO TO 702                                                             568
 708  KVALUE = LOCX - LOOKX + 1                                             569
      CALL ICNVTI(2,KCNVRT)                                                 570
C                                   ' CONVERT FROM INT TO TYPE OF 2ND ARG   571
      IF(LOCK) GO TO 710                                                    572
      D(LOOK) = RVALUE(1)                                                   573
 710  CALL ICHAR2($9170,31)                                                 574
C                              ' ERROR IF NO )                            575
      TEST = .TRUE.                                                         576
C           OTH   ,                                                       577
      CALL ICHAR2($19,29)                                                   578
C                                  ' SKIP THE COMMA THAT MUST FOLLOW        579
9170  KERTYP=170                                                            580
      GO TO 999                                                             581
9370  KERTYP=370                                                            582
      GO TO 999                                                             583
 997  CONTINUE                                                              584
9770  KERTYP = 770                                                          585
      GO TO 999                                                             586
 999  CALL IERORI                                                           587
      LFRT = 0                                                              588
      LOP = 0                                                               589
      NAME (1)=0                                                            590
      GO TO 19                                                              591
C                                      ' NOW GO TO SWITCH HOUSE ..  GOOD    592
      END                                                                   593
```

```
$IBFTC BLOCK   DECK
      BLOCK DATA                                                          1
C      ICOMNI     BLOCK DATA PROGRAM                                       2
      DIMENSION IFT( 31), IPTAB( 21), ITAB( 65)                           3
      DIMENSION ANAME(15) ,IMAGE(80) ,IMAGE1(81),IPARAM(9)                4
     .          ,KSTACK(27),NAME(15)  ,RVALUE(2) ,STACK(27)              5
C                                                                         6
      COMMON                                                              7
     ./ICOMNI/ VALUE    ,ICOMP    ,IFNTYP   ,IMAGE1   ,IRADIX   ,ISUB    8
     .         ,KCH     ,KCNVRT   ,KCOUNT   ,KDIF     ,KFLD1   ,KFLD2   9
     .         ,LCOMP   ,LCNVRT   ,LEVEL    ,LFRT     ,LOOK              10
     .         ,MCNVRT  ,MDIF     ,MODALL   ,MSTOR                       11
     .         ,NAME    ,NERROR   ,NONEW    ,NOTARG                      12
     .         ,SMCHR   ,TEST     ,ERMARK                                13
     ./ICNSTI/ BLANK    ,BLANKS   ,DOLLAR   ,EOS                         14
     .         ,ICOMMA  ,IDOLAR   ,IFT      ,IPTAB    ,ITAB              15
     .         ,KAM10   ,KBPC     ,KBPW     ,KCPCD    ,KERTYP            16
     .         ,KZERO   ,NOPRNT   ,TAB1                                  17
     ./IPARAM/ ABORT    ,KIUNIT   ,KOUNIT   ,LIMALF   ,LOCK     ,LOCX    18
     .         ,NOLIST  ,NSTDIR   ,TRACE                                 19
     ./ISTACI/ STACK    ,ISTDIM   ,KSTACK   ,LEVLIM                      20
C                                                                         21
      INTEGER  BLANK    ,BLANKS   ,EOS      ,IDOLAR   ,TAB1     ,TRACE   22
      DOUBLE PRECISION STACK, VALUE                                       23
      LOGICAL ABORT,DOLLAR,ERMARK,LIMALF,LOCK,NOLIST,NONEW,MODALL,        24
     .NSTDIR,SMCHR,TEST                                                   25
      DATA NERROR,TRACE/0,0/                                              26
      DATA ITAB/   65* 20572347824/                                       27
      DATA ITAB( 49)/-11890146992/                                        28
     ., ITAB( 44)/ 11923699376/, ITAB( 61)/ 29355228304/                  29
     ., ITAB( 29)/ 29053238816/, ITAB( 12)/ -3484760752/                  30
     ., ITAB( 28)/-11821997744/, ITAB( 17)/-11903778480/                  31
     ., ITAB( 33)/-12155961008/, ITAB( 45)/-12192136880/                  32
     ., ITAB( 50)/-12208914096/, ITAB( 13)/-12041137840/                  33
     ., ITAB( 60)/-11957255792/, ITAB( 11)/-11890146992/                  34
     ., ITAB(  1)/ 29063724720/, ITAB(  2)/ 29063724720/                  35
     ., ITAB(  3)/ 29063724720/, ITAB(  4)/ 29063724720/                  36
     ., ITAB(  5)/ 29063724720/, ITAB(  6)/ 29063724720/                  37
     ., ITAB(  7)/ 29063724720/, ITAB(  8)/ 29063724720/                  38
     ., ITAB(  9)/ 29063724720/, ITAB( 10)/ 29063724720/                  39
     ., ITAB( 18)/ 20572347824/, ITAB( 20)/ 18961735088/                  40
     ., ITAB( 21)/ 17350532528/, ITAB( 22)/ 17350565296/                  41
     ., ITAB( 23)/ 23256571312/, ITAB( 26)/ 20035476912/                  42
     ., ITAB( 36)/ 22182960560/, ITAB( 38)/ 22182960560/                  43
     ., ITAB( 40)/ 18424864176/, ITAB( 42)/ 19498606000/                  44
     ., ITAB( 51)/ 22719831472/, ITAB( 52)/ 17887731120/                  45
      DATA BLANK,BLANKS,EOS,ICOMMA,IDOLAR,KAM10,KBPC,KBPW,KCH,KCPCD,      46
     . KZERO,NOPRNT,TAB1,IMAGE1(2),IMAGE1(3)/                             47
     .          48,-17997958192,          10,          59,          43,  48
     .           7,           6,          36,          43,          80,  49
     .           0, 11555507248,          64, 11555507248, 11555507248/ 50
      DATA ABORT,IMAGE1(1),IMAGE1(81),IRADIX,ISTDIM,                      51
     . KCOUNT,KDIF,KSTACK,LEVLIM,NSTDIR,STACK/                            52
     . .FALSE.,1HE,1H ,10,27,0,1,27*0,24,.TRUE.,27*0.D0/                  53
      DATA IFT/                                                           54
     .          0,          31,-17716740112, 21051935792,-17716740128,   55
     . 23481748528,-17716740144, -3864988720,-17716740160,-19756682288,   56
     .-17716740176,-20009401392,-17716740192, 19113857200,-17716740208,   57
     . -8210767088,-17716740224, -8428915760,-17716740240, -8433110064,   58
     .-17716740256, 18568907824,-17716740272, 21907455024, -9126805536,   59
     . -9954237936, -9126805552, -3863968816, -9126805696, -3863883248,   60
     .          0/                                                        61
```

```
      DATA IPTAB/                                                          62
     .           0,           21,  -536870928, 18565733616,  -536870976,   63
     . -3650164950,  -536870992, -3863882800,  -536871024, -6015524019,   64
     .  -535871040, -6221022825, 17716740128, -2580698739, 17716740144,   65
     . -2793802547, 17716740192, -3863968816, 17716740240,-21093496176,   66
     .           0/                                                       67
      END                                                                  68
```

```
$IBFTC IARITI  DECK
C      ARITHMETIC OPERATIONS FOR INPUT R. U. A. S. 2                        1
       SUBROUTINE IARITI                                                    2
C       CALLED FROM INPUT                                                   3
       DIMENSION IFT( 31), IPTAB( 21), ITAB( 65)                            4
       DIMENSION ANAME(15) ,IMAGE(80) ,IMAGE1(81),IPARAM(9)                 5
      .         ,KSTACK(27),NAME(15)  ,RVALUE(2) ,STACK(27)                 6
C                                                                           7
       COMMON                                                               8
      ./ICOMNI/ VALUE     ,ICOMP     ,IFNTYP    ,IMAGE1    ,IRADIX    ,ISUB  9
      .         ,KCH      ,KCNVRT    ,KCOUNT    ,KDIF      ,KFLD1     ,KFLD2 10
      .         ,LCOMP    ,LCNVRT    ,LEVEL     ,LFRT      ,LOOK              11
      .         ,MCNVRT   ,MDIF      ,MODALL    ,MSTOR                        12
      .         ,NAME     ,NERROR    ,NONEW     ,NOTARG                       13
      .         ,SMCHR    ,TEST      ,ERMARK                                  14
      ./ICNSTI/ BLANK     ,BLANKS    ,DOLLAR    ,EOS                          15
      .         ,ICOMMA   ,IDOLAR    ,IFT       ,IPTAB     ,ITAB              16
      .         ,KAM10    ,KBPC      ,KBPW      ,KCPCD     ,KERTYP            17
      .         ,KZERO    ,NOPRNT    ,TAB1                                    18
      ./IPARAM/ ABORT     ,KIUNIT    ,KOUNIT    ,LIMALF    ,LOCK      ,LOCX   19
      .         ,NOLIST   ,NSTDIR    ,TRACE                                   20
      ./ISTACI/ STACK     ,ISTDIM    ,KSTACK    ,LEVLIM                       21
C                                                                           22
       INTEGER  BLANK     ,BLANKS    ,EOS       ,IDOLAR    ,TAB1      ,TRACE 23
       DOUBLE PRECISION STACK, VALUE                                        24
       LOGICAL ABORT,DOLLAR,ERMARK,LIMALF,LOCK,NOLIST,NONEW,MODALL,         25
      .NSTDIR,SMCHR,TEST                                                    26
       EQUIVALENCE (STACK,ISTACK), (VALUE,KVALUE,RVALUE),(NAME,ANAME)       27
       EQUIVALENCE (ICOMNI,ISUB),(IMAGE,IMAGE1),(IPARAM,ABORT)              28
C      CALL DEBUGC(6HIARITI)                                                29
C      CALL STACKP                                                          30
C                    *                    PRINT STACK                     31
C                                                                           32
       IF (KERTYP.NE.0) GO TO 100                                           33
       IF ( (LEVEL.LE.0).OR.(LEVEL.GT.LEVLIM) ) GO TO 120                   34
C      BRANCH ON KSTACK(  LEVEL)= -, 0, 1, 2, 3, 4, 5, 6, 7, 8 AND UP       35
  2    K=MAXO(1,KSTACK(  LEVEL)+2)                                          36
       IF(K.GE.8) GO TO 60                                                  37
C              -  0    1   2   3   4   5    =KSTACK(LEVEL)                  38
     3 GO TO (120,90, 120, 20, 30, 40, 50),K                                39
  20   VALUE=STACK(  LEVEL)*VALUE                                           40
       GO TO 90                                                             41
  30   VALUE=STACK(  LEVEL)/VALUE                                           42
       GO TO 90                                                             43
  40   VALUE=STACK(  LEVEL)+VALUE                                           44
       GO TO 90                                                             45
  50   VALUE=STACK(  LEVEL)-VALUE                                           46
       GO TO 90                                                             47
  60   LEVEL1= LEVEL-K+9                                                    48
       DO 61 I=LEVEL1,LEVEL                                                 49
```

```
 61    KSTACK(  I)=0                                                    50
       LEVEL = LEVEL1-1                                                 51
C      CALL DEBUG 2(5HLEVEL,LEVEL)                                      52
C      CALL DEBUG 2(5HVALUE,VALUE)                                      53
        IF (LOCK)   GO TO 62                                            54
       CALL IXQTI(VALUE,STACK(  LEVEL))                                 55
 62     CONTINUE                                                        56
C      CALL DEBUG 2(5HVALUE,VALUE)                                      57
       IF (LEVEL .LE. NOTARG) NOTARG = ISTDIM                           58
       IF (STACK(LEVEL).LT.0.DO)  GO TO 110                             59
       GO TO 90                                                         60
 90    STACK(  LEVEL)=VALUE                                             61
       KSTACK(  LEVEL)=1                                                62
 100   CONTINUE                                                         63
C      CALL STACKP                                                      64
C                    *                      PRINT STACK                65
C      CALL DEBUGR                                                      66
       RETURN                                                           67
 110    LFRT=0                                                          68
C                                    * SPECIAL TREATMENT FOR SUBROUTINES 69
C       CALL DEBUG2(6HSTATMT,110)                                       70
        KSTACK(LEVEL)=0                                                 71
        LEVEL=0                                                         72
C            OTH    ,                                                   73
       CALL ICHAR2($100,29)                                             74
       KERTYP = 150                                                     75
       GO TO 100                                                        76
 120   KERTYP=750                                                       77
       GO TO 100                                                        78
       END                                                              79
```

```
$IBFTC ICHAR4  DECK
        SUBROUTINE ICHAR4(*,*,LIST1,LIST2)                               1
       DIMENSION IFT( 31), IPTAB( 21), ITAB( 65)                         2
       DIMENSION ANAME(15) ,IMAGE(80) ,IMAGE1(81),IPARAM(9)              3
      *          ,KSTACK(27),NAME(15)  ,RVALUE(2) ,STACK(27)            4
C                                                                        5
       COMMON                                                            6
      */ICOMNI/ VALUE     ,ICOMP     ,IFNTYP    ,IMAGE1    ,IRADIX    ,ISUB      7
      *          ,KCH       ,KCNVRT    ,KCOUNT    ,KDIF      ,KFLD1     ,KFLD2     8
      *          ,LCOMP     ,LCNVRT    ,LEVEL     ,LFRT      ,LOOK                 9
      *          ,MCNVRT    ,MDIF      ,MODALL    ,MSTOR                           10
      *          ,NAME      ,NERROR    ,NONEW     ,NOTARG                          11
      *          ,SMCHR     ,TEST      ,ERMARK                                     12
      */ICNSTI/ BLANK     ,BLANKS    ,DOLLAR    ,EOS                              13
      *          ,ICOMMA    ,IDOLAR    ,IFT       ,IPTAB     ,ITAB                14
      *          ,KAM10     ,KBPC      ,KBPW      ,KCPCD     ,KERTYP              15
      *          ,KZERO     ,NOPRNT    ,TAB1                                       16
      */IPARAM/ ABORT     ,KIUNIT    ,KOUNIT    ,LIMALF    ,LOCK      ,LOCX      17
      *          ,NOLIST    ,NSTDIR    ,TRACE                                      18
      */ISTACI/ STACK     ,ISTDIM    ,KSTACK    ,LEVLIM                           19
C                                                                        20
       INTEGER  BLANK     ,BLANKS    ,EOS       ,IDOLAR    ,TAB1      ,TRACE     21
      *,COMPR                                                            22
       DOUBLE PRECISION STACK, VALUE, IDEBUA, DEBGNA(2)                  23
       DATA DEBGNA/6HICHAR ,5HITCHR/                                     24
       LOGICAL ABORT,DOLLAR,ERMARK,LIMALF,LOCK,NOLIST,NONEW,MODALL,      25
      *NSTDIR,SMCHR,TEST                                                 26
```

```
      EQUIVALENCE (STACK,ISTACK), (VALUE,KVALUE,RVALUE),(NAME,ANAME)          27
      EQUIVALENCE (ICOMNI,ISUB),(IMAGE,IMAGE1),(IPARAM,ABORT)                28
       LOGICAL GOTCD                                                         29
C                     * TRUE IF NEW CARD WAS READ                            30
      LOGICAL SMCHR                                                          31
C                                  * RE-PROCESS THE SAME CHARACTER AS LAS     32
       KFLD2=LIST2                                                           33
       IBITS=2                                                               34
       ASSIGN 36 TO COMPR                                                    35
      IDEBUN = 4                                                             35
      GO TO 10                                                               37
       ENTRY ICHARI(*,*,LIST1)                                               38
       IBITS = 2                                                             39
      IDEBUN = 3                                                             40
       GO TO 4                                                               41
       ENTRY ICHAR2(*,LIST1)                                                 42
       IBITS=1                                                               43
      IDEBUN = 2                                                             44
 4     KFLD2 = -1                                                            45
       ASSIGN 37 TO COMPR                                                    46
       IF(MODALL)GO TO 40                                                    47
 10    ASSIGN 20 TO IGETR                                                    48
  12   KFLD1=LIST1                                                           49
      IDEBUA = DEBGNA(1)                                                     50
       ASSIGN 110 TO NEXT                                                    51
       GOTCD=.FALSE.                                                         52
       IF(SMCHR)  GO TO 35                                                   53
C                                  * SKIP GETTING NEW CHARACTER               54
       GO TO 200                                                             55
C                                  * GET CHARACTER RETURN TO 20               56
 20    IF(KCH.EQ.BLANK)GO TO 200                                             57
C                                       * BYPASS BLANKS                      58
       IF (KCH.NE.EOS)  GO TO 30                                             59
C                                     * EOS= END OF STATEMENT CHARACTER       60
       ASSIGN 200 TO INEWR                                                   61
C                            * PROVIDE TO GET FIRST CHARACTER FROM NEXT C     62
       GO TO 300                                                             63
 30    IF(TEST.AND.GOTCD)GO TO 100                                           64
 35    ITEMP = ITAB(KCH+1)                                                   65
       ICOMP=IFLD(LIST1,IBITS,ITEMP)                                         66
      GO TO COMPR,(36,37)                                                    67
 36    LCOMP=IFLD(LIST2,2,ITEMP)+1                                           68
 37   CONTINUE                                                               69
      IF(TRACE .LT.4)  GO TO 38                                              70
C     CALL DEBUG2(IDEBUA,IDEBUN)                                             71
 38    SMCHR = .FALSE.                                                       72
      IF(ICOMP-1)   381,382,383                                              73
 381  RETURN                                                                 74
 382  RETURN1                                                                75
 383  RETURN2                                                                76
 40    ASSIGN 35 TO IGETR                                                    77
       GO TO 12                                                              78
C   -    -   -     -    -     ITCHR     -    -    -    -    -    -    -      79
C              SPECIAL ROUTINE TO INSERT COMMA AT END OF CARD IF             80
C              THE NEXT CARD BEGINS WITH $ OR A LEFT MEMBER                  81
C                    TO THIS ROUTINE, A LEFT MEMBER BEGINS WITH A-Z          82
C                     FOLLOWED BY ANY OF 0-9()A-Z FOLLOWED BY =              83
 100  IDEBUA = DEBGNA(2)                                                     84
       ITEMP = ITAB(KCH+1)                                                   85
       ICOMP=IFLD(0,3,ITEMP)                                                 86
      GO TO NEXT,(110,120)                                                   87
```

```
C                              * 110 FOR 1ST CHR ON NEW CARD, 120 FOR FOLL      88
 110   NONEW=.TRUE.                                                             89
       ASSIGN 120 TO NEXT                                                       90
C            $  A-Z 0-9() = OTH                                                 91
       GO TO(130,200,140,140,140),ICOMP                                         92
C                                                                               93
C            $  A-Z 0-9() = OTH                                                 94
 120   GO TO(140,200,200,130,140),ICOMP                                         95
 130   KCOUNT=0                                                                 96
       KCH=ICOMMA                                                               97
       NONEW=.FALSE.                                                            98
       GOTCD = .FALSE.                                                          99
       GO TO 35                                                                100
C              * COMMA IS CHARACTER RETURNED                                    101
 140   KCOUNT=0                                                                102
       NONEW=.FALSE.                                                           103
       GOTCD = .FALSE.                                                         104
C      GO TO 200                                                               105
C              * FIRST NON-BLANK CHARACTER ON CARD IS RETURNED                  106
C   -    -    -    -    -    -    -    -    -    -    -    -    -    -         107
C             ROUTINE TO GET NEXT CHARACTER                                    108
C                                                                              109
 200   IF(KCOUNT.LT.KCPCD)GO TO 210                                            110
       ASSIGN 210 TO INEWR                                                     111
       GO TO 300                                                               112
 210   KCOUNT=KCOUNT+1                                                         113
C                      * CARD COLUMN OF NEW CHARACTER                          114
       KCH=IFLD(0,KBPC,IMAGE(KCOUNT))                                          115
      GO TO IGETR,(20,35)                                                      116
C                                    * 35 IS USED ONLY FOR MODALL .TRU         117
C   -    -    -    -    -    -    -    -    -    -    -    -    -    -         118
C             ROUTINE TO PRINT OLD CARD AND READ NEXT                          119
C              IF NONEW IS TRUE, STORE TAB1 IN KCH AND RETURN                  120
 300   IF(NONEW)GO TO 310                                                      121
       KCH=IMAGE(KCOUNT+1)                                                     122
C                           * GET CARRIAGE CONTROL (IMAGE(81) IS A BLANK)     123
       IF((KCH.EQ.NOPRNT).OR.NOLIST)  GO TO 305                                124
       WRITE(KOUNIT,398)KCH,IMAGE                                              125
 398   FORMAT(1A1,5X,80A1)                                                     126
 305   READ(KIUNIT,399)IMAGE                                                   127
 399   FORMAT(80A1)                                                            128
       GOTCD=.TRUE.                                                            129
       KCOUNT=0                                                                130
      GO TO INEWR,(200,210)                                                    131
 310   KCH=TAB1                                                                132
      GO TO 30                                                                 133
C                                  * TAB1 IS RETURNED, INDICATES END OF C      134
       END                                                                     135
```

```
$IBFTC ICNVTI  DECK
       SUBROUTINE ICNVTI(IFROM,ITO)                                             1
       DIMENSION IFT( 31), IPTAB( 21), ITAB( 65)                                2
       DIMENSION ANAME(15) ,IMAGE(80) ,IMAGE1(81),IPARAM(9)                     3
      .          ,KSTACK(27),NAME(15)  ,RVALUE(2) ,STACK(27)                    4
C                                                                               5
       COMMON                                                                   6
      ./ICOMVI/ VALUE     ,ICOMP     ,IFNTYP    ,IMAGE1    ,IRADIX    ,ISUB    7
      .         ,KCH       ,KCNVRT    ,KCOUNT    ,KDIF      ,KFLD1     ,KFLD2   8
```

```
     .         ,LCOMP    ,LCNVRT   ,LEVEL    ,LFRT     ,LOOK                    9
     .         ,MCNVRT   ,MDIF     ,MODALL   ,MSTOR                          10
     .         ,NAME     ,NERROR   ,NONEW    ,NOTARG                         11
     .         ,SMCHR    ,TEST     ,ERMARK                                   12
     ./ICNSTI/ BLANK     ,BLANKS   ,DOLLAR   ,EOS                            13
     .         ,ICOMMA   ,IDOLAR   ,IFT      ,IPTAB    ,ITAB                 14
     .         ,KAM10    ,KBPC     ,KBPW     ,KCPCD    ,KERTYP               15
     .         ,KZERO    ,NOPRNT   ,TAB1                                     16
     ./IPARAM/ ABORT     ,KIUNIT   ,KOUNIT   ,LIMALF   ,LOCK     ,LOCX       17
     .         ,NOLIST   ,NSTDIR   ,TRACE                                    18
     ./ISTACI/ STACK     ,ISTDIM   ,KSTACK   ,LEVLIM                         19
C                                                                            20
      INTEGER  BLANK     ,BLANKS   ,EOS      ,IDOLAR   ,TAB1     ,TRACE     21
      DOUBLE PRECISION STACK, VALUE                                          22
      LOGICAL ABORT,DOLLAR,ERMARK,LIMALF,LOCK,NOLIST,NONEW,MODALL,           23
     .NSTDIR,SMCHR,TEST                                                      24
      EQUIVALENCE (STACK,ISTACK), (VALUE,KVALUE,RVALUE),(NAME,ANAME)         25
      EQUIVALENCE (ICOMNI,ISUB),(IMAGE,IMAGE1),(IPARAM,ABORT)                26
      DIMENSION NTYPE(4)                                                     27
      DOUBLE PRECISION NTYPE                                                 28
      DATA NTYPE / 6HREAL  ,6HINT   ,6HDP    ,6HNOCONV/                      29
      IF((IFROM.LE.0).OR.(ITO.LE.0)) GO TO 100                               30
      IF (IFROM - 4) 1,99,100                                                31
1     IF (ITO - 4) 2,99,100                                                  32
2     ITOM2 = ITO - 2                                                        33
      IF (IFROM-2) 3,4,5                                                     34
3     IF (ITOM2) 99,10,20                                                    35
4     IF (ITOM2) 30,99,40                                                    36
5     IF (ITOM2) 50,60,99                                                    37
10    KVALUE = RVALUE(1)                                                     38
      GO TO 99                                                               39
20    VALUE = RVALUE(1)                                                      40
      GO TO 99                                                               41
30    RVALUE(1) = KVALUE                                                     42
      GO TO 99                                                               43
40    VALUE = KVALUE                                                         44
      GO TO 99                                                               45
50    RVALUE(1) = VALUE                                                      46
      GO TO 99                                                               47
60    KVALUE = VALUE                                                         48
99    CONTINUE                                                               49
C     CALL DEBUG3 (6HICNVTI,0.D0,3)                                          50
C     CALL DEBUG3(NTYPE(IFROM),NTYPE(ITO) ,3)                                51
      RETURN                                                                 52
 100  WRITE(KOUNIT,101) IFROM,ITO                                            53
 101  FORMAT(35H ARGUMENTS OF ICNVTI BAD.  IFROM = ,I13,8H, ITO = ,I13,      54
     . 41H(1 TO 4 ALLOWABLE).  CHECK IPTAB IN COMNJ)                         55
      GO TO 99                                                               56
      END                                                                    57
```

```
$IBFTC IERORI  DECK
      SUBROUTINE IERORI                                                       1
      DIMENSION IFT( 31), IPTAB( 21), ITAB( 65)                               2
      DIMENSION ANAME(15) ,IMAGE(80) ,IMAGE1(81),IPARAM(9)                    3
     .         ,KSTACK(27),NAME(15)  ,RVALUE(2) ,STACK(27)                    4
C                                                                             5
```

```
      COMMON                                                                  5
     ./ICOMNI/ VALUE    ,ICOMP    ,IFNTYP   ,IMAGE1   ,IRADIX   ,ISUB       7
     .        ,KCH      ,KCNVRT   ,KCOUNT   ,KDIF     ,KFLD1    ,KFLD2      8
     .        ,LCOMP    ,LCNVRT   ,LEVEL    ,LFRT     ,LOOK                 9
     .        ,MCNVRT   ,MDIF     ,MODALL   ,MSTOR                         10
     .        ,NAME     ,NERROR   ,NONEW    ,NOTARG                        11
     .        ,SMCHR    ,TEST     ,ERMARK                                  12
     ./ICNSTI/ BLANK    ,BLANKS   ,DOLLAR   ,EOS                           13
     .        ,ICOMMA   ,IDOLAR   ,IFT      ,IPTAB    ,ITAB                14
     .        ,KAM10    ,KBPC     ,KBPW     ,KCPCD    ,KERTYP              15
     .        ,KZERO    ,NOPRNT   ,TAB1                                    16
     ./IPARAM/ ABORT    ,KIUNIT   ,KOUNIT   ,LIMALF   ,LOCK     ,LOCX       17
     .        ,NOLIST   ,NSTDIR   ,TRACE                                   18
     ./ISTACI/ STACK    ,ISTDIM   ,KSTACK   ,LEVLIM                        19
C                                                                            20
      INTEGER  BLANK    ,BLANKS   ,EOS      ,IDOLAR   ,TAB1     ,TRACE      21
      DOUBLE PRECISION STACK, VALUE                                          22
      LOGICAL ABORT,DOLLAR,ERMARK,LIMALF,LOCK,NOLIST,NONEW,MODALL,           23
     .NSTDIR,SMCHR,TEST                                                      24
      EQUIVALENCE (STACK,ISTACK), (VALUE,KVALUE,RVALUE),(NAME,ANAME)         25
      EQUIVALENCE (ICOMNI,ISUB),(IMAGE,IMAGE1),(IPARAM,ABORT)                26
      INTEGER H(4,7)                                                         27
      EQUIVALENCE (H(1,1),H1),(H(1,2),H2),(H(1,3),H3),(H(1,4),H4)            28
     .,(H(1,5),H5),(H(1,6),H6),(H(1,7),H7)                                   29
      DATA KA/1H*/                                                           30
      DATA KB/1H /                                                           31
      DATA KC/1H,/                                                           32
      DATA KD/1H'/                                                           33
      INTEGER MSGTYP(2,2), H1(4), H2(4), H3(4), H4(4), H5(4),H6(4),H7(4)     34
      DATA MSGTYP(1,1)/24H*DIAGNOSTIC**ERROR**          /                    35
      DATA H1(1) /24HINAPPROPRIATE CHARACTER              /                  36
      DATA H2(1) /24HNAME TOO LONG                        /                  37
      DATA H3(1) /24HTABLE FULL OR DESTROYED              /                  38
      DATA H4(1) /24H$D INCOMPLETE OR MISSING             /                  39
      DATA H5(1) /24HNAME NOT IN TABLE                    /                  40
      DATA H6(1) /24HFUNCTN OR SUB NOT ABOARD             /                  41
      DATA H7(1) /24HFORMULA ILL-FORMED                   /                  42
C     CALL DEBUGC(6HIERORI)                                                  43
      NONEW = .FALSE.                                                        44
      NERROR = NERROR + 1                                                    45
C                                      * COUNT DIAGONISTICS                  46
      ERMARK = .TRUE.                                                        47
C                                      * WARN PROGRAMER OF POSSIBLE ERRO     48
       IOP = 0                                                               49
C                                      * COUNT OPERATORS  +-,=(*             50
       MODE = 1                                                              51
      IF(NOTARG.LT.LEVEL) MODE = 2                                           52
      KC1=KB                                                                 53
      IF(KCOUNT.EQ.0) KC1=KC                                                 54
      L = KCOUNT + 1                                                         55
      MODALL = .FALSE.                                                       56
      TEST = .TRUE.                                                          57
      M =IABS(KERTYP)                                                        58
      J = M/100                                                              59
      K = 2                                                                  60
      IF(DOLLAR) MODE = 2                                                    61
      IF(KERTYP.GT.0)  LOCK = .TRUE.                                         62
      IF(KERTYP.LT.0)  K=1                                                   63
11    WRITE(KOUNIT,90)(MSGTYP(I,K),I=1,2),M,(H(I,J),I=1,4),KC1,              64
     .IMAGE,(KB,I=1,L),KA,(KB,I=L,81),NERROR,LOCK                            65
 90   FORMAT(1H ,2A6,2H (,I3,2H) ,4A6,2X,81A1/45X,83A1,                      66
     . /14X,11HERROR COUNT,I4,13H     LOCK = .,L1,1H.)                      67
       IF(NERROR.GT.64)STOP                                                  68
```

```
      IF(KERTYP.LT.0) GO TO 99                                          69
       SMCHR = .TRUE.                                                   70
 30   CALL ICHAR4($31,$65,7,10)                                         71
C           0-9. +   $  )                                               72
      GO TO (30,65,39,80),LCOMP                                         73
C            ,  '  A-Z =                                                74
 31   GO TO (60,65,30,60),LCOMP                                         75
 39    SMCHR = .TRUE.                                                   76
 40   L = KCOUNT + 1                                                    77
      KC1 = KB                                                          78
      IF(KCOUNT.EQ.0)KC1=KC                                             79
      WRITE(KOUNIT,91)KC1,IMAGE,(KB,I=1,L),KD,(KB,I=L,81)               80
 91   FORMAT(14X,43HSKIP AHEAD AND GUESS AT NEXT GOOD STATEMENT,        81
     . /14X,32HBEGIN PROCESSING AT SYMBOL          ,81A1/45X,83A1        82
     . /14X48HLOOK FOR DIAGONISTICS BUT DON''T STORE ANYTHING.//)       83
      IFNTYP = -1                                                       84
       DO 1  I=1,ISTDIM                                                85
 1     KSTACK(I) = 0                                                    86
       LEVEL = 0                                                        87
       NOTARG = ISTDIM                                                  88
 99   CONTINUE                                                          89
      KERTYP = 0                                                        90
C     CALL DEBUGR                                                       91
      RETURN                                                            92
C    ,=,=,=,=,=,=,=,=,=,=,=,=,=,=,=,=                                  93
60    IF(MODE.EQ.1) GO TO 40                                           94
C        ALL OPERATORS                                                  95
 65   IOP = IOP + 1                                                     96
      IF(IOP.LE.16)   GO TO 30                                          97
C       IF YOU FIND 16 OPERATORS BEFORE )   GIVE UP                     98
C                                                                       99
C    ))))))))))))))))))))                                             100
  80   MODE = 1                                                        101
       DOLLAR = .FALSE.                                                102
       GO TO 30                                                        103
C                                                                      104
C   MODE        ACTION                                                 105
C                                                                      106
C      1        SKIP TO NEXT $ OR = OR , (UNCONDITIONAL)               107
C      2        SKIP TO NEXT $ (UNCONDITIONAL) OR TO = OR , AFTER )    108
      END                                                             109
```

```
$IBFTC ILOOKI  DECK
       SUBROUTINE ILOOKI(*,IT)                                          1
C      CALLED FROM                                                      2
C                   ITABLI                                              3
C                   INAMEI                                              4
      DIMENSION IT(1)                                                   5
      DIMENSION IFT( 31), IPTAB( 21), ITAB( 65)                         6
      DIMENSION ANAME(15) ,IMAGE(80) ,IMAGE1(81),IPARAM(9)              7
     .          ,KSTACK(27),NAME(15)  ,RVALUE(2) ,STACK(27)            8
C                                                                       9
      COMMON                                                           10
     ./ICOMNI/ VALUE     ,ICOMP     ,IFNTYP    ,IMAGE1    ,IRADIX    ,ISUB    11
     .         ,KCH      ,KCNVRT    ,KCOUNT    ,KDIF      ,KFLD1     ,KFLD2   12
     .         ,LCOMP    ,LCNVRT    ,LEVEL     ,LFRT      ,LOOK                13
     .         ,MCNVRT   ,MDIF      ,MODALL    ,MSTOR                          14
     .         ,NAME     ,NERROR    ,NONEW     ,NOTARG                         15
```

```
     .        ,SMCHR    ,TEST     ,ERMARK                                  16
     ./ICNSTI/ BLANK    ,BLANKS   ,DOLLAR   ,EOS                           17
     .        ,ICOMMA   ,IDOLAR   ,IFT      ,IPTAB    ,ITAB               18
     .        ,KAM10    ,KBPC     ,KBPW     ,KCPCD    ,KERTYP             19
     .        ,KZERO    ,NOPRNT   ,TAB1                                    20
     ./IPARAM/ ABORT    ,KIUNIT   ,KOUNIT   ,LIMALF   ,LOCK     ,LOCX      21
     .        ,NOLIST   ,NSTDIR   ,TRACE                                   22
     ./ISTACI/ STACK    ,ISTDIM   ,KSTACK   ,LEVLIM                        23
C                                                                           24
      INTEGER  BLANK    ,BLANKS   ,EOS      ,IDOLAR   ,TAB1     ,TRACE     25
      DOUBLE PRECISION STACK, VALUE                                         26
      LOGICAL ABORT,DOLLAR,ERMARK,LIMALF,LOCK,NOLIST,NONEW,MODALL,          27
     .NSTDIR,SMCHR,TEST                                                     28
      EQUIVALENCE (STACK,ISTACK), (VALUE,KVALUE,RVALUE),(NAME,ANAME)        29
      EQUIVALENCE (ICOMNI,ISUB),(IMAGE,IMAGE1),(IPARAM,ABORT)               30
      LOOK=3                                                                31
C                                     * FIRST USABLE POSITION               32
1     IF(IT(LOOK)  .EQ.0) GO TO 7                                           33
C                                     * RETURN WITH NEXT AVAILABLE ENTR     34
       J=IFLD(3,4,IT(LOOK))                                                 35
C                                        * MAX POSSIBLE J IS 15             36
      IF (J .NE.MSTOR) GO TO 8                                              37
C                                     * 8 IF NAME IS WRONG LENGTH, TRY      38
      DO 4 K=1,J                                                            39
C                                     * CHECK NAME FOR MATCH                40
      LOOKK = LOOK + K                                                      41
      IF (NAME(K).NE.IT(LOOKK))  GO TO 8                                    42
 4    CONTINUE                                                              43
C     CALL DEBUG2(6H*LOOKF,LOOK)                                            44
C                                   * ENTRY WAS FOUND                       45
      RETURN 1                                                              46
 7    CONTINUE                                                              47
C     CALL DEBUG2(6H*LOOKN,LOOK)                                            48
C                                   * NO ENTRY WAS FOUND                    49
      RETURN                                                                50
8     LOOK = LOOK+J+1                                                       51
                                                                            52
                                                                            53
C                                      * TRY NEXT ENTRY                     54
      GO TO 1                                                               55
      END                                                                   56
```

```
$IBFTC INAMEI  DECK
       SUBROUTINE INAMEI(*,D,IT)                                            1
C      CALLED FROM INPUT                                                    2
C     CALL DEBUGC(6HINAMEI)                                                 3
C     SUBROUTINE TO OBTAIN LOCATION, MODE, AND CONTENTS OF A NAMED CELL     4
C                                                                           5
      DIMENSION IFT( 31), IPTAB( 21), ITAB( 65)                             6
      DIMENSION ANAME(15) ,IMAGE(80) ,IMAGE1(81),IPARAM(9)                  7
     .         ,KSTACK(27),NAME(15)  ,RVALUE(2) ,STACK(27)                  8
C                                                                           9
      COMMON                                                               10
     ./ICOMNI/ VALUE    ,ICOMP    ,IFNTYP   ,IMAGE1   ,IRADIX   ,ISUB     11
     .        ,KCH      ,KCNVRT   ,KCOUNT   ,KDIF     ,KFLD1    ,KFLD2    12
     .        ,LCOMP    ,LCNVRT   ,LEVEL    ,LFRT     ,LOOK               13
     .        ,MCNVRT   ,MDIF     ,MODALL   ,MSTOR                        14
     .        ,NAME     ,NERROR   ,NONEW    ,NOTARG                       15
     .        ,SMCHR    ,TEST     ,ERMARK                                 16
```

```
     ./ICNSTI/ BLANK    ,BLANKS   ,DOLLAR   ,EOS                              17
     .        ,ICOMMA   ,IDOLAR   ,IFT      ,IPTAB    ,ITAB                  18
     .        ,KAM10    ,KBPC     ,KBPW     ,KCPCD    ,KERTYP                19
     .        ,KZERO    ,NOPRNT   ,TAB1                                      20
     ./IPARAM/ ABORT    ,KIUNIT   ,KOUNIT   ,LIMALF   ,LOCK     ,LOCX        21
     .        ,NOLIST   ,NSTDIR   ,TRACE                                     22
     ./ISTACI/ STACK    ,ISTDIM   ,KSTACK   ,LEVLIM                          23
C                                                                             24
      INTEGER  BLANK    ,BLANKS   ,EOS      ,IDOLAR   ,TAB1     ,TRACE       25
      DOUBLE PRECISION STACK, VALUE                                           26
      LOGICAL ABORT,DOLLAR,ERMARK,LIMALF,LOCK,NOLIST,NONEW,MODALL,            27
     .NSTDIR,SMCHR,TEST                                                       28
      EQUIVALENCE (STACK,ISTACK), (VALUE,KVALUE,RVALUE),(NAME,ANAME)          29
      EQUIVALENCE (ICOMNI,ISUB),(IMAGE,IMAGE1),(IPARAM,ABORT)                 30
      DIMENSION IT(1)                                                         31
C                                     * TABLE OF NAMES PROVIDED BY USER       32
      DIMENSION D(1)                                                          33
C                                     * USERS VARIABLES ARE IN D ARRAY        34
      ISUB = 1                                                                35
C                                     * UNDERSTOOD SUBSCRIPT                  36
      KDIF = 1                                                                37
      CALL INAMEN                                                             38
      CALL ILOOKI($1,IT)                                                      39
      CALL ILOOKI($64,IFT)                                                    40
 9540 KERTYP=540                                                              41
C                                     * NAME NOT IN TABLE                     42
      GO TO 99                                                                43
 1    CONTINUE                                                                44
C     CALL DEBUG2(6HSTATMT,1)                                                 45
      ITL = IT(LOOK)                                                          46
       KCNVRT=IFLD(0,3,ITL)                                                   47
C     CALL DEBUG 2 (6HKCNVRT,KCNVRT)                                          48
C           R  I  D  T  S  F                                                  49
      GO TO(12,12,10,12,62,61),KCNVRT                                         50
 10   KDIF = 2                                                                51
C          (     OTH                                                        52
 12   CALL ICHAR2($90,30)                                                     53
C                                  * GO TO 90 FOR NO SUBSCRIPT                54
C            A-Z   0-9  OTH                                                   55
       CALL ICHARI($82,$9140,12)                                              56
      CALL INAMEN                                                             57
      CALL ILOOKI($83,IT)                                                     58
      GO TO 9540                                                              59
 82   SMCHR = .TRUE.                                                          60
      CALL ISUBI                                                              61
      GO TO 84                                                                62
 83    ITYPE=IFLD(0,3,IT(LOOK))                                               63
       LOC=IFLD(7,25,IT(LOOK))                                                64
      RVALUE(1) = D(LOC)                                                      65
      RVALUE(2) = D(LOC+1)                                                    66
      CALL ICNVTI (ITYPE,2)                                                   67
      ISUB = KVALUE                                                           68
C           )     OTH                                                       69
 84    CALL ICHAR2($9140,31)                                                  70
C                             * ERROR IF NO )                                 71
      GO TO 91                                                                72
 90   SMCHR = .TRUE.                                                          73
 91    LOC=IFLD(7,25,ITL)                                                     74
C     CALL DEBUG 2 (5HLOC 1,LOC)                                              75
      LOC = LOC + (ISUB-1)*KDIF                                               76
 50   RVALUE(1) = D(LOC)                                                      77
      RVALUE(2) = D(LOC+1)                                                    78
```

```
C      CALL DEBUG 3(5HIT(L),ITL,2)                                          79
       CALL ICNVTI (KCNVRT,3)                                               80
 52    LOOK = LOC                                                           81
 98    CONTINUE                                                             82
C      CALL DEBUG 3(5HVALUE,VALUE,4)                                        83
C      CALL DEBUG 2 (6HLOOK  ,LOOK)                                         84
C      CALL DEBUG 2 (5HLOC 2,LOC)                                           85
C      CALL DEBUG 2(6HKCNVRT,KCNVRT)                                        86
C      CALL DEBUGR                                                          87
       RETURN                                                               88
 61    IFNTYP = 0                                                           89
C                                     * FUNCTION                            90
       GO TO 63                                                             91
 62    IFNTYP = 1                                                           92
C                                     * SUBROUTINE                          93
 63     KVALJE=IFLD(7,25,ITL)                                              94
       GO TO 98                                                             95
 64    IFNTYP = 0                                                           96
C                                     * LIBRARY FUNCTION OR SUBROUTINE      97
        KVALJE=IFLD(7,25,IFT(LOOK))                                         98
C                                     * PROGRAM NUMBER (USED BY IXQTI)      99
       MSTOR = 0                                                           100
        KCNVRT=IFLD(0,3,IFT(LOOK))                                         101
C                                     * 5 FOR SUBROUTINES, 6 FOR FUNCTIONS 102
       IF(KCNVRT.EQ.5)IFNTYP=KVALUE                                        103
C                                     * PROVIDE FOR EXECUTION OF INPUT SUBRO 104
C      CALL DEBUG2(6HLIBF   ,KVALUE)                                       105
C     MEANING OF IFNTYP                                                    106
C       VALUE       NAME IS                                              107
C     -1(NORMAL) AN ORDINARY VARIABLE                                      108
C       0          FUNCTION (USER OR FORTRAN MATH)                       109
C       1          USER SUBROUTINE                                       110
C       2          RADIX (INPUT FUNCTION)                                111
C       3          LOCX (INPUT SUBROUTINE)                               112
C         $CALL LOCX(Y,I) CAUSES I TO BE SET SO THAT Y(I)REFERS TO THE CUR 113
C         LEFT SIDE.                                                       114
       GO TO 98                                                            115
 9140  KERTYP =140                                                         116
 99     CONTINUE                                                           117
C      CALL DEBUG2(6HRETURN,1)                                             118
C      CALL DEBUGR                                                         119
C                                          * REGESTER RETURN              120
       RETURN 1                                                            121
       END                                                                 122
```

```
$IBFTC INAMEN  DECK
       SUBROUTINE INAMEN                                                    1
C       CALLED FROM                                                         2
C                    INAMEI                                                 3
C                    ITABLI                                                 4
C                    INPUT                                                  5
C      CALL DEBUGC(6HINAMEN)                                                6
C                                                                           7
       DIMENSION IFT( 31), IPTAB( 21), ITAB( 65)                            8
       DIMENSION ANAME(15) ,IMAGE(80) ,IMAGE1(81),IPARAM(9)                 9
     .          ,KSTACK(27),NAME(15)  ,RVALUE(2) ,STACK(27)                10
C                                                                           11
```

```
      COMMON                                                                    12
     ./ICOMNI/ VALUE     ,ICOMP     ,IFNTYP    ,IMAGE1    ,IRADIX    ,ISUB     13
     .         ,KCH      ,KCNVRT    ,KCOUNT    ,KDIF      ,KFLD1     ,KFLD2    14
     .         ,LCOMP    ,LCNVRT    ,LEVEL     ,LFRT      ,LOOK                15
     .         ,MCNVRT   ,MDIF      ,MODALL    ,MSTOR                          16
     .         ,NAME     ,NERROR    ,NONEW     ,NOTARG                         17
     .         ,SMCHR    ,TEST      ,ERMARK                                    18
     ./ICNSTI/ BLANK     ,BLANKS    ,DOLLAR    ,EOS                            19
     .         ,ICOMMA   ,IDOLAR    ,IFT       ,IPTAB     ,ITAB                20
     .         ,KAM10    ,KBPC      ,KBPW      ,KCPCD     ,KERTYP              21
     .         ,KZERO    ,NOPRNT    ,TAB1                                      22
     ./IPARAM/ ABORT     ,KIUNIT    ,KOUNIT    ,LIMALF    ,LOCK      ,LOCX     23
     .         ,NOLIST   ,NSTDIR    ,TRACE                                     24
     ./ISTACI/ STACK     ,ISTDIM    ,KSTACK    ,LEVLIM                         25
C                                                                               26
      INTEGER  BLANK     ,BLANKS    ,EOS       ,IDOLAR    ,TAB1      ,TRACE    27
      DOUBLE PRECISION STACK, VALUE, DNAME                                      28
      LOGICAL ABORT,DOLLAR,ERMARK,LIMALF,LOCK,NOLIST,NONEW,MODALL,              29
     .NSTDIR,SMCHR,TEST                                                         30
      EQUIVALENCE (STACK,ISTACK), (VALUE,IVALUE,RVALUE),(NAME,ANAME)            31
      EQUIVALENCE (ICOMNI,ISUB),(IMAGE,IMAGE1),(IPARAM,ABORT)                   32
      EQUIVALENCE(NAME,DNAME)                                                   33
C     COLLECTS NAME (UP TO 15 WORDS) TERMINATED BY ANY SPECIAL CHAR             34
       ASSIGN 6 TO NEXT                                                         35
       IF(MODALL)ASSIGN 2 TO NEXT                                               36
       MSTOR = 0                                                                37
       J = IBPW                                                                 38
      NAME(2) = BLANKS                                                          39
 1    GO TO NEXT,(2,6,7)                                                        40
C              '     OTH                                                        41
 2     CALL ICHAR2($8 ,23)                                                      42
       TEST = .TRUE.                                                            43
       MODALL = .FALSE.                                                         44
       CALL ICHAR2($99,23)                                                      45
C                                       ' PAIR OF APOSTROPHYS DOES NOT EN       46
      TEST = .FALSE.                                                            47
      MODALL = .TRUE.                                                           48
      GO TO 8                                                                   49
 6     ASSIGN 7 TO NEXT                                                         50
      GO TO 8                                                                   51
C         A-Z-0-9  OTH                                                        52
 7     CALL ICHAR2($99,12)                                                      53
 8     IF(J.LT.KBPW) GO TO 9                                                    54
       IF(MSTOR.EQ.15) GO TO 10                                                 55
       MSTOR = MSTOR + 1                                                        56
       NAME(MSTOR) = BLANKS                                                     57
       J = 0                                                                    58
 9     NAME(MSTOR)=IFLD4(KCH,J,KBPC,NAME(MSTOR))                                59
       J=J+IBPC                                                                 60
       GO TO 1                                                                  61
 10   IF(MODALL) GO TO 99                                                       62
      IERTYP = -260                                                             63
      CALL IERORI                                                               64
 95    CALL ICHAR2($99,12)                                                      65
C                                       ' SKIP REST OF NAME                     66
       GO TO 95                                                                 67
 99   CONTINUE                                                                  68
      SMCHR = .TRUE.                                                            69
C     CALL DEBUG3(6HNAME  ,DNAME,3)                                             70
C     CALL DEBUG2(5HMSTOR,MSTOR)                                                71
C     CALL DEBUGR                                                               72
      RETURN                                                                    73
      END                                                                       74
```

```
$IBFTC INMBRI  DECK
C      SUBROUTINE TO TRANSLATE A NUMERIC FIELD                                  1
       SUBROUTINE INMBRI                                                        2
C       CALLED FROM INPUT                                                       3
C      INMBRI IS CALLED WITH FIRST DIGIT IN KCH                                 4
C      CALL DEBUGC(6HINMBRI)                                                    5
       DIMENSION IFT( 31), IPTAB( 21), ITAB( 65)                                6
       DIMENSION ANAME(15) ,IMAGE(80) ,IMAGE1(81),IPARAM(9)                     7
      .         ,KSTACK(27),NAME(15)  ,RVALUE(2) ,STACK(27)                     8
C                                                                               9
       COMMON                                                                  10
      ./ICOMNI/ VALUE     ,ICOMP     ,IFNTYP    ,IMAGE1    ,IRADIX    ,ISUB   11
      .         ,KCH      ,KCNVRT    ,KCOUNT    ,KDIF      ,KFLD1     ,KFLD2  12
      .         ,LCOMP    ,LCNVRT    ,LEVEL     ,LFRT      ,LOOK              13
      .         ,MCNVRT   ,MDIF      ,MODALL    ,MSTOR                        14
      .         ,NAME     ,NERROR    ,NONEW     ,NOTARG                       15
      .         ,SMCHR    ,TEST      ,ERMARK                                  16
      ./ICNSTI/ BLANK     ,BLANKS    ,DOLLAR    ,EOS                         17
      .         ,ICOMMA   ,IDOLAR    ,IFT       ,IPTAB     ,ITAB             18
      .         ,KAM10    ,KBPC      ,KBPW      ,KCPCD     ,KERTYP           19
      .         ,KZERO    ,NOPRNT    ,TAB1                                    20
      ./IPARAM/ ABORT     ,KIUNIT    ,KOUNIT    ,LIMALF    ,LOCK      ,LOCX   21
      .         ,NOLIST   ,NSTDIR    ,TRACE                                   22
      ./ISTACI/ STACK     ,ISTDIM    ,KSTACK    ,LEVLIM                      23
C                                                                              24
       INTEGER  BLANK     ,BLANKS    ,EOS       ,IDOLAR    ,TAB1      ,TRACE  25
       DOUBLE PRECISION STACK, VALUE, DNBR, H, FD(4)                           26
       LOGICAL ABORT,DOLLAR,ERMARK,LIMALF,LOCK,NOLIST,NONEW,MODALL,            27
      .NSTDIR,SMCHR,TEST                                                       28
       EQUIVALENCE (STACK,ISTACK), (VALUE,KVALUE,RVALUE),(NAME,ANAME)          29
       EQUIVALENCE (ICOMNI,ISUB),(IMAGE,IMAGE1),(IPARAM,ABORT)                 30
       LOGICAL LVALUE                                                          31
       EQUIVALENCE (KVALUE,LVALUE)                                             32
       LOGICAL SWITCH                                                          33
       DIMENSION LD(4)                                                         34
       DATA LD(1),LD(2),LD(3),LD(4)/8,4,2,1/                                   35
       DATA FD(1),FD(2),FD(3),FD(4)/1.0D8,1.0D4,1.0D2,10.D0/                   36
       DNBR=0                                                                  37
C                 * THE NUMBER  COLLECTED SO FAR                               38
        ICSC=0                                                                 39
C                 *THE CHARACTERISTIC SCALE FACTOR                             40
       IPF = 1                                                                 41
C                                    * SIGN OF EXPONENT                        42
       IESE = 0                                                                43
C                                    * THE EXPONENT                            44
       ASSIGN 1 TO NEXT                                                        45
       SWITCH = .FALSE.                                                        46
       SMCHR = .TRUE.                                                          47
        CALL ICHAR2($70,21)                                                    48
C                             * GO TO 70 FOR LOGICAL CONSTANTS                 49
        SMCHR = .TRUE.                                                         50
C             +-    OTH 0-9                                                    51
 1      CALL ICHAR4($2, $3,   13,15)                                           52
        GO TO 50                                                               53
3      DNBR = DNBR*10.D0+FLOAT(KCH-KZERO)                                      54
       GO TO NEXT,(1,15)                                                       55
 15    ICSC = ICSC - 1                                                         56
       GO TO 1                                                                 57
C              . DE OTH                                                        58
 2      GO TO(20,30,50),LCOMP                                                  59
 19     SMCHR=.TRUE.                                                           60
C                                     *ENTER HERE FOR INITIAL DECIMAL POINT    61
 20    IF (SWITCH)  GO TO 9130                                                 62
```

```
C     CALL DEBUG2(6HSTAT .,20)                                          63
      ASSIGN 15 TO NEXT                                                 64
      SWITCH = .TRUE.                                                   65
      GO TO 1                                                           66
 37    IPF=-1                                                           67
       GO TO 36                                                         68
 30    CONTINUE                                                         69
C     CALL DEBUG 2(6HSTAT E,30)                                         70
C            +-    OTH 0-9                                            71
       CALL ICHAR4($50,$35, 13,15)                                      72
C             +  -                                                     73
       GO TO(36,37),LCOMP                                               74
 35    SMCHR=.TRUE.                                                     75
 36    CALL ISUBI                                                       76
C                                  * TEST WILL BE TRUE                 77
 44   ICSC = ICSC+ISIGN(ISUB,IPF)                                       78
C                                     * RESOLVE SCALE FACTORS          79
50    CONTINUE                                                         80
C     CALL DEBUG 2(6HSTAT  ,50)                                        81
C     CALL DEBUG3 (5HDNBR1,DNBR ,4)                                    82
      H = 1.DO                                                         83
      IESC=IABS(ICSC)                                                  84
      DO 63 I=1,4                                                      85
 61    IF (IESC.LT. LD(I)) GO TO 63                                    86
 62    IESC=IESC-LD(I)                                                 87
       H=H*FD(I)                                                       88
       GO TO 61                                                        89
 63    CONTINUE                                                        90
      IF (ICSC.LT.0) GO TO 65                                          91
 64   DNBR = DNBR*H                                                    92
      GO TO 98                                                         93
C              T    F  OTH                                            94
 70    CALL ICHARI($73,$19,17)                                         95
       LVALJE=.TRUE.                                                   96
 71    IF(NJTARG.GT.LEVEL)LCNVRT=4                                     97
C                                  * LOGICAL CONSTANTS NOT CONVERTED   98
       RVALUE(2)=0.                                                    99
C             A-Z   OTH   .                                           100
 72    CALL ICHARI($9130,$99,21)                                       101
C                                     *DISCARD REST OF WORD, MUST FIND 102
       GO TO 72                                                        103
 73    LVALUE=.FALSE.                                                  104
       GO TO 71                                                        105
 65   DNBR = DNBR/H                                                    106
98    VALUE = DNBR                                                     107
      SMCHR = .TRUE.                                                   108
 99   CONTINJE                                                         109
C     CALL DEBUG3(6HDNBR 2,DNBR,4)                                     110
C     CALL DEBUG3(5HVALUE,VALUE,4 )                                    111
C     CALL DEBUG2(6HICSC  ,ICSC)                                       112
C     CALL DEBUG2(6HIPF   ,IPF)                                        113
C     CALL DEBUG 2(6HIESC  ,IESC)                                      114
C     CALL DEBUGR                                                      115
      RETURN                                                           116
 9130 KERTYP = 130                                                     117
      GO TO 99                                                         118
      END                                                              119
```

```
$IBFTC ITABLI  DECK
C      SUBROUTINE TO CONSTRUCT TABLE ENTRIES                                  1
       SUBROUTINE ITABLI(IT)                                                  2
C       CALLED FROM INPUT                                                     3
C      CALL DEBUGC(6HITABLI)                                                  4
C                                                                             5
       DIMENSION IFT( 31), IPTAB( 21), ITAB( 65)                              6
       DIMENSION ANAME(15) ,IMAGE(80) ,IMAGE1(81),IPARAM(9)                   7
      .          ,KSTACK(27),NAME(15)  ,RVALUE(2) ,STACK(27)                 8
C                                                                             9
       COMMON                                                                10
      ./ICOMNI/ VALUE     ,ICOMP     ,IFNTYP    ,IMAGE1    ,IRADIX    ,ISUB  11
      .         ,KCH      ,KCNVRT    ,KCOUNT    ,KDIF      ,KFLD1     ,KFLD2 12
      .         ,LCOMP    ,LCNVRT    ,LEVEL     ,LFRT      ,LOOK              13
      .         ,MCNVRT   ,MDIF      ,MODALL    ,MSTOR                        14
      .         ,NAME     ,NERROR    ,NONEW     ,NOTARG                       15
      .         ,SMCHR    ,TEST      ,ERMARK                                  16
      ./ICNSTI/ BLANK     ,BLANKS    ,DOLLAR    ,EOS                         17
      .         ,ICOMMA   ,IDOLAR    ,IFT       ,IPTAB     ,ITAB             18
      .         ,KAM10    ,KBPC      ,KBPW      ,KCPCD     ,KERTYP           19
      .         ,KZERO    ,NOPRNT    ,TAB1                                    20
      ./IPARAM/ ABORT     ,KIUNIT    ,KOUNIT    ,LIMALF    ,LOCK      ,LOCX  21
      .         ,NOLIST   ,NSTDIR    ,TRACE                                   22
      ./ISTACI/ STACK     ,ISTDIM    ,KSTACK    ,LEVLIM                       23
C                                                                             24
       INTEGER  BLANK     ,BLANKS    ,EOS       ,IDOLAR    ,TAB1      ,TRACE 25
       DOUBLE PRECISION STACK, VALUE                                          26
       LOGICAL ABORT,DOLLAR,ERMARK,LIMALF,LOCK,NOLIST,NONEW,MODALL,           27
      .NSTDIR,SMCHR,TEST                                                      28
       EQUIVALENCE (STACK,ISTACK), (VALUE,KVALUE,RVALUE),(NAME,ANAME)         29
       EQUIVALENCE (ICOMNI,ISUB),(IMAGE,IMAGE1),(IPARAM,ABORT)                30
       DIMENSION IT (1)                                                       31
C                                                                             32
       KDIF = 1                                                               33
       ISUBX = 1                                                              34
       ITYPE = 1                                                              35
C                                    * ALWAYS INITIALIZE TO .REAL.            36
C              (   A-Z  OTH                                                   37
 1     CALL ICHARI ($1,$9120,26)                                              38
C                                     * SKIP 'ABLE' IN TABLE                  39
 3     CONTINUE                                                               40
C      CALL DEBUG2(6HSTATMT,3)                                                41
       CALL ICHAR4($4,$9120,7,9)                                              42
C              .   )   0-9+  OTH                                              43
        GO TO (30 ,98 ,10 ,9120),LCOMP                                        44
C              ,  A-Z  OTH  OTH                                               45
 4      GO TO (3  ,20, 9120,9120),LCOMP                                       46
 9120 KERTYP= 120                                                             47
C                    *                    ILLEGAL CHARACTER                   48
       GO TO 98                                                               49
 10    CONTINUE                                                               50
C      CALL DEBUG2(6HST 0-9 ,10)                                              51
       SMCHR = .TRUE.                                                         52
       CALL ISUBI                                                             53
       ISUBX = ISUB                                                           54
       CALL ICHAR2($9120,25)                                                  55
C                                    *ERROR IF NO =                           56
       GO TO 3                                                                57
 30     CONTINUE                                                              58
C      CALL DEBUG 2(6HSTATMT,30)                                              59
 31    KDIF = 1                                                               60
```

```
C     SPLIT TYPES (INT,REAL,DP,NO CONVERSION,FUNCTION ,SUBROUTINE)          61
      CALL ICHAR4($32,$33,3,5)                                              62
      IF(LCOMP.GT.1) GO TO 9120                                             63
      KDIF = 2                                                              64
      GO TO 33                                                              65
 32   IF (LCOMP.EQ.3) GO TO 9120                                            66
      ITYPE = LCOMP                                                         67
      GO TO 34                                                              68
 33   ITYPE = LCOMP+2                                                       69
C              A-Z  OTH   .                                                 70
 34   CALL ICHARI($9120,$3,21)                                              71
      GO TO 34                                                              72
 20   CONTINUE                                                              73
C     CALL DEBUG2(6HSTATMT,20)                                              74
      CALL INAMEN                                                           75
 50   CONTINUE                                                              76
C     CALL DEBUG2(6HSTATMT,50)                                              77
       ITBUFF=IFLD4(ITYPE,0,3,ITBUFF)                                       78
       ITBUFF=IFLD4(MSTOR,3,4,ITBUFF)                                       79
       ITBUFF=IFLD4(ISUBX,7,25,ITBUFF)                                      80
C     CALL DEBUG2 (5HITYPE,ITYPE)                                           81
C     CALL DEBUG2 (5HMSTOR,MSTOR)                                           82
C     CALL DEBUG2 (5HISUBX,ISUBX)                                           83
C     CALL DEBUG4 (6HITBUFF,ITBUFF,2)                                       84
      ISUBX = ISUBX + KDIF                                                  85
      CALL ILOOKI($56,IT)                                                   86
      IF((IT(2).NE.0).AND.((LOOK+MSTOR +2).GT.IT(2)))   GO TO 9320          87
      IT(LOOK)=ITBUFF                                                       88
      DO 55 K=1,MSTOR                                                       89
       LOOK=LOOK+1                                                          90
  55   IT(LOOK)=NAME(K)                                                      91
C     CALL DEBUG2(6HSTATMT,55)                                              92
      LOOK=LOOK+1                                                           93
      IT(LOOK)=0                                                            94
      GO TO 3                                                               95
 56   IT(LOOK)=ITBUFF                                                       96
C     CALL DEBUG2(6HSTATMT,56)                                              97
      GO TO 3                                                               98
 98   CONTINUE                                                              99
C     CALL DEBUGR                                                          100
      RETURN                                                               101
9320  KERTYP =-320                                                         102
      CALL IERORI                                                          103
      GO TO  3                                                             104
      END                                                                  105
```

```
$IBFTC ISUBI   DECK
      SUBROUTINE ISUBI                                                       1
C      ISUBI FINDS SUBSCRIPTS AND INTEGER CONSTANTS                          2
C      CALLED FROM                                                           3
C                  INAMEI                                                    4
C                  INMBRI                                                    5
C                  INPUT                                                     6
C                  ITABLI                                                    7
C        ISUB BEGINS PROCESSING WITH THE NEXT CHARACTER.                     8
C     CALL DEBUGC(5HISUBI)                                                   9
C     COLLECTS INTEGER OF BASE IRADIX TERMINATED BY A SPECIAL CHARACTER      10
      DIMENSION IFT( 31), IPTAB( 21), ITAB( 65)                             11
```

```
      DIMENSION ANAME(15) ,IMAGE(80) ,IMAGE1(81),IPARAM(9)                    12
     .          ,KSTACK(27),NAME(15)  ,RVALUE(2) ,STACK(27)                   13
C                                                                             14
      COMMON                                                                  15
     ./ICOMNI/ VALUE    ,ICOMP    ,IFNTYP   ,IMAGE1   ,IRADIX   ,ISUB        16
     .         ,KCH      ,KCNVRT   ,KCOUNT   ,KDIF     ,KFLD1   ,KFLD2       17
     .         ,LCOMP    ,LCNVRT   ,LEVEL    ,LFRT     ,LOOK                  18
     .         ,MCNVRT   ,MDIF     ,MODALL   ,MSTOR                         19
     .         ,NAME     ,NERROR   ,NONEW    ,NOTARG                        20
     .         ,SMCHR    ,TEST     ,ERMARK                                  21
     ./ICNSTI/ BLANK    ,BLANKS   ,DOLLAR   ,EOS                           22
     .         ,ICOMMA   ,IDOLAR   ,IFT      ,IPTAB    ,ITAB                23
     .         ,KAM10    ,KBPC     ,KBPW     ,KCPCD    ,KERTYP              24
     .         ,KZERO    ,NOPRNT   ,TAB1                                    25
     ./IPARAM/ ABORT    ,KIUNIT   ,KOUNIT   ,LIMALF   ,LOCK     ,LOCX        26
     .         ,NOLIST   ,NSTDIR   ,TRACE                                   27
     ./ISTACI/ STACK    ,ISTDIM   ,KSTACK   ,LEVLIM                        28
C                                                                             29
      INTEGER  BLANK    ,BLANKS   ,EOS      ,IDOLAR   ,TAB1     ,TRACE       30
      DOUBLE PRECISION STACK, VALUE                                           31
      LOGICAL ABORT,DOLLAR,ERMARK,LIMALF,LOCK,NOLIST,NONEW,MODALL,            32
     .NSTDIR,SMCHR,TEST                                                       33
      EQUIVALENCE (STACK,ISTACK), (VALUE,KVALUE,RVALUE),(NAME,ANAME)          34
      EQUIVALENCE (ICOMNI,ISUB),(IMAGE,IMAGE1),(IPARAM,ABORT)                 35
      ISUB = 0                                                                36
C             A-Z  0-9  OTH                                                   37
 80    CALL ICHARI($10,$99,12)                                                38
       IDIGIT=KCH-KAM10                                                       39
C                        * VALUE OF LETTER USED AS DIGIT                      40
 30    IF(IDIGIT .GE. IRADIX)   GO TO 99                                      41
35     ISUB = ISUB * IRADIX + IDIGIT                                          42
C                                                 * ACCUM TOTAL.   IRADIX     43
       GO TO 80                                                               44
99     SMCHR = .TRUE.                                                         45
C                                      * ALLOW SAME CHARACTER TO BE READ      46
C      CALL DEBUG2(6H*ISUBI,ISUB)                                             47
C      CALL DEBUGR                                                            48
       RETURN                                                                 49
 10    IDIGIT=KCH-KZERO                                                       50
C                        * VALUE OF DIGIT                                     51
       GO TO 30                                                               52
       END                                                                    53
```

```
$IBFTC IXQTI   DECK
       SUBROUTINE IXQTI (ARGL,ARGS)                                            1
C       USER MAY PUT HIS OWN COMMON STATEMENTS IN THIS ROUTINE AND              2
C       USE THEM TO SUPPLY ARGUMENTS TO HIS CALLS IF HE DESIRES                 3
       COMMON                                                                  4
      ./IPARAM/ ABORT ,KIUNIT ,KOUNIT, LIMALF ,LOCK, LOCX, NOLIST, NSTDIR      5
      .,        TRACE                                                         6
       DOUBLE PRECISION ARGS(27), ARGL, ARG22                                  7
       DIMENSION ARG2(2)                                                       8
       EQUIVALENCE (ARG2,ARG22)                                                9
C                                                                             10
       M = DABS(ARGS(1))                                                      11
       IF (M.LT.1 .OR. M.GT.16)  GO TO 99                                     12
       GO TO (1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16),M                       13
```

```
    1 ARGL = COS(ARGL)                                                      14
      GO TO 100                                                             15
    2 ARGL = EXP(ARGL)                                                      15
      GO TO 100                                                             17
    3 ARGL = ALOG(ARGL)                                                     18
      GO TO 100                                                             19
    4 ARGL = SIN(ARGL)                                                      20
      GO TO 100                                                             21
    5 ARGL = SQRT(ARGL)                                                     22
      GO TO 100                                                             23
    6 ARGL = ATAN2(ARGS(2),ARGL)                                            24
      GO TO 100                                                             25
C      PRINT FUNCTION                                                       26
    7 ARG22 = ARGS(2)                                                       27
      WRITE (KOUNIT,101) ARG2,ARGL                                          28
  101 FORMAT(1H 2A6,3H = ,D26.17)                                           29
      GO TO 100                                                             30
    8 ARGL = SNGL(ARGS(2))**IFIX(SNGL(ARGL+DSIGN(.5D0,ARGL)))               31
      GO TO 100                                                             32
    9 ARGL = ABS(SNGL(ARGS(2)))**SNGL(ARGL)                                 33
      GO TO 100                                                             34
   10 ARGL = ABS(ARGL)                                                      35
      GO TO 100                                                             36
C      DISC(RIMINENT) FUNCTION                                              37
   11 IF (ARGL) 102,103,104                                                 38
  102 ARGL = ARGS(2)                                                        39
      GO TO 100                                                             40
  103 ARGL = ARGS(3)                                                        41
      GO TO 100                                                             42
  104 ARGL = ARGS(4)                                                        43
      GO TO 100                                                             44
   12 CALL LOCKX(ARGL)                                                      45
      GO TO 100                                                             46
   13 CONTINUE                                                              47
      GO TO 100                                                             48
   14 CONTINUE                                                              49
      GO TO 100                                                             50
   15 CONTINUE                                                              51
   16 CONTINUE                                                              52
  100 CONTINUE                                                              53
C     CALL DEBUGR                                                           54
      RETURN                                                                55
   99 KERTYP =-610                                                          56
      CALL IERORI                                                           57
      GO TO 100                                                             58
      END                                                                   59
```

```
$IBFTC LOCKX   DECK
      SUBROUTINE LOCKX(J)                                                    1
      COMMON                                                                 2
     ./IPARAM/ ABORT    ,KIUNIT   ,KOUNIT   ,LIMALF   ,LOCK     ,LOCX       3
     .        ,NOLIST   ,NSTDIR   ,TRACE                                    4
      LOGICAL J,LOCK                                                         5
      LOCK = J                                                               6
      RETURN                                                                 7
      END                                                                    8
```

```
$IBFTC DEBUGX  DECK
      SUBROUTINE DEBUGX                                                      1
C                                        *INITALIZATION                       2
      DIMENSION ISUBN(20)                                                    3
C     TRACE  = 0 NO PRINTING                                                 4
C     TRACE  = 1      PRINT DEBUG 2+3 CALLS ONLY                             5
C     TRACE  = 2      PRINT DEBUG 2+3 CALLS ONLY                             6
C     TRACE  = 3      PRINT  DEBUG 2+3 AND STACK PRINT                       7
C     TRACE  = 4      PRINT DEBUG 2+3 AND STACK PRINT AND CALLS FROM C+AR    8
      DIMENSION IFT(27), IPTAB(21), ITAB(65)                                 9
      DIMENSION ANAME(15) ,IMAGE(80) ,IMAGE1(81),IPARAM(9)                  10
     *          ,KSTACK(27),NAME(15)  ,RVALUE(2) ,STACK(27)                 11
C                                                                            12
      COMMON                                                                 13
     */ICOMNI/ VALUE    ,ICOMP    ,IFNTYP   ,IMAGE1   ,IRADIX   ,ISUB       14
     *         ,KCH      ,KCNVRT   ,KCOUNT   ,KDIF     ,KFLD1   ,KFLD2      15
     *         ,LCOMP    ,LCNVRT   ,LEVEL    ,LFRT     ,LOOK                 16
     *         ,MCNVRT   ,MDIF     ,MODALL   ,MSTOR                        17
     *         ,NAME     ,NERROR   ,NONEW    ,NOTARG                       18
     *         ,SMCHR    ,TEST     ,ERMARK                                 19
     */ICNSTI/ BLANK     ,BLANKS   ,DOLLAR   ,EOS                          20
     *         ,ICOMMA   ,IDOLAR   ,IFT      ,IPTAB    ,ITAB               21
     *         ,KAM10    ,KBPC     ,KBPW     ,KCPCD    ,KERTYP             22
     *         ,KZERO    ,NOPRNT   ,TAB1                                   23
     */IPARAM/ ABORT     ,KIUNIT   ,KOUNIT   ,LIMALF   ,LOCK     ,LOCX      24
     *         ,NOLIST   ,NSTDIR   ,TRACE                                  25
     */ISTACI/ STACK     ,ISTDIM   ,KSTACK   ,LEVLIM                       26
C                                                                            27
      INTEGER  BLANK    ,BLANKS   ,EOS      ,IDOLAR   ,TAB1     ,TRACE     28
      DATA BADCAL/6HBADCAL/                                                  29
      DOUBLE PRECISION ALFARG, ISUBN, STACK, VALUE, DBLANK, DARG             30
      LOGICAL ABORT,DOLLAR,ERMARK,LIMALF,LOCK,NOLIST,NONEW,MODALL,           31
     .NSTDIR,SMCHR,TEST                                                      32
      EQUIVALENCE (STACK,ISTACK), (VALUE,KVALUE,RVALUE),(NAME,ANAME)         33
      EQUIVALENCE (ICOMNI,ISUB),(IMAGE,IMAGE1),(IPARAM,ABORT)                34
     .,(DBLANK,BLANK)                                                        35
      ISUBC = 0                                                              36
      DO 10 I = 1,10                                                         37
10    ISUBN(I) = DBLANK                                                      38
      IF(TRACE.EQ.0) GO TO 99                                                39
       WRITE (KOUNIT,410)                                                    40
      GO TO 99                                                               41
      ENTRY DEBUGC(ISUBNA)                                                   42
      DOUBLE PRECISION ISUBNA                                                43
C                              * NEW SUBROUTINE CALLED                       44
      IF (ISUBC.GT.10)  GO TO 98                                             45
      ALFARG = DBLANK                                                        46
      NUMARG = -1                                                            47
      ISUBC = ISUBC+1                                                        48
      ISUBN(ISUBC) = ISUBNA                                                  49
      IF(TRACE .GE.4) GO TO 400                                              50
      GO TO 99                                                               51
C                                                                            52
98    ALFARG = BADCAL                                                        53
C                                        *  CALLS MIGHT GET OUT OF RANGE     54
      NUMARG = ISUBC                                                         55
      GO TO 400                                                              56
C                                                                            57
      ENTRY DEBUGR                                                           58
```

```
C                                       * CALL AT RETURN                        59
      IF (ISUBC.LT.1)   GO TO 98                                                60
      ALFARG = DBLANK                                                           61
      NUMARG = -1                                                               62
      ISUBN(ISUBC) = DBLANK                                                     63
      ISUBC = ISUBC - 1                                                         64
      IF(TRACE .GE.4) GO TO 400                                                 65
      GO TO 99                                                                  66
C                                                                               67
      ENTRY DEBUG2(ALFAR,NUMAR)                                                 68
      DOUBLE PRECISION ALFAR                                                    69
      NUMARG = NUMAR                                                            70
      ALFARG = ALFAR                                                            71
 20   IF (TRACE .LT.1) GO TO 99                                                 72
 400  WRITE (KOUNIT,405) (ISUBN(I),I=1,4),ALFARG,NUMARG,                       73
     .KCOUNT,SMCHR,KCH,KFLD1,ICOMP,KFLD2,LCOMP                                  74
 99   RETURN                                                                    75
C                                                                               76
      ENTRY DEBUG3(ALFAR,DNUMAR,ITYPE)                                          77
      DOUBLE PRECISION DNUMAR                                                   78
      ENTRY DEBUG4(ALFAR,DNUMAR,ITYPE)                                          79
      DARG = DNUMAR                                                             80
      NUMARG=NUMAR                                                              81
      ALFARG = ALFAR                                                            82
      IF (TRACE  .LT.1) GO TO 99                                                83
      GO TO (30,40,50,60), ITYPE                                                84
30    WRITE (KOUNIT,406) (ISUBN(I),I=1,4),ALFARG,NUMARG,                        85
     .KCOUNT,SMCHR,KCH,KFLD1,ICOMP,KFLD2,LCOMP                                  86
      GO TO 99                                                                  87
40    WRITE (KOUNIT,407) (ISUBN(I),I=1,4),ALFARG,NUMARG,                        88
     .KCOUNT,SMCHR,KCH,KFLD1,ICOMP,KFLD2,LCOMP                                  89
      GO TO 99                                                                  90
50    WRITE (KOUNIT,408) (ISUBN(I),I=1,4),ALFARG,NUMARG,                        91
     .KCOUNT,SMCHR,KCH,KFLD1,ICOMP,KFLD2,LCOMP                                  92
      GO TO 99                                                                  93
60    WRITE (KOUNIT,409) (ISUBN(I),I=1,4),ALFARG,NUMARG,                        94
     .KCOUNT,SMCHR,KCH,KFLD1,ICOMP,KFLD2,LCOMP                                  95
      GO TO 99                                                                  96
405   FORMAT(1H ,29X,5(A6,1X),I24,                                              97
     .1H(,I3,L2,1H),A6,2H (,I3,I2,1H),2H (,I3,I2,1H))                           98
406   FORMAT(1H ,29X,5(A6,1X),E24.8,                                            99
     .1H(,I3,L2,1H),A6,2H (,I3,I2,1H),2H (,I3,I2,1H))                          100
407   FORMAT(1H ,29X,5(A6,1X),11X,O12,1X,                                       101
     .1H(,I3,L2,1H),A6,2H (,I3,I2,1H),2H (,I3,I2,1H))                          102
408   FORMAT(1H ,29X,5(A6,1X),16X,A8,                                           103
     .1H(,I3,L2,1H),A6,2H (,I3,I2,1H),2H (,I3,I2,1H))                          104
409   FORMAT(1H ,29X,5(A6,1X),D24.18,                                           105
     .1H(,I3,L2,1H),A6,2H (,I3,I2,1H),2H (,I3,I2,1H))                          106
410   FORMAT(29X,11HDEBUG TRACE,52X,9HI--KCOUNT,5X,8HI--LIST1/                  107
     .68X,9HD ARG  OR,15X,9HI I-SMCHR,5X,10HI I--ICOMP /                       108
     .29X,18HSUBROUTINES CALLED,11X,7HALF ARG,7X,11HNUMERIC ARG,9X,             109
     .3HI I,1X,5HKCH-I,5X,16HI I      I--LIST2 /                               110
     .92X,3HI I,5X,1HI,5X,18HI I      I I--LCOMP)                              111
      END                                                                       112
```

```
$IBFTC STAC<P  DECK
      SUBROJTINE STACKP                                                      1
      DIMENSION IFT(27), IPTAB(21), ITAB(65)                                 2
      DIMENSION ANAME(15) ,IMAGE(80) ,IMAGE1(81),IPARAM(9)                   3
     .          ,KSTACK(27),NAME(15)  ,RVALUE(2) ,STACK(27)                 4
C                                                                            5
      COMMON                                                                 6
     ./ICOMNI/ VALUE    ,ICOMP    ,IFNTYP   ,IMAGE1   ,IRADIX   ,ISUB       7
     .         ,KCH     ,KCNVRT   ,KCOUNT   ,KDIF     ,KFLD1   ,KFLD2      8
     .         ,LCOMP   ,LCNVRT   ,LEVEL    ,LFRT     ,LOOK                  9
     .         ,MCNVRT  ,MDIF     ,MODALL   ,MSTOR                         10
     .         ,NAME    ,NERROR   ,NONEW    ,NOTARG                        11
     .         ,SMCHR   ,TEST     ,ERMARK                                  12
     ./ICNSTI/ BLANK    ,BLANKS   ,DOLLAR   ,EOS                           13
     .         ,ICOMMA  ,IDOLAR   ,IFT      ,IPTAB    ,ITAB                14
     .         ,KAM10   ,KBPC     ,KBPW     ,KCPCD    ,KERTYP              15
     .         ,KZERO   ,NOPRNT   ,TAB1                                    16
     ./IPARAM/ ABORT    ,KIUNIT   ,KOUNIT   ,LIMALF   ,LOCK     ,LOCX       17
     .         ,NOLIST  ,NSTDIR   ,TRACE                                   18
     ./ISTA<I/ STACK    ,ISTDIM   ,KSTACK   ,LEVLIM                         19
C                                                                           20
      INTEGER  BLANK    ,BLANKS   ,EOS      ,IDOLAR   ,TAB1     ,TRACE     21
      DOUBLE PRECISION STACK, VALUE                                         22
      LOGICAL ABORT,DOLLAR,ERMARK,LIMALF,LOCK,NOLIST,NONEW,MODALL,          23
     .NSTDIR,SMCHR,TEST                                                     24
      EQUIVALENCE (STACK,ISTACK), (VALUE,KVALUE,RVALUE),(NAME,ANAME)        25
      EQUIVALENCE (ICOMNI,ISUB),(IMAGE,IMAGE1),(IPARAM,ABORT)               26
      IF(TRACE .LT. 3)  GO TO 99                                            27
      LEVELX = LEVEL + 3                                                    28
      WRITE(KOUNIT,85)LEVEL,VALUE,KVALUE,RVALUE,LOCX                        29
      WRITE(KOUNIT,89)(STACK(I),I=1,LEVELX)                                 30
      WRITE(<OUNIT,86)(KSTACK(I),I=1,LEVELX)                                31
89    FORMAT(11D12.4)                                                       32
86    FORMAT(11I12)                                                         33
85    FORMAT(7H LEVEL=I3,7H VALUE=D25.17,8H KVALUE=I3,3H ,O,2(1X,O12),      34
     .6H LOCX=I6)                                                           35
 99   RETURN                                                                36
      END                                                                   37
```

```
$IBMAP IFLD     DECK
       TTL      IFLD AND IFLD4 PROGRAM                                      1
       ENTRY    IFLD                                                        2
       ENTRY    IFLD4                                                       3
*      FUNCTION (I,N,DATA)                                                 4
*                START EXTRACTION WITH BIT I+1                             5
*                EXTRACT N BITS FROM DATA AND RETURN IN REGESTER 1         6
IFLD   SAVE                                                               7
       CAL*     3,4             I                                         8
       STA      LGL1                                                      9
       CAL*     4,4             N                                        10
       STA      LGL2                                                     11
       LDQ*     5,4             DATA                                     12
LGL1   LGL      **        **=I                                           13
       ZAC                                                               14
```

```
$IBFTC STACKP  DECK
      SUBROUTINE STACKP                                                  1
      DIMENSION IFT(27), IPTAB(21), ITAB(65)                             2
      DIMENSION ANAME(15) ,IMAGE(80) ,IMAGE1(81),IPARAM(9)               3
     .          ,KSTACK(27),NAME(15)  ,RVALUE(2) ,STACK(27)             4
C                                                                        5
      COMMON                                                             6
     ./ICOMNI/ VALUE    ,ICOMP    ,IFNTYP   ,IMAGE1   ,IRADIX   ,ISUB   7
     .         ,KCH      ,KCNVRT   ,KCOUNT   ,KDIF     ,KFLD1   ,KFLD2  8
     .         ,LCOMP    ,LCNVRT   ,LEVEL    ,LFRT     ,LOOK            9
     .         ,MCNVRT   ,MDIF     ,MODALL   ,MSTOR                     10
     .         ,NAME     ,NERROR   ,NONEW    ,NOTARG                    11
     .         ,SMCHR    ,TEST     ,ERMARK                              12
     ./ICNSTI/ BLANK     ,BLANKS   ,DOLLAR   ,EOS                       13
     .         ,ICOMMA   ,IDOLAR   ,IFT      ,IPTAB    ,ITAB            14
     .         ,KAM10    ,KBPC     ,KBPW     ,KCPCD    ,KERTYP          15
     .         ,KZERO    ,NOPRNT   ,TAB1                                16
     ./IPARAM/ ABORT     ,KIUNIT   ,KOUNIT   ,LIMALF   ,LOCK    ,LOCX   17
     .         ,NOLIST   ,NSTDIR   ,TRACE                               18
     ./ISTACI/ STACK     ,ISTDIM   ,KSTACK   ,LEVLIM                    19
C                                                                        20
      INTEGER  BLANK     ,BLANKS   ,EOS      ,IDOLAR   ,TAB1    ,TRACE  21
      DOUBLE PRECISION STACK, VALUE                                      22
      LOGICAL ABORT,DOLLAR,ERMARK,LIMALF,LOCK,NOLIST,NONEW,MODALL,       23
     .NSTDIR,SMCHR,TEST                                                  24
      EQUIVALENCE (STACK,ISTACK), (VALUE,KVALUE,RVALUE),(NAME,ANAME)     25
      EQUIVALENCE (ICOMNI,ISUB),(IMAGE,IMAGE1),(IPARAM,ABORT)            26
      IF(TRACE .LT. 3)  GO TO 99                                         27
      LEVELX = LEVEL + 3                                                 28
      WRITE(KOUNIT,85)LEVEL,VALUE,KVALUE,RVALUE,LOCX                     29
      WRITE(KOUNIT,89)(STACK(I),I=1,LEVELX)                              30
      WRITE(KOUNIT,86)(KSTACK(I),I=1,LEVELX)                             31
89    FORMAT(11D12.4)                                                    32
86    FORMAT(11I12)                                                      33
85    FORMAT(7H LEVEL=I3,7H VALUE=D25.17,8H KVALUE=I3,3H ,O,2(1X,O12),   34
     .6H LOCX=I6)                                                        35
 99   RETURN                                                             36
      END                                                                37
```

```
$IBMAP IFLD     DECK
       TTL      IFLD AND IFLD4 PROGRAM                                   1
       ENTRY    IFLD                                                     2
       ENTRY    IFLD4                                                    3
*      FUNCTION (I,N,DATA)                                              4
*                START EXTRACTION WITH BIT I+1                          5
*                EXTRACT N BITS FROM DATA AND RETURN IN REGESTER 1      6
IFLD   SAVE                                                             7
       CAL*     3,4             I                                       8
       STA      LGL1                                                    9
       CAL*     4,4             N                                      10
       STA      LGL2                                                   11
       LDQ*     5,4             DATA                                   12
LGL1   LGL      **        **=I                                         13
       ZAC                                                            14
```

```
LGL2    LGL     **        **=N                                                  15
        XCL                                                                     16
        XCA                                                                     17
        RETURN  IFLD                                                            18
        SPACE   2                                                               19
*      FUNCTION OR SUBROUTINE IFLD4(NUDATA,I,N,DATA)                            20
*        PUT LOW ORDER N BITS OF NUDATA IN DATA                                 21
*         STARTING WITH THE ITH+1 BIT.                                          22
*        THE MODIFIED DATA IS LEFT IN REG 0 FOR FUNCTION TYPE USAGE             23
*        I.E.   IX=IFLD4(NUDATA),I,N,DATA)                                      24
*       DATA IS UNCHANGED  IX CONTAINS THE CHANGED DATA                         25
IFLD4   SAVE                                                                    26
        CAL*    4,4             I                                               27
        STA     I1                                                              28
        STA     I2                                                              29
        CAL*    5,4             N                                               30
        STA     N1                                                              31
        STA     N2                                                              32
        ZAC                                                                     33
        LDQ*    6,4             DATA                                            34
I1      LGL     **        **=I                                                  35
        SLW     TEMP                                                            36
N1      LGL     **        **=N                                                  37
        CAL*    3,4             Z                                               38
N2      LGR     **        **=N                                                  39
        CAL     TEMP                                                            40
I2      LGR     **        **=I                                                  41
        XCA                                                                     42
        RETURN  IFLD4                                                           43
TEMP    PZE                                                                     44
        END                                                                     45
```

APPENDIX B

HUFF INPUT ROUTINE

The first version of the Huff Input Routine was reported in reference 6. The Huff Input Routine provides more versatility in reading input data into the computer than the NAMELIST feature in FORTRAN. The Huff Input Routine has the ability to make simple arithmetic manipulations (such as conversion of units) during loading and to load alphanumeric data. While not an indispensable feature, it has been found to be quite convenient. The Huff Input Routine also allows for the automatic printout of data cards at execution time.

The following sections contain a general description of the Huff Input Routine and its usage.

Usage

The programmer transfers control to the INPUT routine with a standard FORTRAN IV call

CALL INPUT (5, 6, 1, X, ITABLE)

Argument 1 is the system input tape number (5 on the Lewis system). Argument 2 is the system output tape number (6 on the Lewis system). Argument 3 is the identifying number of a data group. This value is compared with an identification number occurring on the input card ($DATA card). If the values agree, the data are processed until another $DATA or end-of-data ($END) card is encountered. If the values do not agree, no data are processed and control is returned to the calling program. Argument 4 is the Array X, which serves as a reference point for the storing of input data. Since all data are stored relative to X, the programmer must provide fixed relations between the location of X and other locations to be loaded (e.g., through the use of common blocks and/or equivalence statements). In this case, X is "WORD," the first name in the labeled common block "ALL." Common blocks ALL, DESIGN, FRONT, SIDE, BACK, and DUMMY are in all routines and hence are loaded sequentially so that the location of all variables is known. Argument 5 is the array ITABLE, which contains the names of the variables used on the cards and their subscript location relative to X. Sufficient space must be provided in the calling program for storing the table of names. This is done by a DIMENSION statement. The dimension of ITABLE(3) must initially be zero.

Types of Input Statements

$DATA statement. - The $DATA statement identifies a group of data with an identification number. It must be the first statement on a card. For example, $DATA(1) or $D(1) on the first card of a data group causes the value 1 to be compared with argument 3 in the calling sequence. If unequal, control is returned to the calling program. If equal, data are loaded until the next $DATA or $END statement is reached.

$TABLE statement. - The $TABLE statement makes a list of names needed for loading data. Consider for example that the real variable names VELOCITY, MASS, and RADIUS are to be assigned to memory locations X(1), X(2), and X(3), respectively. The card would be punched $TABLE (.REAL., 1 = VELOCITY, 2 = MASS, 3 = RADIUS). These variables will be treated as real in any subsequent loading of data. A limit of 15 computer words is placed on the length of a name. Since .REAL. is what designates the mode of a name, a name may begin with any alphabetic letter. For example, the statement $TABLE (.INTEGER., 20 = INDEX, SUBSCRIPT, I) will place these names in the table and any values subsequently loaded will be stored in X(20), X(21), and X(22), respectively, as integers. In a similar manner $TABLE (.DOUBLE PRECISION., 10 = RADIUS DOUBLE, .LOGICAL., 12 = SWITCH1) causes the name RADIUS DOUBLE to be stored in the table as a double-precision variable equivalent to X(10) and X(11), and the logical variables SWITCH 1 and SWITCH 2 will be equivalent to X(12) and X(13).

Note that $TABLE statements are loaded as Number = Name to avoid confusion with loading statements.

Loading Statement

The loading statement loads data by taking the name of a variable previously appearing in a $TABLE statement and setting it equal to a value which may be of several forms.

Numeric values. - Standard FORTRAN language is used; for example, VELOCITY = 3.4, MASS = 32 (no decimal point is needed and MASS will have the REAL value 32), RADIUS = 4E21, and INDEX = 3. Data can be continued from one card to another; for example, SUBSCRIPT may appear at the end of one card and = 47 on the next card.

Subscripts may be used. Since 3 = RADIUS, RADIUS(2) = 6, 10, 12,, 14 will put real numbers in X(4), X(5), X(6), and X(8) and leave X(7) unchanged because of the double comma. If new values are assigned to a variable before the next $D(1) card, the new value will override the previous one. For example, RADIUS(2) = 8 will override the RADIUS(2) = 6 card.

Internally addressed values. - An internally addressed value is one that refers to the contents of memory by name. RADIUS(7) = RADIUS(3); RADIUS(INDEX) causes RADIUS(7) to be replaced by the value of RADIUS(3) and RADIUS(8) to also be replaced

by RADIUS(3) since INDEX = 3.

The statement RADIUS(7) = RADIUS(INDEX + 1), however, is ILLEGAL.

Arithmetic expressions. - Provisions have been made to allow arithmetic operations to be performed on data at execution time. The operations + (addition), - (subtraction), *(multiplication), and /(division) and the functions, included among which are SQRT, EXP, SIN, COS, and PWR(x, y)(=x**y), may be used with name or numbers (or any expression that has a value) to compute the value of an arithmetic expression. Parentheses may be used to indicate the order of performing the operations. The computations are analyzed from left to right and any intermediate results are stored in up to 24 locations in the core (the stack) which is sufficient for fairly complex expressions. All numeric operations are carried out in double-precision floating-point FORTRAN arithmetic. As an example, RADIUS(2) = RADIUS(2)*SQRT(RADIUS(2)) or RADIUS(2) = PWR(RADIUS(2), 1.5) will set RADIUS(2) = $8^{3/2}$.

Alphanumeric expressions. - Alphanumeric data may be entered by placing the variable name in the "REAL" list and then setting the variable equal to the data by first enclosing in parentheses the length of the word to be read in. As an example,

Q = (A39)THIS IS AN EXAMPLE OF ALPHANUMERIC DATA

The (A39) gives the length of the data including imbedded blanks. Of course, since on the IBM 7094 there are six characters per word, Q must internally be dimensioned to at least 7.

Printing Input Cards

Each input card processed will normally be written on the tape specified by the second argument of the calling sequence. An end-of-statement symbol read on the card will cause interpretation of the card to stop at that point and permit comments to be placed on the remainder of the card to be printed with the output. In order to avoid printing the card at all, the nonprint character is placed in the next column following the end-of-statement character. The developers of the routine selected the sign ǂ for both characters. This is punched as a colon on an IBM Model 29 Keypunch and corresponds to a 2-8 punch.

If the character following the end-of-statement symbol is other than a nonprint character, it is inserted as the printer control character in the first position of the output format before the card is written on the output tape. If no end-of-statement character occurs on the card, a blank printer control character is used. Comment cards having the end-of-statement character as the first nonblank character will be printed and may be placed anywhere except in a continued alphabetic field.

In summary, the end-of-statement character has the effect of moving the end of the card forward to the column ahead of the end-of-statement character. The column following it is printer control.

If the control parameter NOLIST is true, printing is suppressed for all cards.

APPENDIX C

SYMBOLS

General Symbols Internal to Program

Variables in program are formed by combining these symbols.

Station Numbers

See figures 1 to 4 for each type of engine.

Thermodynamic Properties

AM	Mach number
FAR	fuel-air ratio, f/a
H	enthalpy, Btu/lbm
P	total pressure, atm
PS	static pressure, atm
S	entropy, Btu/^{o}R/lbm
T	total temperature, ^{o}R
TS	static temperature, ^{o}R
V	velocity, ft/sec

Component Symbols

A,AFT	afterburner
B	burner
C	inner compressor
COM	combustor
D	fan duct
F	first or fan compressor

M	core nozzle
NOZ	nozzle
OB	overboard
T	total
THP	inner (high pressure) turbine
TLP	outer (low pressure) turbine

Engine Symbols

BL	bleed, lbm/sec
CN	ratio of corrected speed to design corrected speed
DHT	turbine delta enthalpy, Btu/lbm
DHTC	turbine delta enthalpy (temperature corrected), $(H_{in} - H_{out})/T_{in}$, $Btu/^{o}R/lbm$
DP	pressure drop, $\Delta P/P$
DT	temperature change, ^{o}R
ETA	efficiency
ETAR	ram recovery, P_2/P_1
HPEXT	horsepower extracted
PCBL	fractional bleed
PCN	percent of design shaft speed
PR	pressure ratio
TFF	turbine flow function, $lbm\sqrt{^{o}R}/(psia)(sec)$
WA	airflow, lbm/sec
WF	fuel flow, lbm/sec
WG	gas flow, lbm/sec
Z	ratio of pressure ratios

Miscellaneous Symbols

A	area, ft
ALTP	altitude, ft

AM	Mach number of aircraft
BYPASS	bypass ratio (fan duct air/air entering intermediate compressor)
C	when following component symbol, signifies "corrected"
CF	correction factor, when used following component symbol
CS	ambient speed of sound, ft/sec
CV	nozzle velocity coefficient
DEL	delta degradation coefficient
DS	design value
DUM	dummy value
FG	gross thrust, lbf
FGM	momentum thrust, lbf
FGP	pressure thrust, lbf
FN	net thrust, lbf
FRD	ram drag, lbf
GU	initial or guessed values
ITRYS	number of loops through engine before quitting
LOOP	variable counter
LOOPER	number of loops through engine counter
SFC	specific fuel consumption, lbm/lbf/hr
TOLALL	tolerance on convergence
VA	velocity of aircraft, ft/sec
VJ	jet velocity, ft/sec

Input Symbols

ALTP	altitude, ft
AM	Mach number of aircraft
AM6	design afterburner entrance Mach number
AM23	design duct-burner entrance Mach number

AM55	design low-pressure-turbine exit Mach number
A6	area at afterburner entrance (calculated from AM6), ft^2
A8	main nozzle throat area (can be changed at off-design), ft^2
A28	fan duct nozzle throat area (see A8), ft^2
CNHPDS	design corrected speed - inner turbine
CNLPDS	design corrected speed - outer turbine
CVDNOZ	nozzle thrust coefficient (tabular lookup)
CVMNOZ	nozzle thrust coefficient (tabular lookup)
DELFG	gross-thrust delta degradation multiplier
DELFN	net-thrust delta degradation multiplier
DELSFC	specific-fuel-consumption delta degradation multiplier
DPAFDS	afterburner design pressure drop, $\Delta P/P$
DPCODS	combustor design pressure drop, $\Delta P/P$
DPDUDS	duct design pressure drop, $\Delta P/P$
DTCODS	combustor design temperature increase (automatically set to T4 - T3), ^oR
ETAA	afterburner efficiency (not required)
ETAADS	afterburner efficiency at design
ETABDS	combustor efficiency at design
ETACDS	inner compressor adiabatic efficiency at design
ETAD	duct-burner combustion efficiency
ETAFDS	front (outer) compressor adiabatic efficiency at design
ETAR	inlet pressure recovery (ram recovery)
ETHPDS	high-pressure-(inner) turbine design adiabatic efficiency
ETLPDS	low-pressure-(outer) turbine design adiabatic efficiency
FAN	logical control for fan and turbojet engines
HPEXT	horsepower extraction
IAFTBN	index on afterburning desired
IAMTP	index on ram or inlet operation desired
IDBURN	index on duct burning desired
IDCD	duct nozzle convergent-divergent when IDCD equals 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
IGASMX	index for mixed-flow or non-mixed-flow turbofan
IMCD	main nozzle convergent-divergent when IMCD equals 1 (design or off-design)
ISPOOL	index for number of compressors for turbojet engines
ITRYS	index for maximum number of iterations
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)
PCBLLP	fraction of PCBLC used for low-pressure (outer) turbine (cooling)
PCBLOB	ratio of inner compressor bleed to compressor airflow (overboard for customer use)
PCNC	inner-compressor shaft speed as a percent of design shaft speed
PCNCDS	design inner-compressor shaft speed
PCNF	outer-compressor shaft speed as percent of design
PCNFDS	design outer-compressor shaft speed as percent of design shaft speed
PRCDS	design inner-compressor pressure ratio
PRFDS	design outer-compressor pressure ratio
PS55	static pressure at low-pressure-turbine exit
P2	compressor-face total pressure (for nonstandard days only), atm
TFHPDS	design inner-turbine flow function
TFLPDS	design outer-turbine flow function
TOLALL	tolerance on error matrix
T2	compressor-face total temperature (for nonstandard days only), T1 + T2
T24	duct-burner exit temperature, ^{o}R

T4	combustor exit temperature, ^{o}R
T4DS	design combustor exit temperature, ^{o}R
T7	afterburner exit temperature, ^{o}R
T7DS	design afterburner exit temperature, ^{o}R
WACCDS	design inner-compressor corrected airflow (turbofans only), lbm/sec
WAFCDS	design outer-compressor corrected airflow, lbm/sec
WFA	fuel flow rate to afterburner (IAFTBN = 2 only), lbm/sec
WFB	fuel flow rate to main burner (MODE = 2 only), lbm/sec
WFBDS	design fuel flow rate to main burner (MODE = 2 only), lbm/sec
ZCDS, ZFDS	design ratio of inner compressor and fan compressor pressure ratios, respectively; equals pressure ratio at design point on design speed line minus value of pressure ratio of lowest point on speed line divided by high (surge) value minus low value of pressure ratio on the design speed line

Output Symbols[1]

A	area, ft^2
ALTP	altitude, ft
AM	Mach number
BLC	bleed flow out of compressor, lbm/sec
BLF	bleed flow out of fan (dumped overboard), lbm/sec
BLHP	bleed flow into high-pressure turbine, lbm/sec
BYPASS	ratio of airflow into fan duct to airflow into inner compressor
CNC	corrected shaft speed - inner compressor
CNF	corrected shaft speed - fan
CNHP	corrected shaft speed - high-pressure turbine, $PCNC/\sqrt{T_{in}}$
CNHPCF	corrected speed - high-pressure-turbine correction factor
CNLP	corrected speed - low-pressure turbine, $PCNF/\sqrt{T_{in}}$

[1]Some symbols, such as T4, are followed by station numbers, see appropriate figure for each engine to determine station numbers.

CNLPCF	corrected speed - low-pressure-turbine correction factor
CVDNOZ	velocity coefficient of fan nozzle
CVMNOZ	velocity coefficient of core nozzle
DHHPCF	high-pressure-turbine delta enthalpy correction factor
DHLPCF	low-pressure-turbine delta enthalpy correction factor
DHTC	work done by high-pressure turbine, Btu/lbm
DHTCHP	enthalpy change temperature corrected - high-pressure turbine, Btu/^{o}R/atm/lbm
DHTCLP	enthalpy change temperature corrected - low-pressure turbine, Btu/^{o}R/atm/lbm
DHTF	work done by low-pressure turbine, Btu/lbm
DPCOM	$(\Delta P/P)_{\text{combustor}}$
DPDUC	$(\Delta P/P)_{\text{fan duct}}$
DTCOCF	temperature-rise-across-combustor correction factor
ETAB	combustor efficiency
ETABCF	combustor efficiency correction factor
ETAC	inner-compressor adiabatic efficiency
ETACCF	inner-compressor efficiency correction factor
ETAD	duct-burner efficiency
ETAF	fan adiabatic efficiency
ETAFCF	fan efficiency correction factor
ETATHP	high-pressure-turbine adiabatic efficiency
ETATLP	low-pressure-turbine adiabatic efficiency
ETHPCF	high-pressure-turbine efficiency correction factor
ETLPCF	low-pressure-turbine efficiency correction factor
FAR	fuel-air ratio, f/a
FG	gross thrust, lbf
FGM	momentum thrust, lbf
FGP	pressure thrust, lbf
FN	net thrust, lbf

FRD	ram drag, lbf
HPEXT	horsepower extracted, hp
P	pressure, atm
PCBLC	fraction of compressor exit air bled for cooling or lost to cycle
PCBLDU	fraction of bled 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
PCBLLP	fraction of compressor bleed air put into low-pressure turbine
PCNC	inner compressor shaft speed as fraction of design
PCNF	fan compressor shaft speed as fraction of design
PRC	pressure ratio of inner compressor
PRCCF	pressure-ratio-of-inner-compressor correction factor
PRF	pressure ratio of fan or outer compressor
PRFCF	pressure-ratio-of-fan-or-outer-compressor correction factor
PS	static pressure, atm
SFC	specific fuel consumption, lbm/(lbm/hr)
T	temperature, ^{o}R
TFFHP	high-pressure-turbine flow function, $(lbm)\left(\sqrt{^{o}R}\right)(in.^{2})\Big/(sec)(lbf)$
TFFLP	low-pressure-turbine flow function, $(lbm)\left(\sqrt{^{o}R}\right)(in.^{2})\Big/(sec)(lbf)$
TFHPCF	high-pressure-turbine flow function correction factor
TFLPCF	low-pressure-turbine flow function correction factor
T2DS	design exit temperature of fan, ^{o}R
T21DS	design exit temperature of inner compressor, ^{o}R
V	velocity, ft/sec
VA	velocity of aircraft, ft/sec
VJD	fan duct exhaust velocity, ft/sec
VJM	core exhaust velocity, ft/sec
WA	airflow, lbm/sec
WA3CDS	corrected airflow in combustor at design, lbm/sec
WAC	inner-compressor airflow, lbm/sec

WACC	inner-compressor corrected airflow, lbm/sec
WACCF	inner-compressor corrected airflow correction factor
WAD	fan duct airflow, lbm/sec
WAF	fan airflow, lbm/sec
WAFC	fan corrected airflow, lbm/sec
WAFCF	fan corrected airflow correction factor
WFA	fuel flow rate to afterburner, lbm/sec
WFB	fuel flow rate to combustor, lbm/sec
WFD	fuel flow rate to duct burner, lbm/sec
WFT	total fuel flow rate, lbm/sec
WG	gas flow rate, lbm/sec
WGT	total gas flow rate, lbm/sec
ZC	ratio of inner compressor pressure ratios
ZF	ratio of fan pressure ratios

REFERENCES

1. McKinney, John S.: Simulation of Turbofan Engine. Part I. Description of Method and Balancing Technique. Rep. AFAPL-TR-67-125, pt. 1, Air Force Systems Command, Nov. 1967. (Available from DDC as AD-825197.)

2. McKinney, John S.: Simulation of Turbofan Engine. Part II. User's Manual and Computer Program Listing. Rep. AFAPL-TR-67-125, pt. 2, Air Force Systems Command, Nov. 1967. (Available from DDC as AD-825198.)

3. Fishbach, Laurence H.; and Koenig, Robert W.: GENENG II - A Program for Calculating Design and Off-Design Performance of Two- and Three-Spool Turbofans with as Many as Three Nozzles. NASA TN D-6553, 1972.

4. Keenan, Joseph H.; and Kaye, Joseph: Gas Tables. John Wiley & Sons, Inc., 1948.

5. Anon.: U. S. Standard Atmosphere, 1962. Prepared under sponsorship of NASA, USAF, and USWB, 1962.

6. Turner, Don N.; and Huff, Vearl N.: An Input Routine Using Arithmetic Statements for the IBM 704 Digital Computer. NASA TN D-1092, 1961.

TABLE I. - VARIABLES AND ERRORS

	Two-spool turbofan	Mixed-flow turbofan	Two-spool turbojet	One-spool turbojet
Variable 1	ZF	ZF	ZF	ZF
Variable 2	PCNF	PCNF	PCNF	PCNF
Variable 3	ZC	ZC	ZC	TFFLP
Variable 4	PCNC	PCNC	PCNC	----------
Variable 5	TFFHP	TFFHP	TFFHP	----------
Variable 6	TFFLP	TFFLP	TFFLP	----------
Error 1	$\frac{\text{TFHCAL - TFFHP}}{\text{TFHCAL}}$	$\frac{\text{TFHCAL - TFFHP}}{\text{TFHCAL}}$	$\frac{\text{TFHCAL - TFFHP}}{\text{TFHCAL}}$	$\frac{\text{TFLCAL - TFFLP}}{\text{TFLCAL}}$
Error 2	$\frac{\text{DHTCC - DHTCHP}}{\text{DHTCC}}$	$\frac{\text{DHTCC - DHTCHP}}{\text{DHTCC}}$	$\frac{\text{DHTCC - DHTCHP}}{\text{DHTCC}}$	$\frac{\text{DHTCF - DHTCLP}}{\text{DHTCF}}$
Error 3	$\frac{\text{TFLCAL - TFFLP}}{\text{TFLCAL}}$	$\frac{\text{TFLCAL - TFFLP}}{\text{TFLCAL}}$	$\frac{\text{TFLCAL - TFFLP}}{\text{TFLCAL}}$	$\frac{\text{P7R - P7}}{\text{P7R}}$
Error 4	$\frac{\text{DHTCF - DHTCLP}}{\text{DHTCF}}$	$\frac{\text{DHTCF - DHTCLP}}{\text{DHTCF}}$	$\frac{\text{DHTCF - DHTCLP}}{\text{DHTCF}}$	----------
Error 5	$\frac{\text{P25R - P25}}{\text{P25R}}$	$\frac{\text{PS25 - PS55}}{\text{PS25}}$	$\frac{\text{WAF - WAC - BLF}}{\text{WAC}}$	----------
Error 6	$\frac{\text{P7R - P7}}{\text{P7R}}$	$\frac{\text{P7R - P7}}{\text{P7R}}$	$\frac{\text{P7R - P7}}{\text{P7R}}$	----------
Matrix size	6 × 6	6 × 6	6 × 6	3 × 3

TABLE II. - INPUTS REQUIRED FOR BASIC CYCLES

Variable	Units	Definition	Two-spool turbofan	Mixed-flow turbofan	Two-spool turbojet	One-spool turbojet
PRFDS	---------	Fan pressure ratio	Yes	Yes	Yes	Yes
WAFCDS	lb/sec	Fan corrected airflow	↓	↓	↓	↓
ETAFDS	---------	Fan efficiency	↓	↓	↓	↓
ZFDS	---------	Design Z of fan	↓	↓	↓	↓
PCNFDS	---------	Corrected speed of fan	↓	↓	↓	↓
PRCDS	---------	Compressor pressure ratio	↓	↓	↓	No
WACCDS	lb/sec	Compressor corrected airflow	↓	↓	No	↓
ETACDS	---------	Compressor efficiency	↓	↓	Yes	↓
ZCDS	---------	Design Z of compressor	↓	↓	↓	↓
PCNCDS	---------	Corrected speed of compressor	↓	↓	↓	↓
ETABDS	---------	Combustor efficiency	↓	↓	↓	Yes
DPCODS	---------	Combustor pressure drop, $\Delta P/P$	↓	↓	↓	Yes
T4DS	^{o}R	Turbine inlet temperature	↓	↓	↓	Yes
TFHPDS	$\frac{lb\sqrt{^{o}R}}{(sec)(psia)}$	High-pressure-turbine flow function	↓	↓	↓	No
CNHPDS	---------	Corrected speed - high-pressure turbine	↓	↓	↓	No
ETHPDS	---------	Efficiency - high-pressure turbine	↓	↓	↓	No
TFLPDS	$\frac{lb\sqrt{^{o}R}}{(sec)(psia)}$	Low-pressure-turbine flow function	↓	↓	↓	Yes
CNLPDS	---------	Corrected speed - low-pressure turbine	↓	↓	↓	Yes
ETLPDS	---------	Efficiency - low-pressure turbine	↓	↓	↓	Yes
DPDUDS	---------	$\Delta P/P$ of fan duct	↓	↓	No	No
DPAFDS	---------	$\Delta P/P$ of afterburner	↓	↓	Yes	Yes
FAN	---------	Logical variable	.TRUE.	.TRUE.	.FALSE.	.FALSE.
ISPOOL	---------	Number of spools	2	2	2	1

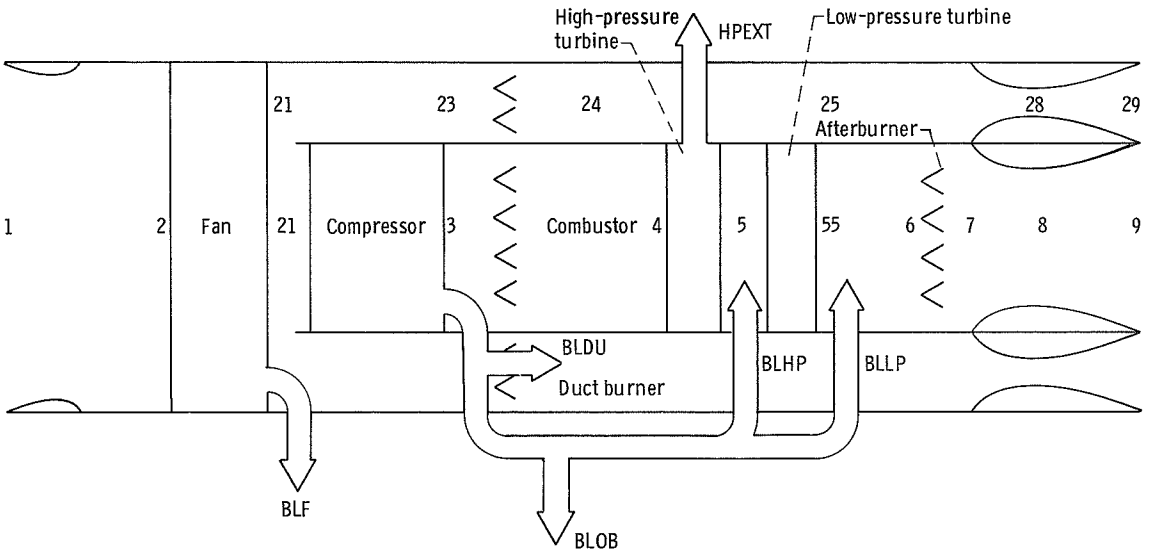


Figure 1. - Schematic of non-mixed-flow duct-burning and/or afterburning turbofan.

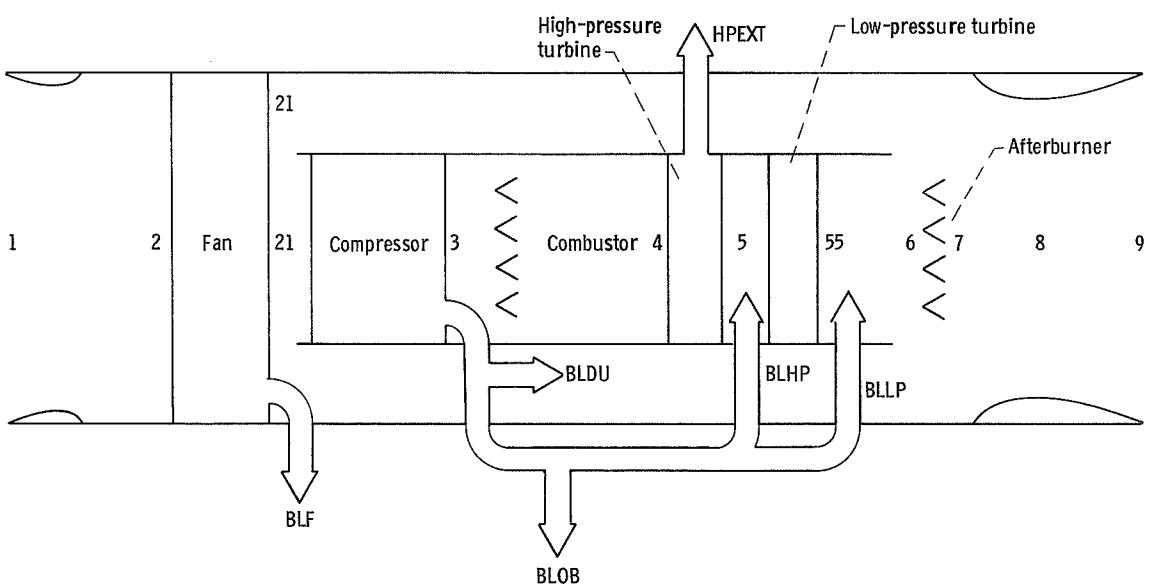


Figure 2. - Schematic of mixed-flow afterburning turbofan.

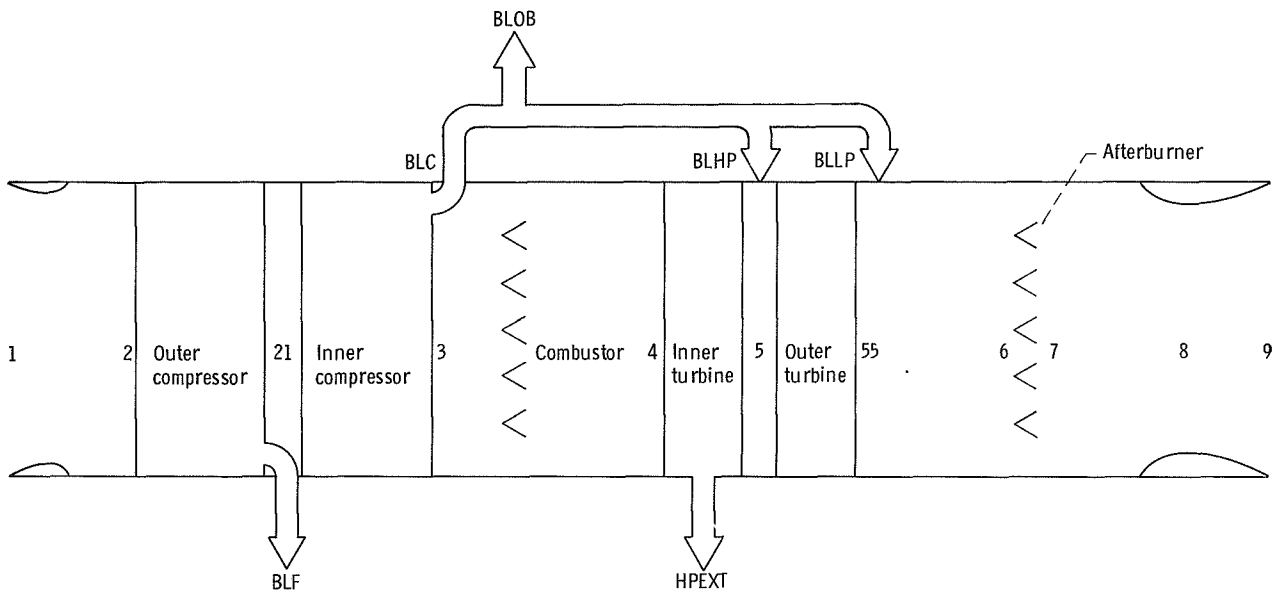


Figure 3. - Schematic of two-spool turbojet.

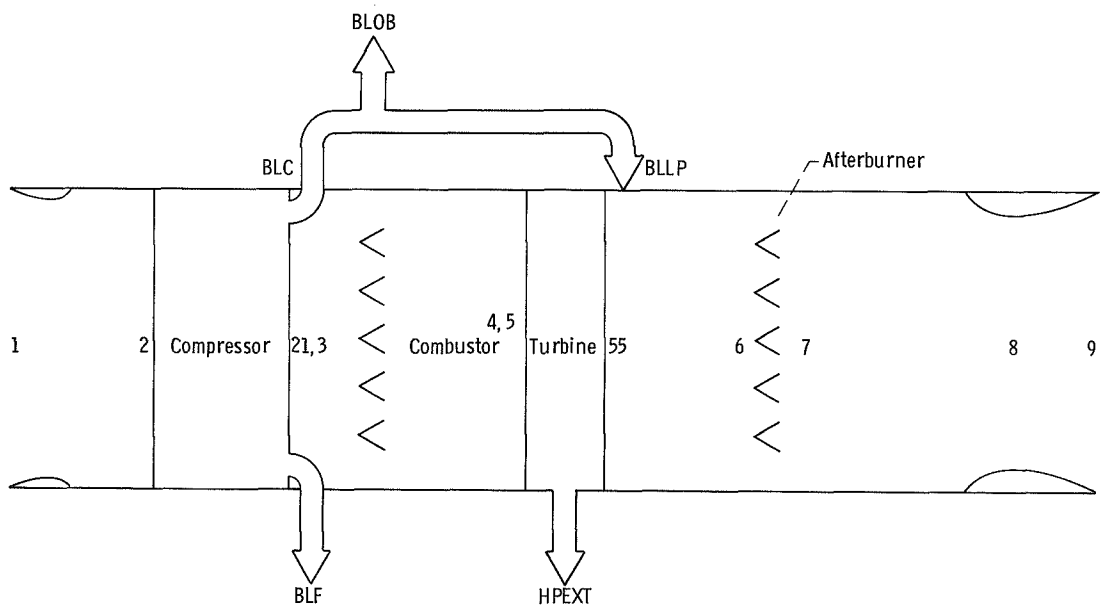


Figure 4. - Schematic of one-spool turbojet.

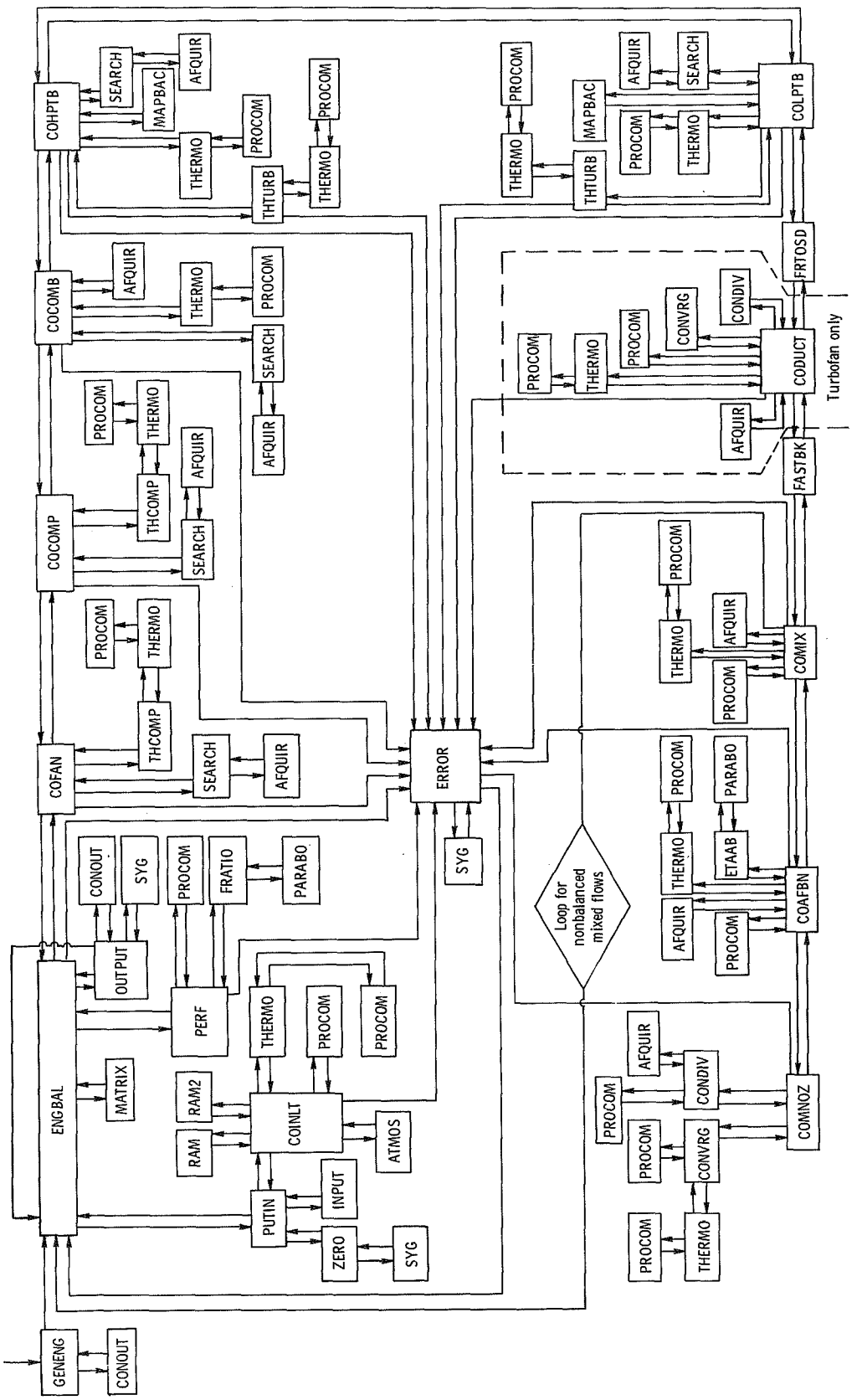


Figure 5. - Flow chart for GENENG computer program.

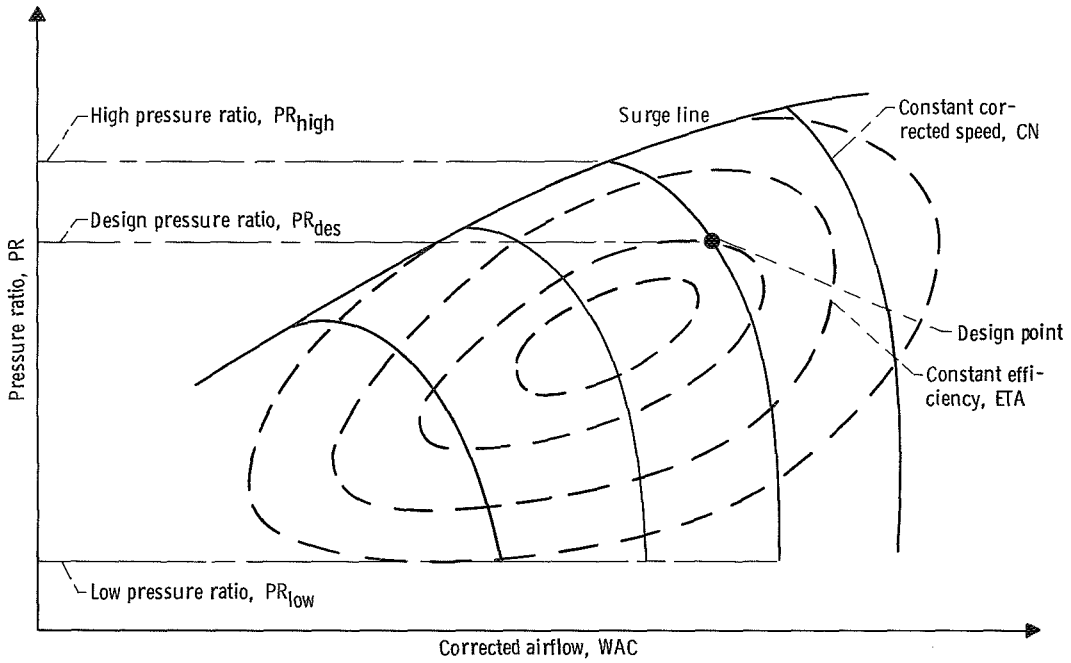


Figure 6. - Example of a specific fan-compressor map. $Z = (PR_X - PR_{low})/(PR_{high} - PR_{low})$.

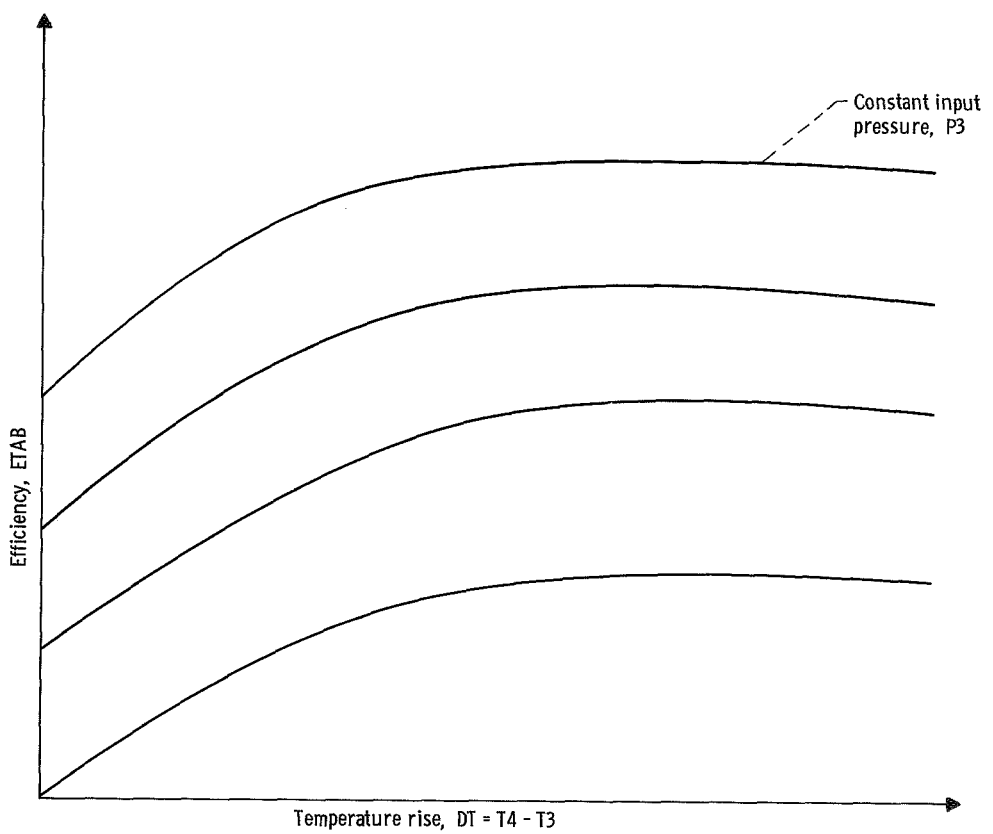


Figure 7. - Example of combustor map.

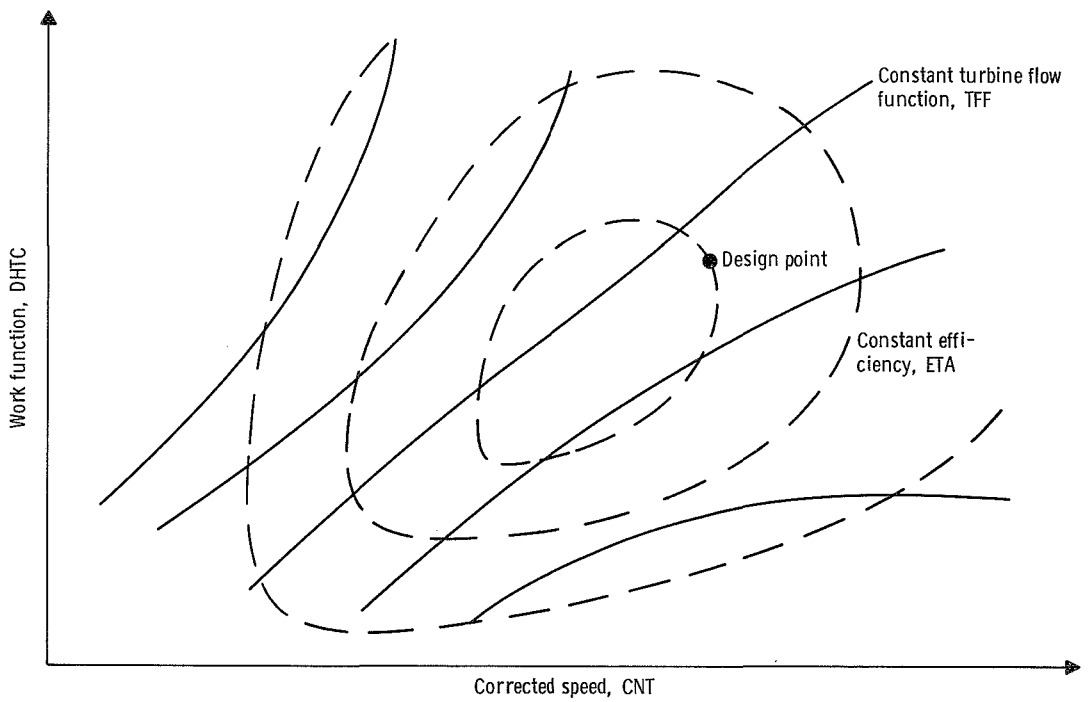
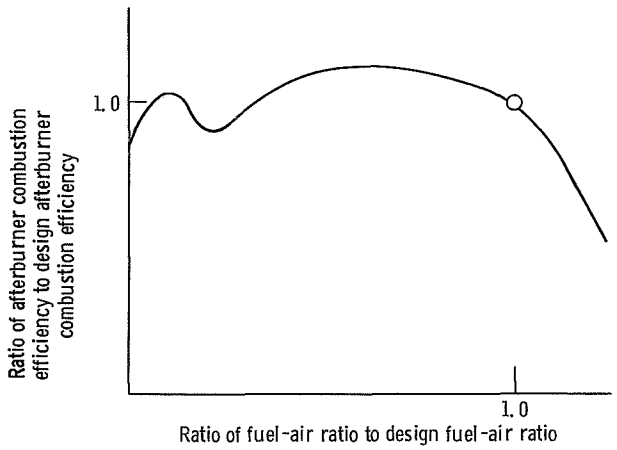
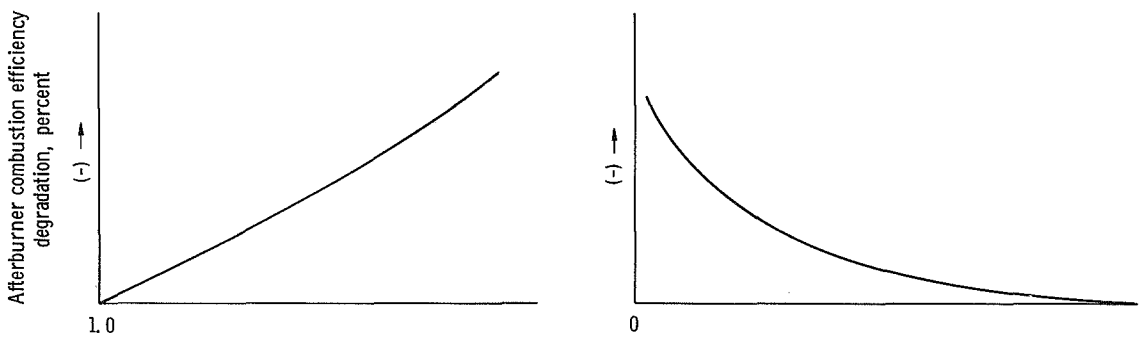


Figure 8. - Example of specific turbine map.



(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 ratio.

Figure 9. - Example of a generalized afterburner combustion efficiency performance map.

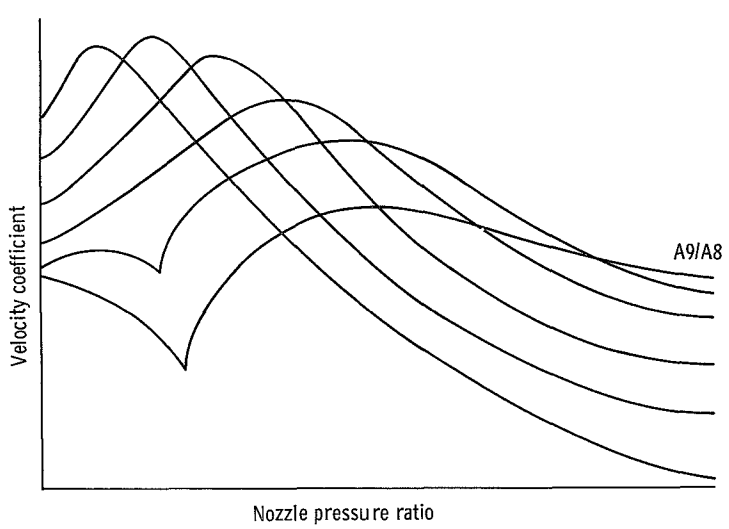


Figure 10. - Performance map for nozzle, giving velocity coefficient.

NASA-Langley, 1972 —— 28 E-5867

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