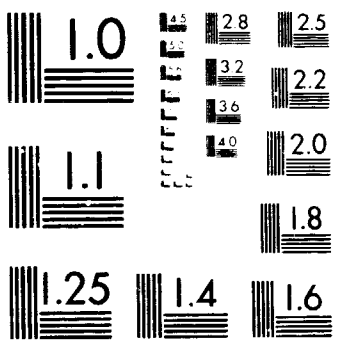
1 OF 2

N79 20159 UNCLAS



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963-A

(NASA-CR-161184) AIR BREATHING ENGINE/ROCKET TRAJECTORY OPTIMIZATION Final Report, 1 Oct. 1978 - 28 Feb. 1979 (Tennessee Univ. Space Inst., Tullahoma.) 189 p HC A09/MF A01 CSCL 22A G3/12

N79-20159

Unclas 17073

AIR BREATHING ENGINE/ ROCKET TRAJECTORY OPTIMIZATION

FINAL REPORT

THE UNIVERSITY of TENNESSEE
SPACE INSTITUTE

Tullahoma, Tennessee

ORIGINAL PAGE IS
OF POOR QUALITY

AIR BREATHING ENGINE/ ROCKET TRAJECTORY OPTIMIZATION

FINAL REPORT

Prepared for

George C. Marshall Space Flight Center

Marshall Space Flight Center, AL 35812

Under Contract

NAS8-33225

Report of Effort During

October 1, 1978 to February 28, 1979

Dr. Virgil K. Smith, III

Principal Investigator

February 28, 1979

The University of Tennessee Space Institute

Tullahoma, Tennessee 37388

FOREWORD

The investigation reported herein was conducted at The University of Tennessee Space Institute under the sponsorship of the National Aeronautics and Space Administration (NASA) Marshall Space Flight Center under contract NAS8-33225. The NASA Principal Representative for the effort was Mr. David Mercier.

The investigation was conducted by Dr. Virgil K Smith, III, Principal Investigator using the computing facilities of The University of Tennessee Space Institute and The University of Tennessee at Knoxville. The Principal Investigator was assisted in this research by Mr. Muftah Abujelala and Mr. C. Lee Cochran, graduate students at UTSI.

Assistance in providing the basic QNEP engine code and answering many questions concerning its modification were provided by Mr. Stanley Shapiro and Mr. Mike Caddy of the Naval Air Development Center, Warminster, Pennsylvania.

ORIGINAL PAGE IS
OF POOR QUALITY

ABSTRACT

Advanced horizontal take-off orbital launch vehicles feature combined air-breathing and rocket propulsion systems. In order to maximize the payload boosted to orbit, an optimization technique is required to define the proper engine sequencing over the flight trajectory. This research has focused on improving the mathematical models of the air-breathing propulsion systems, which can be mated with the rocket engine model and incorporated in trajectory optimization codes.

Improved engine simulations provide accurate representation of the complex cycles proposed for advanced launch vehicles, thereby increasing the confidence in propellant use and payload calculations. The versatile QNEP (Quick Navy Engine Program) has been modified to allow treatment of advanced turboaccelerator cycles using hydrogen or hydrocarbon fuels and operating in the vehicle flowfield. These modifications of the engine code have been exercised along with typical installational loss schedules to demonstrate the utility of the code for turbofan, augmented turbofan and ramjet engine cycles.

Recommendations have been included for incorporation of analytical models of additional, turboaccelerator features in the QNEP code. This improved engine code will provide a versatile, flexible engine model, both for incorporation in accurate trajectory analyses and for assessment of advanced propulsion concepts.

TABLE OF CONTENTS

SECTION	PAGE
ABSTRACT	iii
INTRODUCTION	1
OBJECTIVE	3
RESULTS AND DISCUSSION	5
A. Basic QNEP Model	5
B. Turboaccelerator Cycles	6
C. Installational Effects	10
1. Vehicle Flowfield Effects	10
2. Inlet and Nozzle Afterbody Effects	15
D. Hydrogen Combustion Model	38
E. Modified QNEP Code Application	50
CONCLUSIONS AND RECOMMENDATIONS	60
REFERENCES	61
APPENDICES	67
A. Users' Guide	A.1.
B. Modified QNEP Engine Code Program Listing	B.1.
C. Sample Input and Output	C.1.

ORIGINAL PAGE IS
OF POOR QUALITY

LIST OF FIGURES

FIGURE PAGE

1. Engine Schematic, Mixed Flow, Dry Turbofan 7
2. Engine Schematic, Mixed Flow, Aft Fan, Dry or Augmented 8
3. Engine Schematic, Ramjet 9
4. Engine Installational Considerations 11
5. Subroutine INLET Logic Sequence 14
6. Installational Effects on Augmented Turbofan Performance; $\delta = 10^{o}$ 16
7. Installational Effects on Augmented Turbofan Performance; $\delta = 10^{o}$ 17
8. Typical Effect of Inlet Spillage on Subsonic Specific Fuel Consumption (SFC) 19
9. Pressure Recovery Schedule 22
10. Spillage Drag Coefficient Schedule 23
11. Inlet Performance Effects on Augmented Turbofan Performance; $\delta = 10^{o}$ 25
12. Inlet Performance Effects on Augmented Turbofan Performance; $\delta = 10^{0}$ 26
13. Typical Turboaccelerator Nozzle Requirements and Performance 29
14. Nozzle Internal and External Performance Schedules . . 32
15. Nozzle Performance Effects on Augmented Turbofan Performance; $\delta = 10^{o}$ 34
16. Nozzle Performance Effects on Augmented Turbofan Performance; $\delta = 10^{o}$ 35

FIGURE PAGE

17. Combined Installational Effects on Augmented Turbofan Engine Performance; $\delta = 10^{\circ}$ 36

18. Combined Installational Effects on Augmented Turbofan Engine Performance; $\delta = 10^{\circ}$ 37

19. Part-Power Installation Losses for Unaugmented Turbofan, M = 0.8, Altitude = 10973 m. (36,000') . . 39

20. Unaugmented Aft Fan Engine, Uninstalled vs. Installed Performance, H_2 Fuel 52

21. Unaugmented Aft Fan Engine, Uninstalled vs. Installed Performance, H_2 Fuel 53

22. Unaugmented Aft Fan Engine, Part-power Performance for Installed vs. Uninstalled, H_2 Fuel 54

23. Augmented Aft Fan Engine, Uninstalled vs. Installed Performance, H_2 Fuel 55

24. Augmented Aft Fan Engine, Uninstalled vs. Installed Performance, H_2 Fuel 56

25. Ramjet Engine, Uninstalled vs. Installed Performance, H_2 Fuel 57

26. Ramjet Engine, Uninstalled vs. Installed Performance, H_2 Fuel 58

LIST OF TABLES

TABLE PAGE

1. Comparison of Thermodynamic Models for Augmented Aft Fan Performance Calculation 46
2. Comparison of Thermodynamic Models for Ramjet Performance Calculation 48

LIST OF SYMBOLS

A_c = Inlet Caputre Area

A_{max} = Maximum Area of Nozzle Afterbody

A_∞ = Freestream Area

$C_{D_{Afterbody}}$ = Total Afterbody Drag Coeff.; $\frac{D}{q_\infty A_{max}}$; Sum of $C_{D_{boattail}}$ and $C_{D_{base}}$

$C_{D_{boattail}}$ = Boattail Drag Coeff.

$C_{D_{base}}$ = Base Drag Coeff.

C_{D_S} = Spillage Drag Coef.

FN = Engine Net Thrust

M_∞ = Freestream Mach No.

TSFC = Thrust Specific Fuel Consumption

δ = flow deflection angle

Θ oblique shock wave angle

γ = ratio of specific heats

INTRODUCTION

The challenge of transporting large quantities of payload into orbit has produced a number of innovative space transportation systems [1,2]. Several of the current concepts for advanced orbital launch vehicles feature horizontal take-off, winged craft, powered by combined air-breathing and rocket propulsion systems [2,3,4]. These combined propulsion systems are used in order to exploit the high thrust and specific impulse of air-breathing systems at low altitudes, while reserving the use of the higher thrust, lower specific impulse rocket engines at higher altitudes. In order to maximize the payload boosted into orbit, optimization techniques must define the proper sequencing.

Numerous techniques for flight trajectory optimization currently exist, including NSEG, A Segmented Mission Analysis Program for Low and High Speed Aircraft [5], the Program to Optimize Simulated Trajectories (POST), [6], and the Rutowski Energy Method [7]. The treatment of the propulsion systems in these trajectory calculation methods are limited to scaling of tabulated or generalized engine data. Hence, these approaches are dependent upon flexible engine codes to accurately treat the complex "turboaccelerator" cycles which are common for advanced orbital launch vehicles. These composite engines generally feature both variable geometry and variable operating modes [8,9, 10,11,12]. The variations in engine geometry are usually found in the inlet, ducting, nozzle and compression systems; it is likely that the turbine system will also require geometry

variability over the wide operating range demanded in turbo-accelerator engines. It is also usual for these engines to feature several operating modes, including turbomachinery cycles, thrust augmentation by duct burning or afterburning, ramjet, regenerative cooling, expander cycles, ejectors and other exotic techniques. It is apparent that turboaccelerator cycles can have many possible cycle combinations and much variability.

Therefore, in order to have confidence in trajectory optimization involving these propulsion systems, one must use engine analytical models with a high degree of fidelity to the physical processes and cycle variability being modeled. Only then can one expect to adequately define the performance lapse rate of the engine, its off-design performance variation, and the vehicle/engine installational effects. Since most turbo-accelerators utilize hydrogen fuel, it is also important that the model incorporate the thermodynamic properties for this fuel.

A recent analysis of the state-of-the-art in engine modeling techniques and the associated analysis methods [13] revealed that two versatile engine modeling codes - NEPCOMP (Navy Engine Performance Computer Program) [14] and NNEP (Navy-NASA Engine Program) [15] offer the most complete capabilities for treating turboaccelerator cycles. Yet, even these current codes do not incorporate several of the most important features of the advanced air-breathing cycles. As noted earlier, most turbo-accelerators utilize hydrogen fuel, along with variable geometry inlets and nozzles. In addition, the engine typically utilizes

the compression field about the aircraft as its inlet flow field. Thus, in order to have a high fidelity simulation of the installed engines, these features must be treated by the cycle model. Incorporating these features provides an improved tool for optimizing and validating both the propulsion cycle selection and the propulsion system phasing and, therefore, allows optimization of the propellant consumed and the mass boosted to orbit.

OBJECTIVE

The objective of this research was to incorporate in the QNEP engine code, which is a derivative of the versatile NEPCOMP program, several new capabilities to allow detailed, high fidelity analysis of installed composite air-breathing propulsion systems. Specifically, the research utilized the QNEP engine code as the baseline simulator and incorporated the following new capabilities and test cases: (1) extension of the inlet subroutine to calculate the engine performance when operating in the vehicles' compression and expansion field and application of the modified program to typical turboaccelerator cycles; (2) identification, based upon a literature survey, of typical schedules for inlet spillage drag losses and nozzle afterbody drag losses and application of these loss schedules to typical turboaccelerator cycles; (3) extension of the program to allow simulation of hydrogen fuel; and (4) application of the expanded QNEP program, including the hydrogen model, the installational losses and the vehicle flowfield effects to typical turboaccelerator building block

cycles. The results from each of these areas are discussed in the following sections. Additional developments that are required to improve the degree of fidelity of the engine models and to improve their application have been identified.

RESULTS AND DISCUSSION

This investigation has resulted in improved techniques for assessing propulsion system performance of advanced orbital launch vehicles. These techniques will greatly assist optimization of the flight trajectories of these craft.

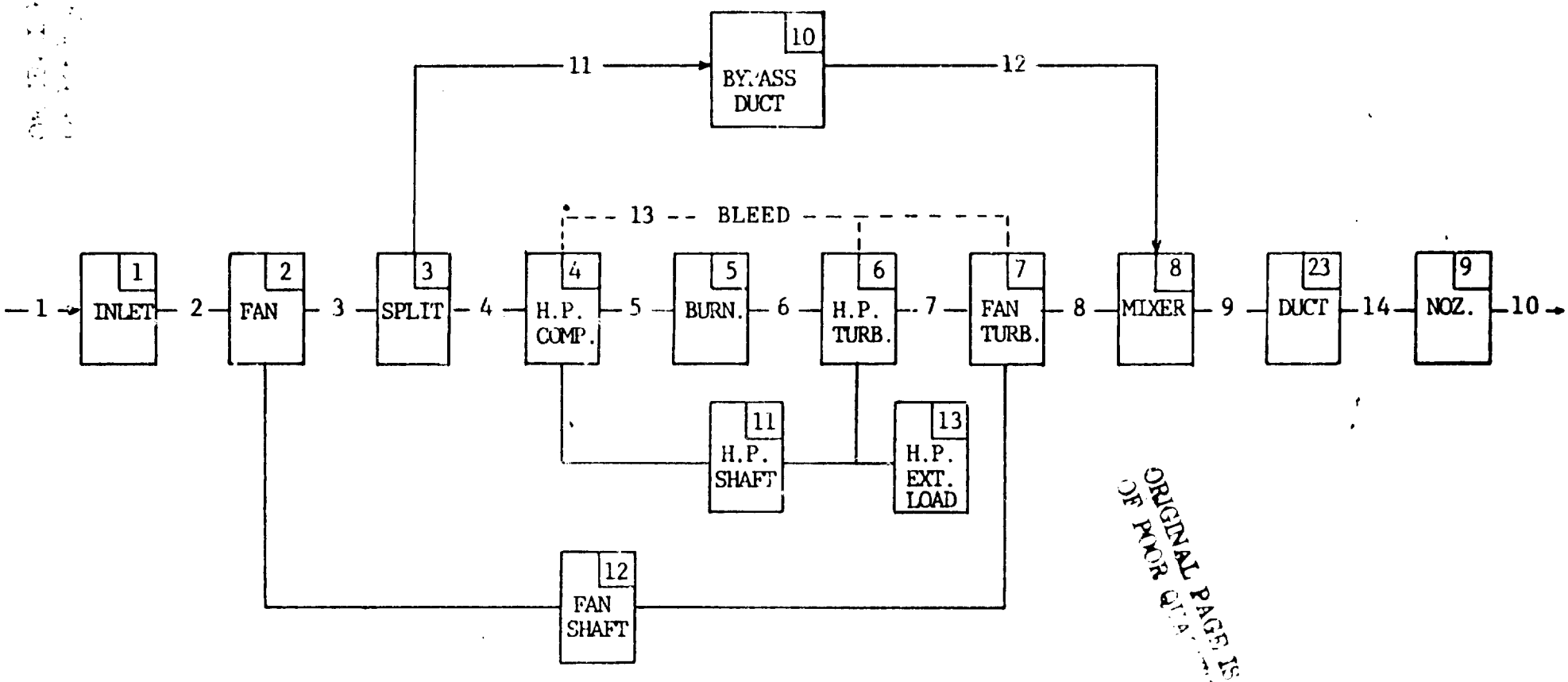
A. Basic QNEP Model. Initial execution of the basic QNEP program on the IBM 360/370 revealed that insufficient data fidelity was present in the single precision version to provide the required convergence accuracy for design point and off-design point engine calculations. This results because the basic word length for the IBM unit is 32 bytes, while the CDC 6600 (for which the program was originally written) has a 60 byte word length. Thus, the CDC 6600, like the Univac 1108, provides good data fidelity and sufficient accuracy for the convergence logic when configured for single precision execution.

Following conversion of the basic QNEP code to double precision, the engine code was exercised on the IBM 360/370 over a wide range of engine design point and off-design point calculations. The data cases revealed the same convergence accuracy as the single precision versions.

The basic QNEP program has been written for the customary engineering units and most calculations have been carried out in this system. The results have been converted to SI units, which are stated first in this report. The customary engineering units are stated afterwards, in parentheses.

B. Turboaccelerator Cycles. There are numerous turboaccelerator cycle configurations which have been proposed for application to orbital launch vehicles [3,4,8,9,10,11,12]. In most cases, these composite cycles are combinations of the turbojet, turbofan, augmentor or ramjet cycles which are activated sequentially over different portions of the launch and recovery mission. The turboaccelerator chosen for analysis with the improved QNEP model is a turboramjet, or, more basically, an afterburning mixed-flow turbofan. A valving system is utilized whereby the inlet airflow is directed either totally into the fan duct or into both the fan and core flow passages. For flight Mach numbers up to 3.5, the engine operates as a turbofan engine, utilizing afterburning for take off and for acceleration up to a Mach number of 3.5. For subsonic cruise after take off and on the return mission, the turbofan operates unaugmented. Above a Mach number of 3.5 the engine functions as a subsonic combustion ramjet, using the afterburner as the combustor.

To demonstrate the application of the improved QNEP program to these multiple engine operating modes, several "building block" engine configurations were exercised using the modified QNEP program. These included design and off-design point performance for typical twin-spool turbofans, twin-spool aft fans, augmented turbofans and ramjets. Schematics of these building block cycles, showing the flow station and component identification numbers which were used in the application of QNEP, are displayed in Figures 1 - 3.



ORIGINAL PAGE IS OF POOR QUALITY

Figure 1. Engine Schematic - Mixed Flow, Dry Turbofan.

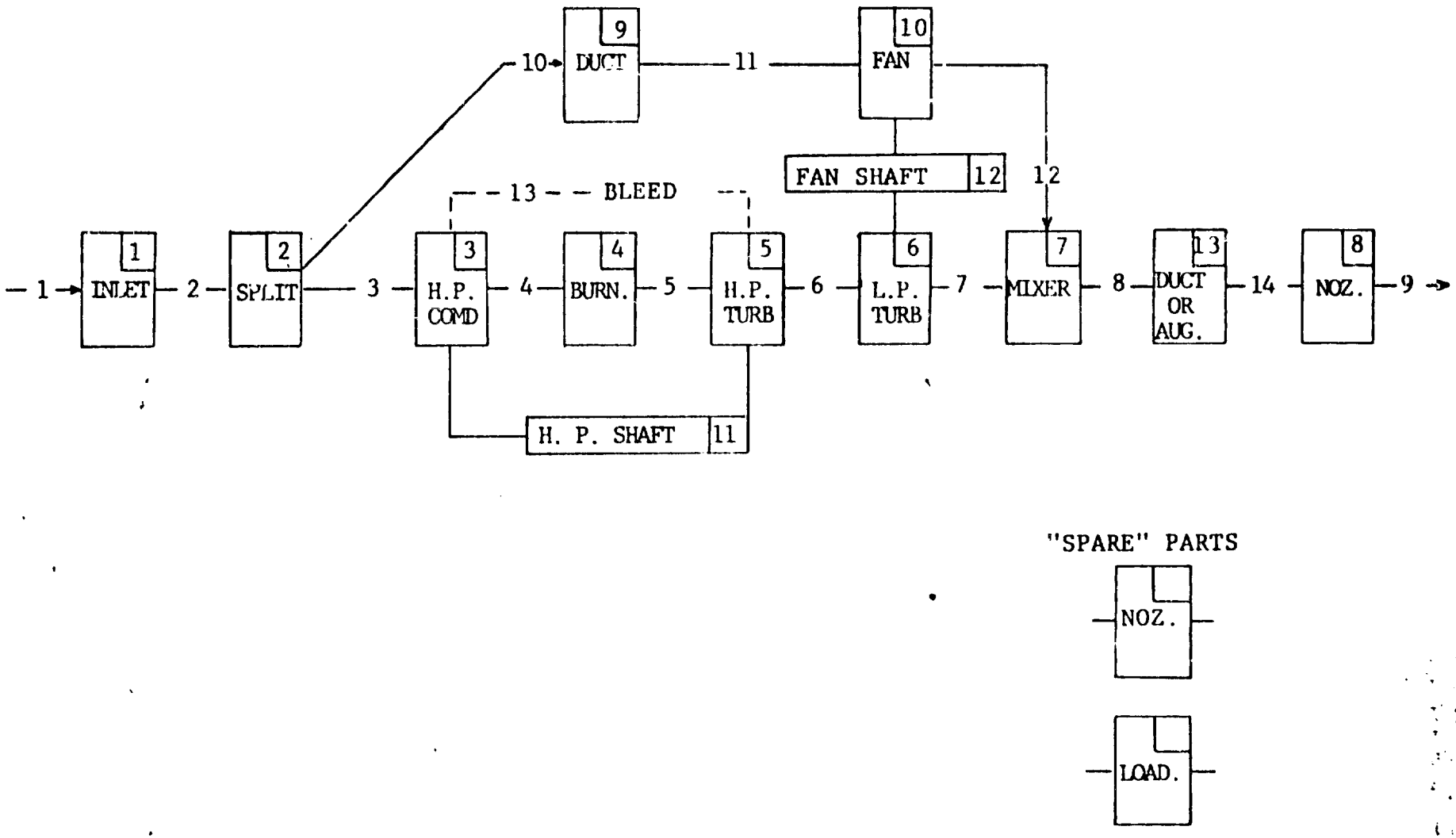


Figure 2. Engine Schematic, Mixed Flow, Aft Fan, Dry or Augmented.

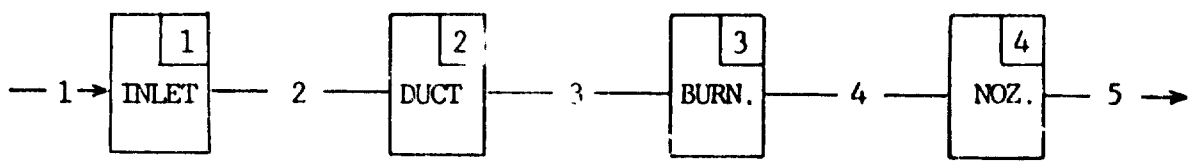


Figure 3. Engine Schematic - Ramjet

The ease of modifying these building block configurations is typified by the augmented aft fan configuration shown in Figure 2. Alternate configurations can be constructed by adding or subtracting components. For example, from this mixed flow turbofan engine, a separate flow turbofan can be configured by selecting another nozzle from the "spare parts" supply and by separating the flow accordingly.

C. Installational Effects. Exclusion of installational effects from the calculation of engine performance can yield unrealistic results. The QNEP code was modified to allow inclusion of additional installational influences and typical installation loss schedules were identified for application to the building block cycles.

1. Vehicle Flowfield Effects. A mathematical model was formulated and a subroutine constructed to allow the influence of vehicle forebody compression and afterbody expansion to be incorporated into QNEP. The model incorporates several operating modes since the aircraft/engine flow field depends upon the location of the engine on the vehicle. As shown in Figure 4, the major influence of these installational considerations is the flow field surrounding the engine inlet and exhaust field. In contrast to the operation of the inlet without flow turning (Case A), the turning provided by the forebody to the incident supersonic flow field results in an increase in pressure and density downstream of the oblique shock. This flow field surrounds the inlet, providing a high pressure and high-density flow field

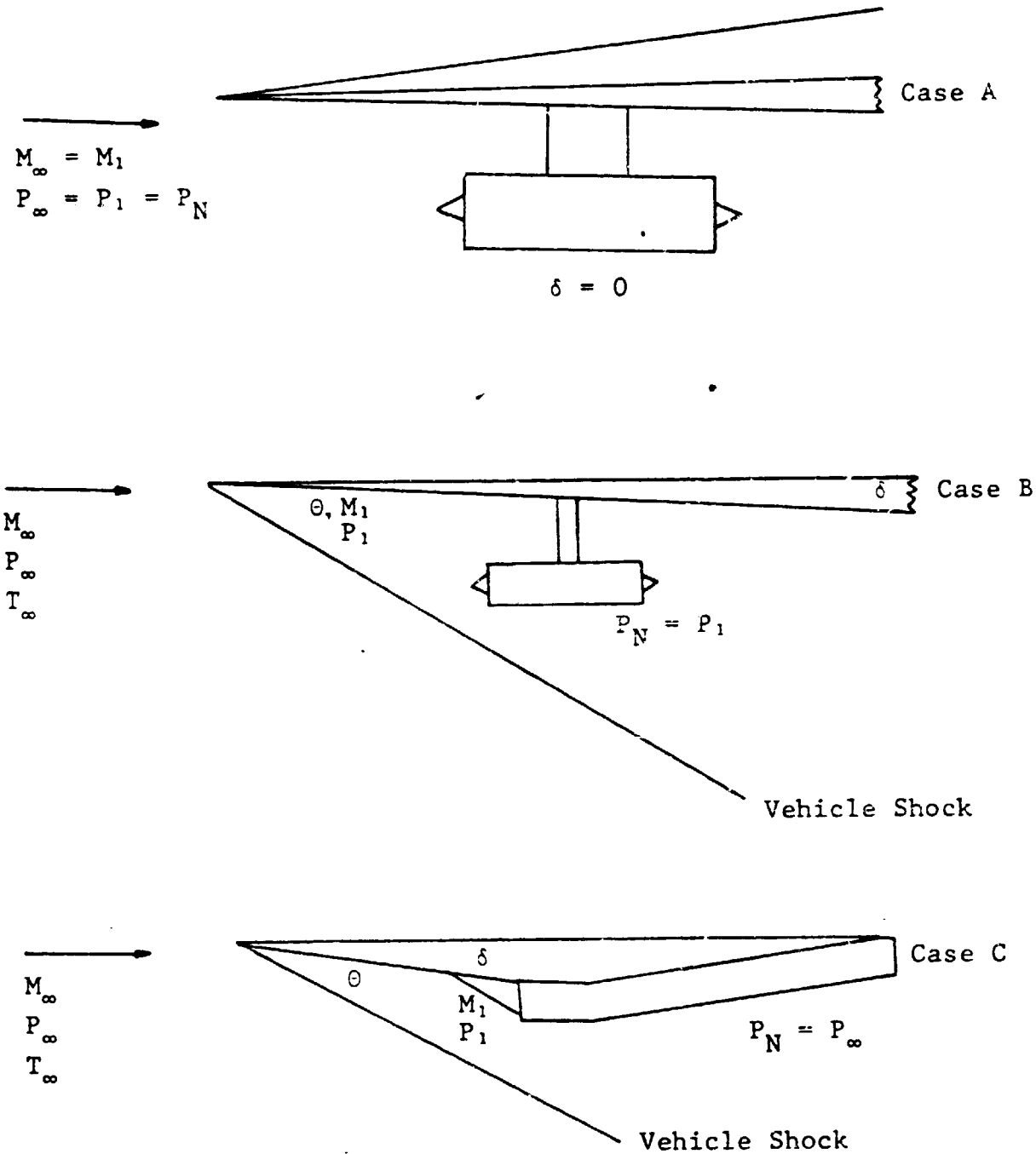


Figure 4. Engine Installational Considerations

from which the engine draws its mass flow.

The location of the engine on the vehicle determines the extent that the rest of the engine, and in particular, the nozzle, is also exposed to the high pressure flow field (Case B and C). The placement of the engine on the mid-to-forward portion of the winged vehicle (Case B) implies that the nozzle will be exhausting into the high pressure field; however, an engine placement on the aft reaches of the vehicle (Case C), yields a nozzle flow/external flow field interaction at essentially ambient conditions. This ambient field results from flowfield expansion over the aft surfaces of the vehicle and engine.

Therefore, the major objective of the mathematical model of the vehicle flowfield is to provide definition of the conditions existing downstream of the shock created by the forebody. Exact definition of these conditions can be very complex since the shock field is dependent upon the specific vehicle geometry. However, since typically the major forebody feature preceding the engine is the vehicle's wing, it can be assumed that the flow turning is essentially two-dimensional (2-D). Hence, the 2-D oblique shock relations are available for treating the flow.

The usual analysis of 2-D supersonic turning involves the use of compressible flow tables and charts (e.g., NACA 1135). However, for the engine model it was deemed desirable to use the analytical description of this flowfield, rather than using interpolation of stored data tables. Thus, the equations describing an oblique shock field were assembled for coding. In addition,

it was desired that only the incident Mach number, M_∞, and the flow turning angle, δ, be specified as inputs, thereby freeing the analysis from dependence upon the oblique shock charts for determination of the shock angle, Θ. However, the equation describing the flow field can not be solved explicitly for Θ.

$$\tan \delta = 2 \cot \Theta \left(\frac{M_\infty^2 \sin^2 \Theta - 1}{M_\infty^2 (\gamma + \cos 2\Theta)} \right) + 2$$

Hence, a numerical solution utilizing the Newton-Raphson method was used to solve the relationship for the shock angle based upon inputs of Mach number and flow deflection angle [16]. This numerical approach has demonstrated excellent stability over the Mach number and turning angle range of interest ($1.0 < M \leq 10.$, $0^\circ < \delta \leq 40^\circ$).

The mathematical model describing the flowfield changes across the oblique shock has been incorporated in subroutine INLET of the QNEP program. The logic for the modified subroutine is shown in Figure 5. If the user desires that the engine performance calculation incorporate the influence of the vehicle flowfield, the flow deflection angle is input in the inlet NAMELIST data by control statement CDAT (15, JCX), where JCX is the component number of the inlet. (If the combination of Mach number and flow deflection angle inputs produces a detached shock, an error message is generated and the performance calculation is made with $\delta = 0^\circ$.) . If the engine is located such that the nozzle exhausts to ambient conditions (Case C), the control

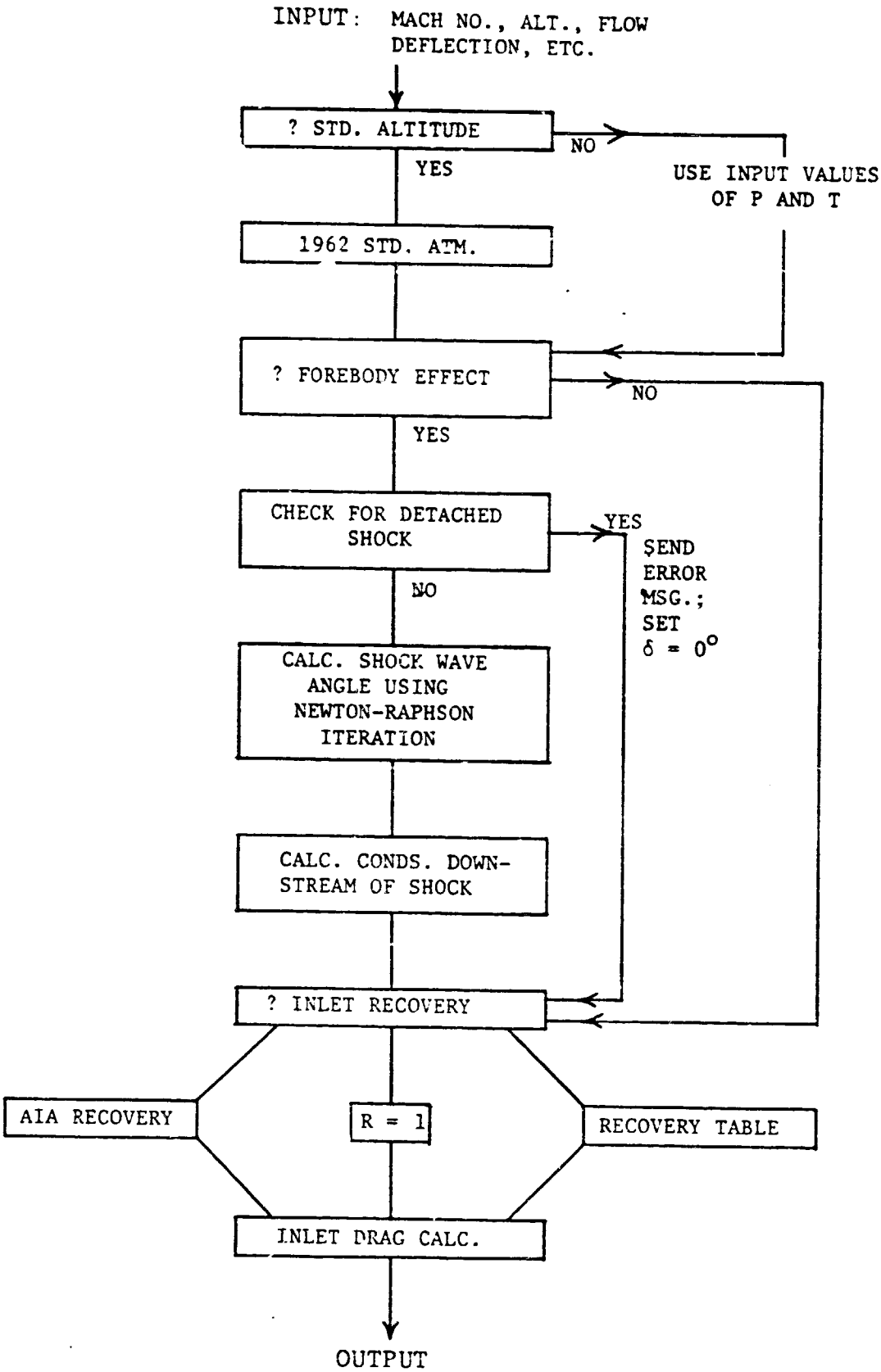


Figure 5. Subroutine INLET Logic Sequence

ORIGINAL PAGE IS
OF POOR QUALITY

statement CDAT (14,JCX) should be input as 1.; if the nozzle exhausts to the forebody shock field (Case B), CDAT (14,JCX) should be input as 0. If the engine is not under the influence of a forebody flowfield (Case A), CDAT (15,JCX) input as 0. will bypass the forebody effect logic.

An example of engine performance calculations with the different forebody flowfield modes and engine location is provided in Figures 6 and 7. The variation in thrust and thrust specific fuel consumption for Cases A, B and C are displayed over a typical altitude and Mach number range for an augmented turbofan engine. A nominal flow deflection angle of 10° was assumed. Both of the performance parameters of these figures reveal the significant decrease in performance which results from the engine inlet and exhaust nozzle in the shock field (Case B); yet, for the engine inlet in the shock field and the exhaust nozzle in the free stream (Case C), a significant performance increase results.

2. <u>Inlet and Nozzle Afterbody Effects</u>. To enable meaningful mission analyses to be conducted on the turboaccelerator engine, installed performance for each of the building block engines was generated considering the drags associated with a typical inlet and afterbody over the flight regime of the engines. Both inlet spillage drag and nozzle afterbody drag were considered in the calculation of the throttle-dependent installation drags associated with the engines. Both of these drag results were based

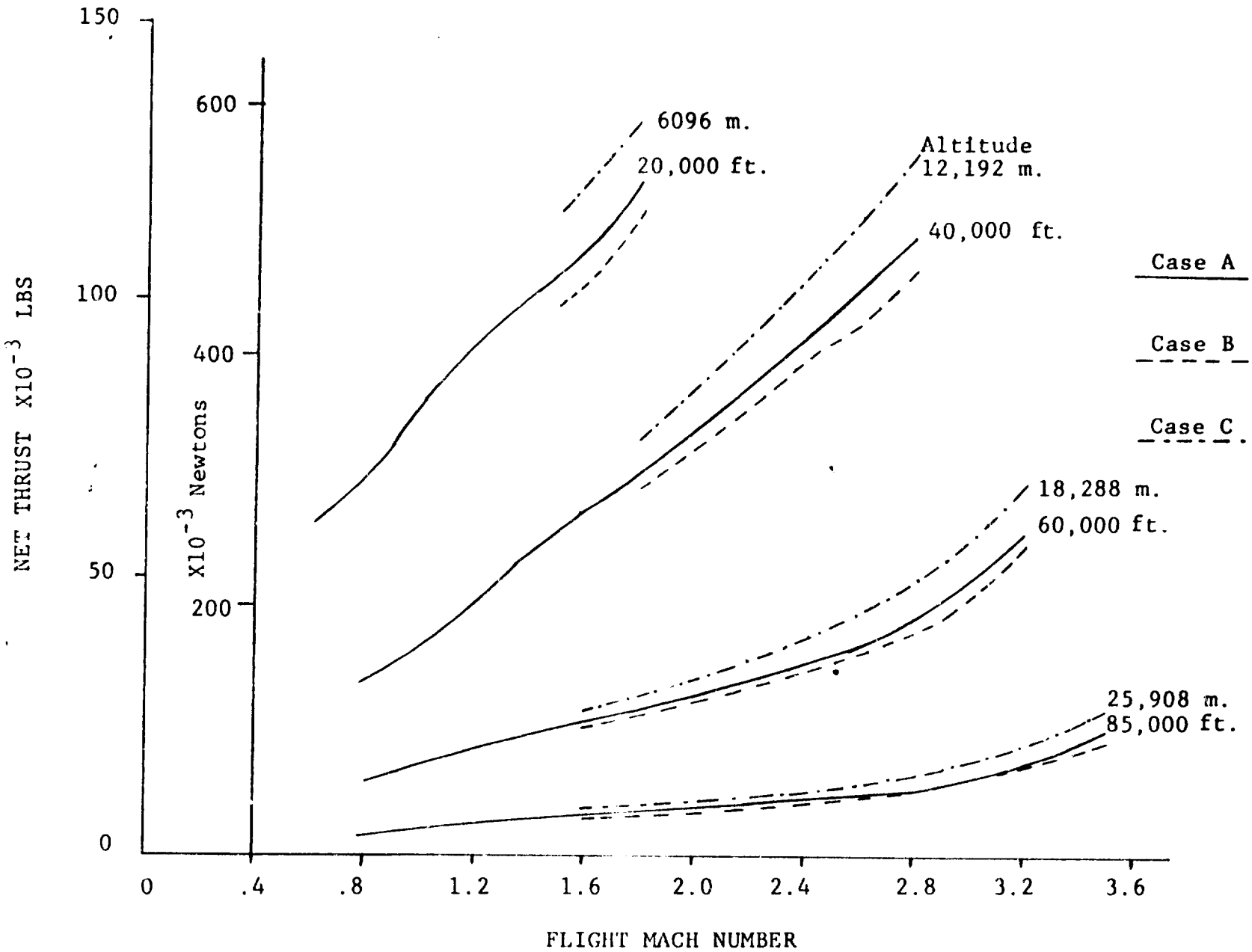


Figure 6. Installational Effects on Augmented Turbofan Performance; $\delta=10^{o}$.

ORIGINAL PAGE IS OF POOR QUALITY

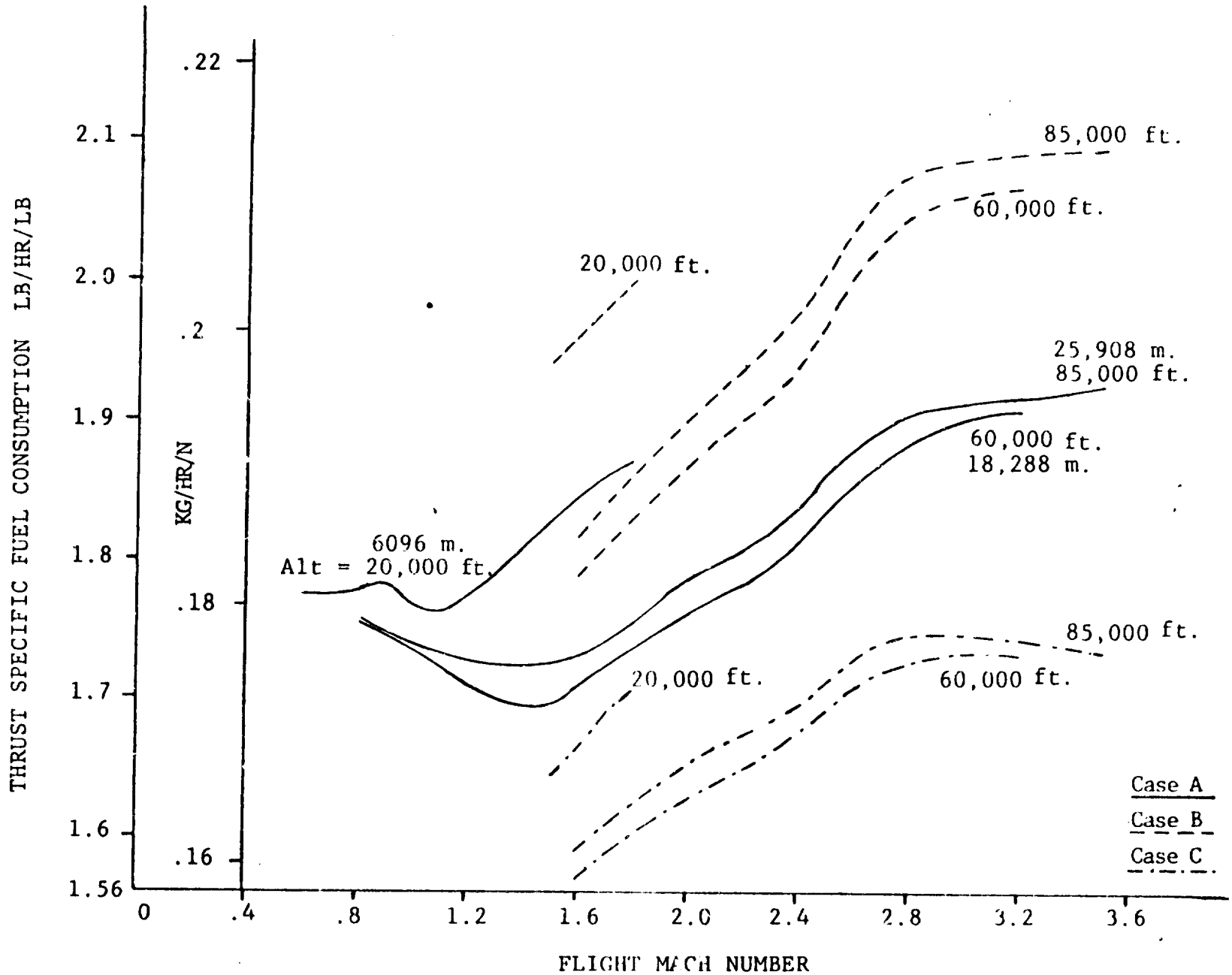


Figure 7. Installational Effects on Augmented Turbofan Performance; $\delta=10^{o}$.

upon an isolated nacelle. Any interference effects of nacelle placement on throttle-dependent drags were not considered, since these effects are a function of a specific vehicle design and are beyond the scope of this study. (Upon selection of a given vehicle configuration, the integrated inlet and nozzle losses can be determined and used in QNEP in the same manner that the isolated nacelle results are used. The data requirements are defined below.)

The inlet spillage and nozzle afterbody drags are a strong function of the particular vehicle mission-especially the maximum Mach number. As evidenced in Figure 8, a more simplified, lower design Mach number inlet is less sensitive to inlet-engine airflow mismatch during part power subsonic flight [17]. The potential losses for a turboaccelerator inlet, (M_{design} = 6-7) when operated at off-design conditions can prove disasterous to a vehicle's performance. In addition, higher Mach number vehicles require larger exhaust areas to be incorporated into the engine nozzles in order to produce maximum thrust. This results in relatively more nozzle closure and, hence, boattail drag during part power, dry operation.

Therefore, in collecting parametric data for inlet and nozzle performance for the composite propulsion systems which are applicable to single-stage-to-orbit vehicles, it is necessary to consider inlet and nozzle designs which provide acceptable cycle matching over the entire subsonic-to-hypersonic speed range. This eliminates, for example, the application in this study of

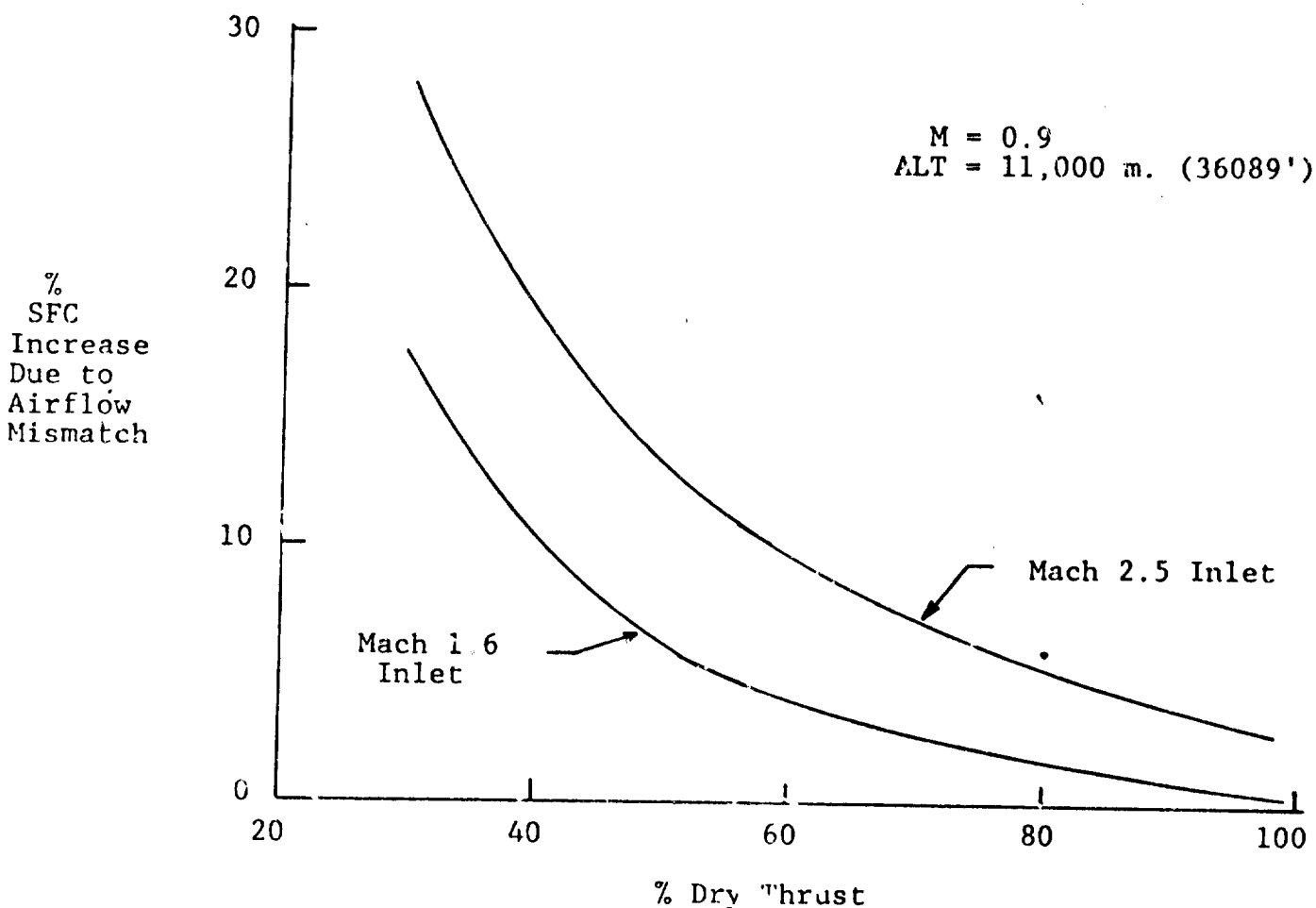


Figure 8. Typical Effect of Inlet Spillage on Subsonic Specific Fuel Consumption (SFC).

the vast multitude of data which has been accumulated for low supersonic [18,19], high supersonic [20,21,22,23,24] and hypersonic inlet designs [25,26,27,28]. However, limited data are available from composite propulsion system studies over the desired Mach number range [9,12,29,30].

The operation of a hypersonic inlet at less than its maximum mass flow ratio is often required in order to permit the air induction system to supply the correct airflow to the engine. This may occur because of throttling the engines or because inlet design requirements conflict for take-off, high subsonic cruise, and supersonic-to-hypersonic acceleration, therefore dictating a compromise in the inlet size. The amount of compromise depends entirely upon the particular vehicle, its mission, the engine types and the sophistication of the air induction system. When estimating the performance of such a vehicle operating at less than its supercritical mass flow, the inlet spillage drag must be included.

Spillage drag is defined as additive drag minus cowl suction [31]. It is a correction that is applied to engine net thrust to obtain net propulsive thrust. The cowl suction is largely a function of cowl shape for a given mass flow ratio, and acts in the thrust direction to cancel some portion of the additive drag. Additive drag can be thought of as "subtractive thrust", since it must be subtracted from engine net thrust to yield propulsive thrust.

The inlet design selected for this study was chosen from three different axisymmetric inlet systems examined by Bencze

and Sorensen [29] for application to turboramjet powered hypersonic cruise vehicles. The inlet data were selected from this source following an extensive examination of unclassified literature (approximately 200 references). These data were chosen because the Mach number range (0 - 6.0) compared closely to that proposed for orbital launch vehicles [4]. Also, the engine type assumed in the reference closely matches the turbo-accelerator cycles considered in the present study, and the previous investigation included inlets of various characteristics and sophistication.

The study of the three inlets indentified an optimum configuration based upon the range performance of a hypersonic cruise vehicle. The inlet pressure recovery schedule for this forward-translating-centerbody design is shown in Figure 9. The discontinuity in the schedule identifies the starting Mach number of the mixed compression inlet system. For Mach numbers greater than the starting Mach number, the recovery is the standard military specification schedule [32].

The schedule of inlet spillage drag coefficient C_{D_S} for the selected inlet as a function of mass-flow ratio and local Mach number is shown in Figure 10. The inlet spillage drag is non-dimensionalized by the local dynamic head and the inlet capture area. The data are based on a combination of experimental and theoretical results. The data points indicated by the individual symbols and the values at a mass flow ratio of unity were provided in the referenced paper. The value at intermediate

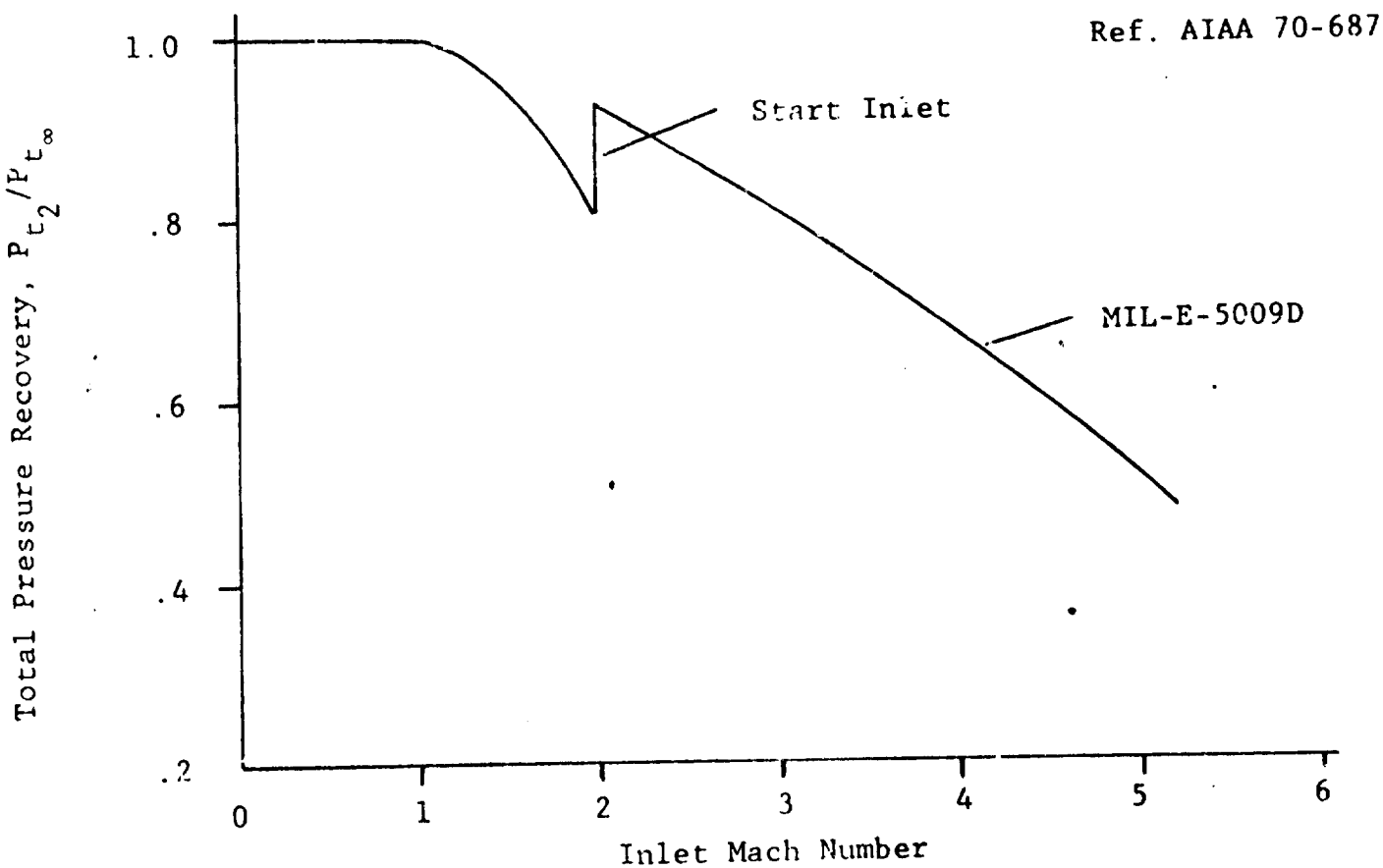


Figure 9. Pressure Recovery Schedule.

Ref. AIAA 70-687

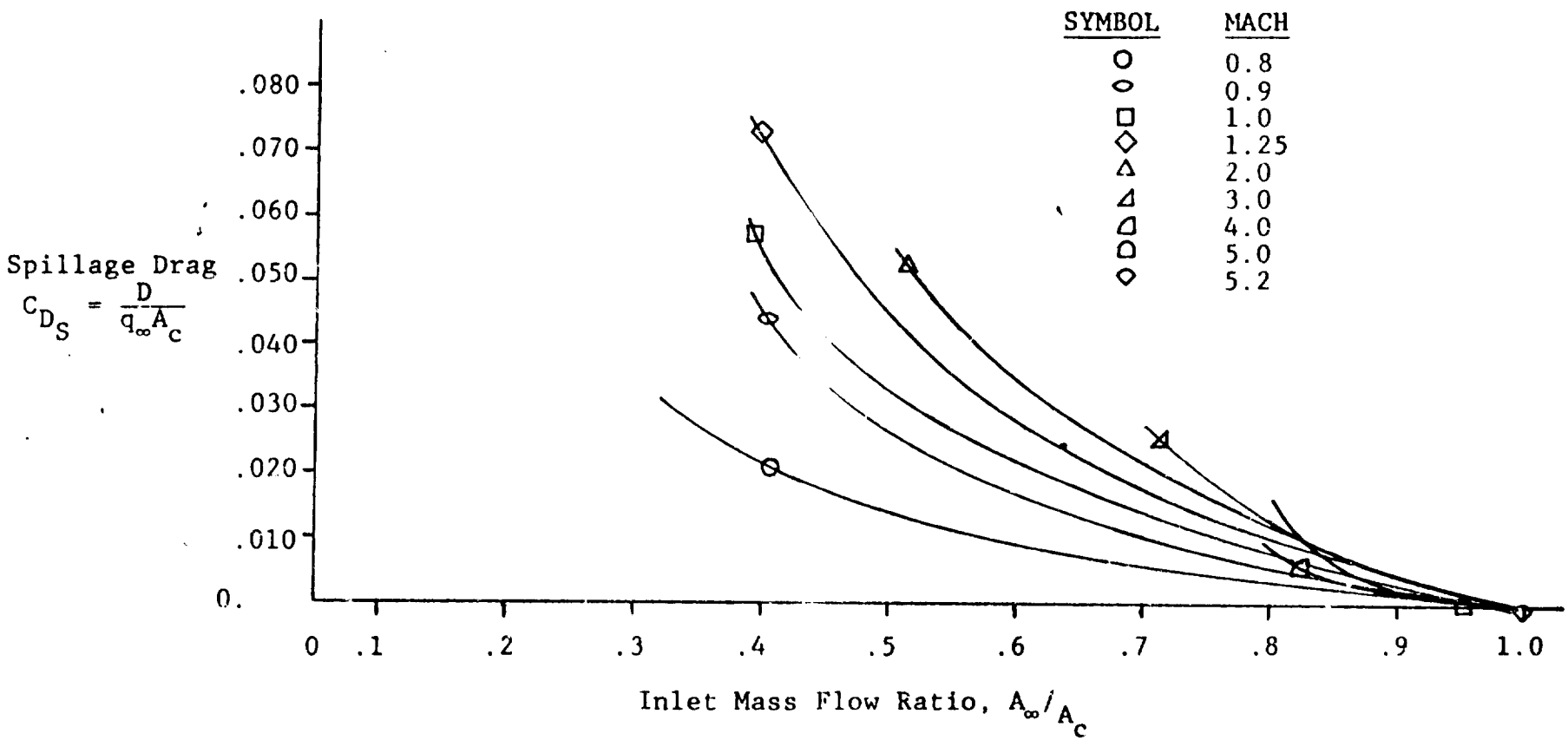


Figure 10. Spillage Drag Coefficient Schedule.

ORIGINAL PAGE IS
OF POOR QUALITY

mass flow ratios were approximated based upon trends noted for the spillage drag variations of similar inlets [21,22,27,31]. The results show the usual increase of spillage drag with decreasing mass flow ratio.

Application of these typical generalized hypersonic inlet data to the turboramjet cycles provides a refined estimate of propulsion system performance. Selection of a specific inlet/engine configuration for an orbital launch vehicle will provide inlet data which can be utilized in QNEP in an identical manner.

The results of applying these typical hypersonic inlet data to the augmented aft fan are shown in Figures 11 and 12. The "uninstalled" performance is based upon no spillage drag, standard inlet recovery [32], a flow deflection of 10° and expansion to ambient conditions. The "installed" performance incorporates the inlet recovery and spillage drag schedules discussed above. The impact of incorporating these inlet losses is to significantly lower the engine performance; failure to incorporate these installation effects can yield a significantly optimistic result.

The installed thrust of a propulsion system is also influenced by the difference between the nozzle thrust level and the overall afterbody and exhaust system drag. These installational effects are in addition to the inlet losses considered in the previous section. Ideally, thrust production is a function of the nozzle performance parameters, and drag production is a function of the aerodynamics of flow over the external body

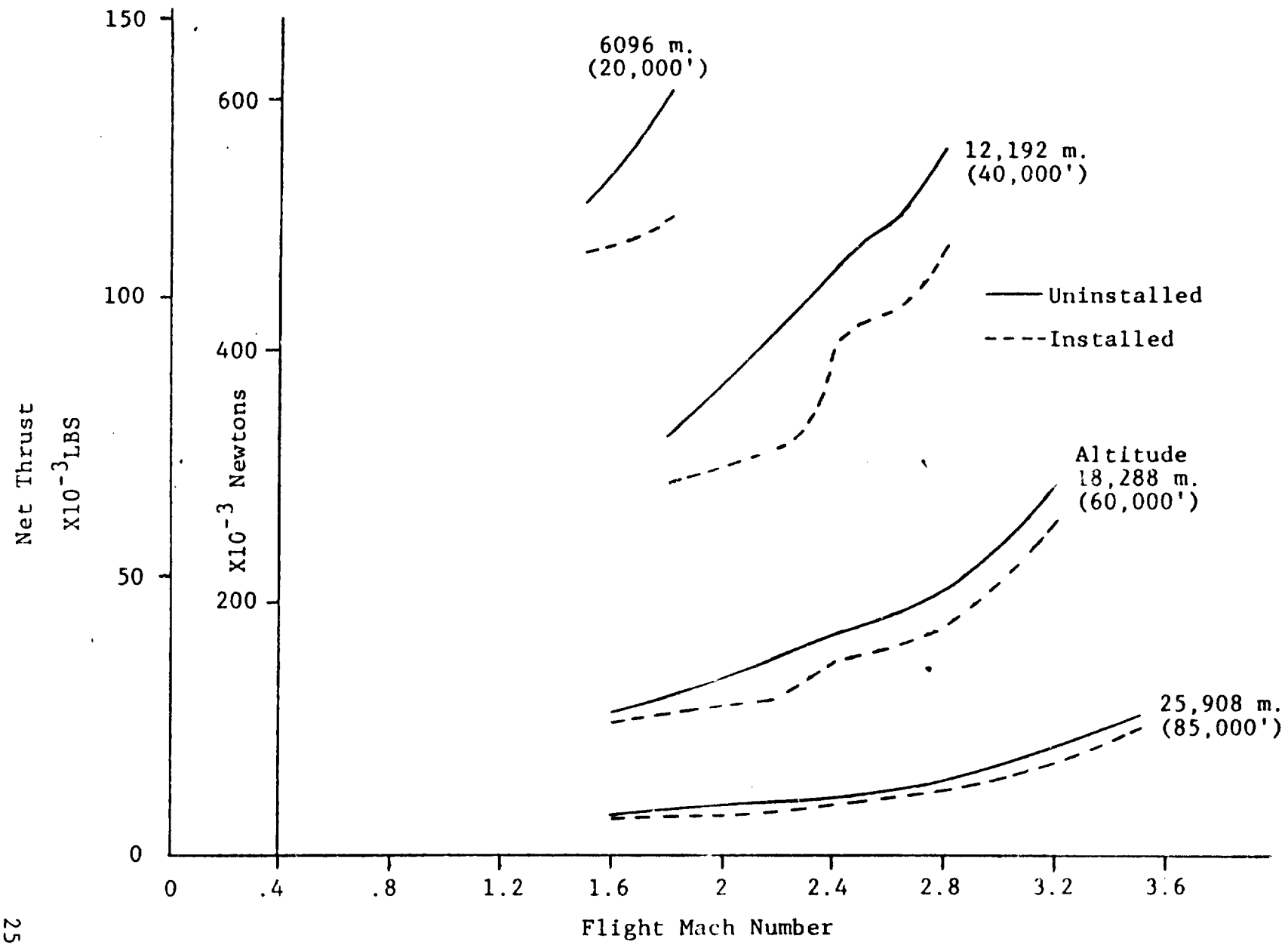


Figure 11. Inlet Performance Effects on Augmented Turbofan Performance; $\delta = 10^{o}$.

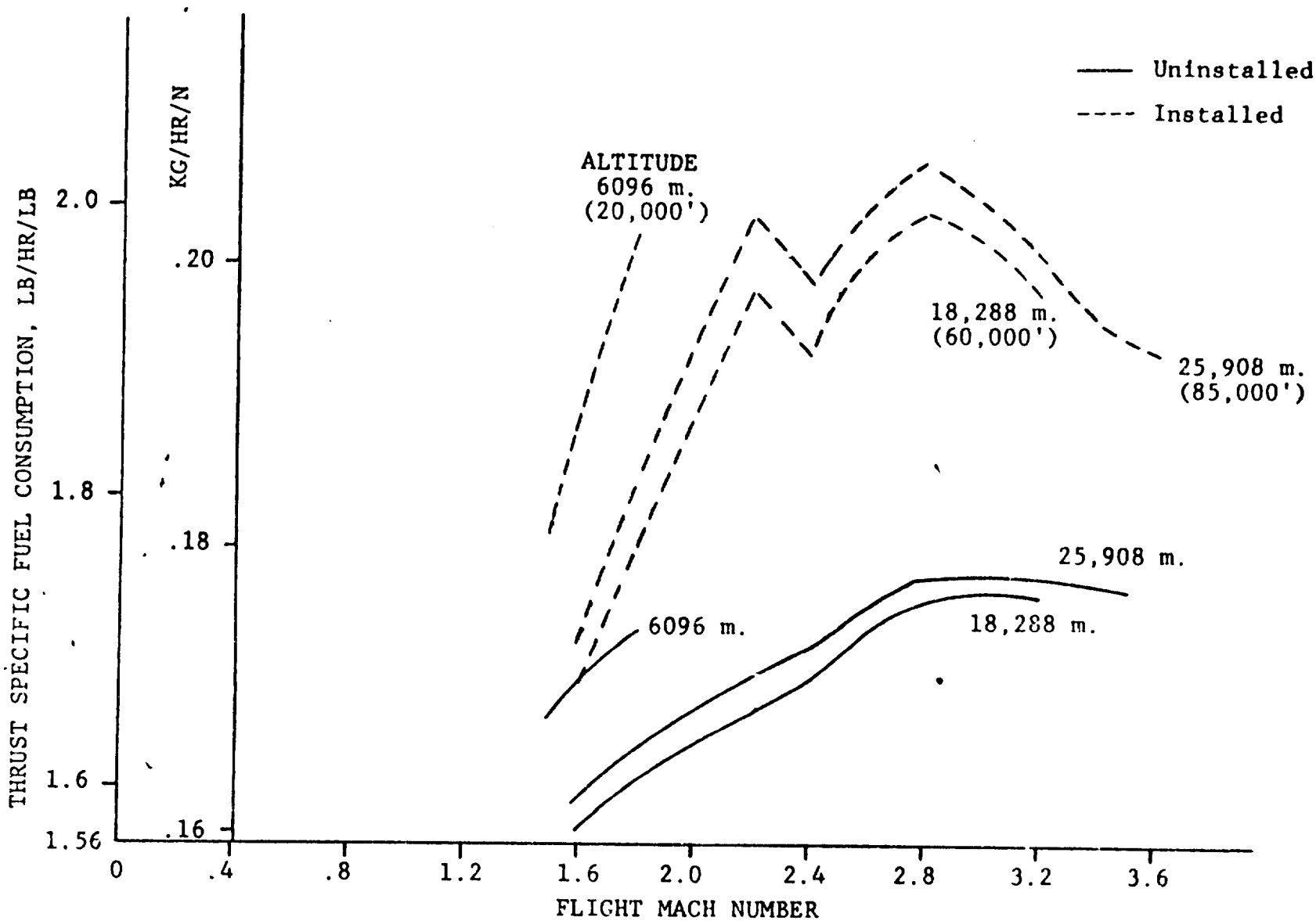


Figure 12. Inlet Performance Effects on Augmented Turbofan Performance; $\delta = 10^{o}$.

ORIGINAL PAGE IS
OF POOR QUALITY

surfaces. In reality, there exists a definite interrelationship between thrust and drag of the installed system due to the interaction of the external airstream with the exhaust stream discharged from the nozzle. Thus, the drag of the installed afterbody and the exhaust system combination is integrally dictated by both the aerodynamic efficiency of the external body geometry and by the interference effects caused by the presence of a thrust producing exhaust stream.

The primary sources of afterbody aerodynamic drag are the result of the viscous and inviscid nature of the external airstream over the afterbody surfaces and on any base surfaces [31]. The drag affecting afterbody surfaces can be considered to consist of skin friction and wave pressure drag components to account for the influence of the boundary layer and the potential flow field, respectively. The drag affecting base surfaces is most correctly classified as a pressure drag, although the fluid mechanisms which produce the pressure forces develop from strong viscous interaction of the total flow entering the base region from both the afterbody surfaces and the exhaust nozzle. As a consequence, base drag is known to depend appreciably upon boundary layer characteristics. Then, in order to determine the total drag of an afterbody and exhaust system, defined herein in coefficient form as,

$$C_{D_{afterbody}} = C_{D_{Boattail}} + C_{D_{Base}}$$

it is necessary to determine not only the Mach number and static

ORIGINAL PAGE IS
OF POOR QUALITY

pressure distributions along the entire length of both the external body surface and the nozzle wall, but also to have knowledge of the manner in which the boundary layer develops along each of these surfaces as well. Each drag component is referenced to the local dynamic head and the maximum cross-sectional area of the afterbody.

Because of the mission and cycle variations of composite propulsion systems, the nozzle systems of these devices will require large variations in pressure ratio and, hence, will require capabilities for large area ratios [9,30,33,34,35]. This trend is illustrated in Figure 13. Yet, large nozzle exit areas will result in large drag increments [30,36,37,38]. This requires a compromise between maximum propulsion efficiency and engine installation drag. In order to provide this compromise, it is likely that the turboaccelerator nozzle that will be utilized in isolated nacelles will be a variable geometry design of either the plug or expansion-deflection type [10,11,33,39,40,41]. With the incorporation of variable geometry, these types of nozzles provide both control of the nozzle throat area (through a translating and/or collapsing centerbody) and the throat-to-exit area ratio, while retaining a fixed shroud and nozzle exit diameter. These features provide the large nozzle area variations required of composite propulsion systems over the subsonic to hypersonic speed range.

However, the data on these nozzle types which is available in the open literature is very limited. The results are generally

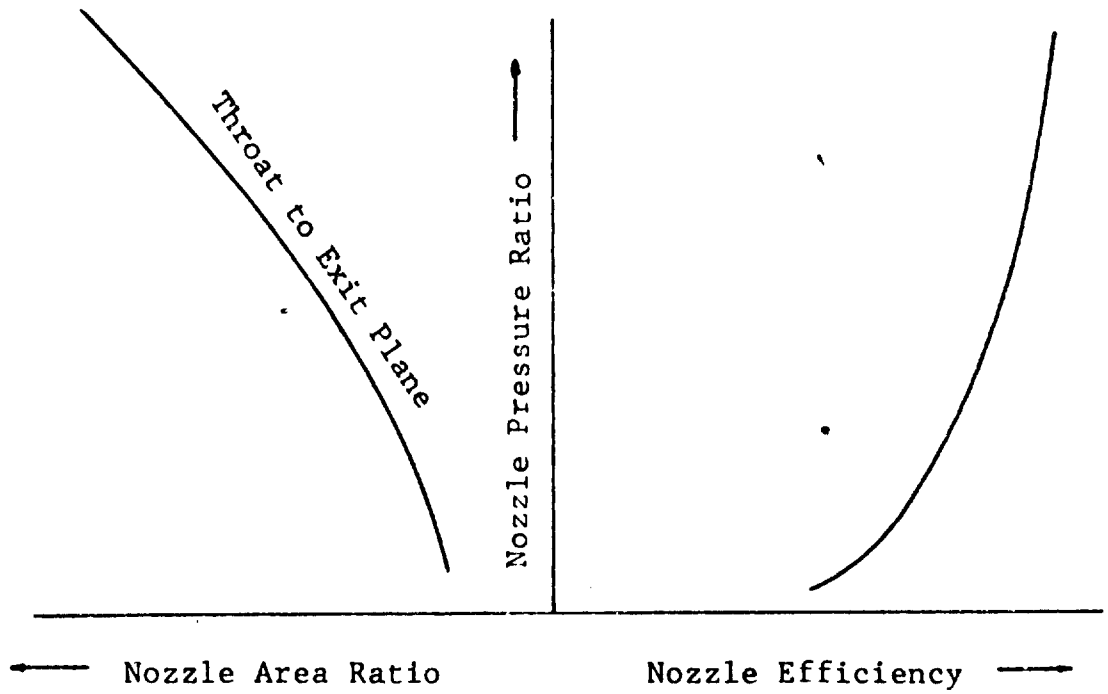


Figure 13. Typical Turboaccelerator Nozzle Requirements and Performance.

confined to performance measurements in the static mode and in the transonic-to-low supersonic flight regimes [42 - 51]. The dearth of high velocity results in the literature likely stems from the lack of specific applications in this flight regime and the potential of these nozzle types for engine infrared radiation suppression. This lack of information is unfortunate since, as noted earlier, the nozzle off-design performance and afterbody drag is very sensitive to the vehicle's maximum Mach number, and, hence, the nozzle pressure ratio and geometry. This restricts the usefulness of nozzle results cited above because these data relate to the lower velocity range with low nozzle pressure ratios and limited variable geometry. Alternately, analytical methods for treating the range of typical turboaccelerator nozzle conditions are restricted by the lack of empirical correlations [52,53,54].

However, noting these limitations, the nozzle data documented in Reference 49 were selected for application to the turboaccelerator cycles. The selected data is for a plug nozzle incorporating both internal and external expansion, having a design total-to-static pressure ratio of 25. It is likely that the turboaccelerator cycles will have a maximum pressure ratio on order of magnitude larger than this; however, variable geometry features in the turboaccelerator nozzle will allow the unit to configure for optimum performance for a large range of pressure ratios. In addition, the limited data on plug nozzles indicate that the major influence of external effects occur in the transonic

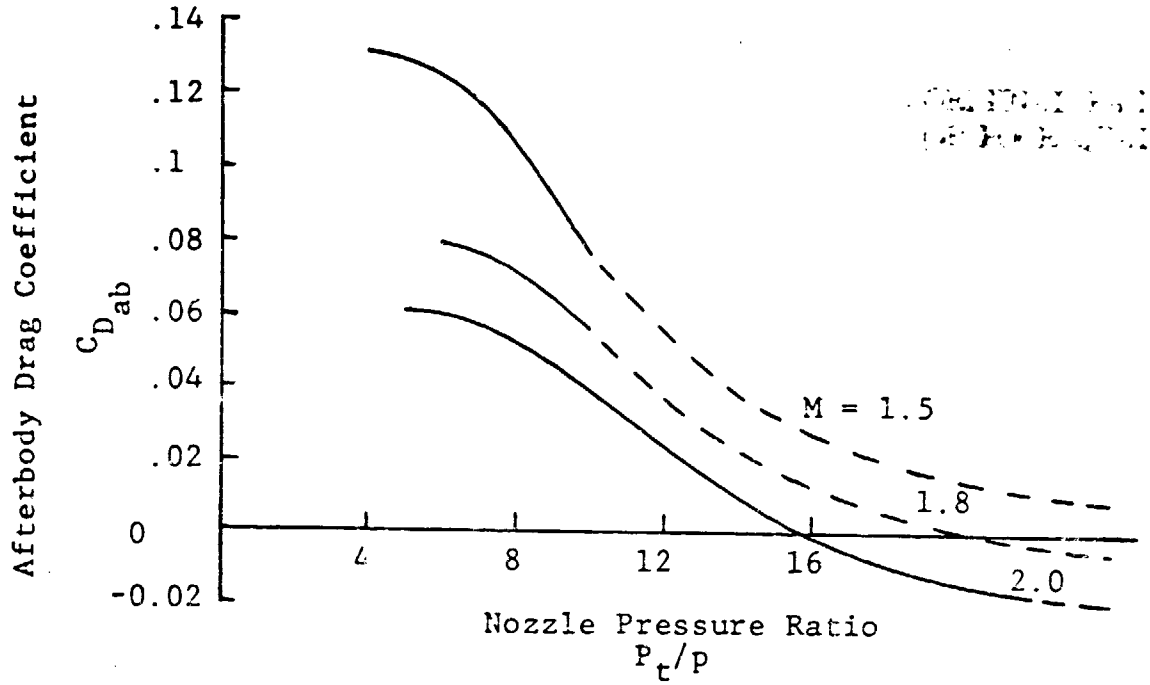
ORIGINAL PAGE IS
OF POOR QUALITY

range. This is an area of nozzle performance which will require detailed test and analysis for selection of an optimized turboaccelerator configuration.

The selected nozzle data have been extended over the pressure ratio range of 4 to 24 using trends of similar data from References 43, 49 and 50. These data extensions are indicated by the dashed portions of the curves in Figure 14.

The afterbody drag characteristics for the selected nozzle are shown in the upper portion of Figure 14, depicting the variation of afterbody drag coefficient as a function of nozzle pressure ratio and the external flowfield Mach number. The data exhibit a typical rise in afterbody drag at transonic speeds and the typical decrease in drag as the design pressure ratio is achieved. In some cases, this decrease in drag can result in "negative drag", or thrust, resulting from significant forces acting on the base areas of the plug nozzle.

The thrust coefficient data for the selected nozzle as a function of nozzle total pressure ratio are shown in the lower portion of Figure 14. The thrust coefficient is the ratio of the actual nozzle thrust to the ideal thrust of the nozzle flow. The ideal thrust equals the actual mass flow rate times the ideal velocity (i.e., the velocity reached by the stream upon isentropic expansion from the total pressure to the ambient pressure.) The data reveal the typical plug nozzle behavior - a cusp in the thrust coefficient values which is associated with the region of nozzle pressure ratios where the relative significance of internal



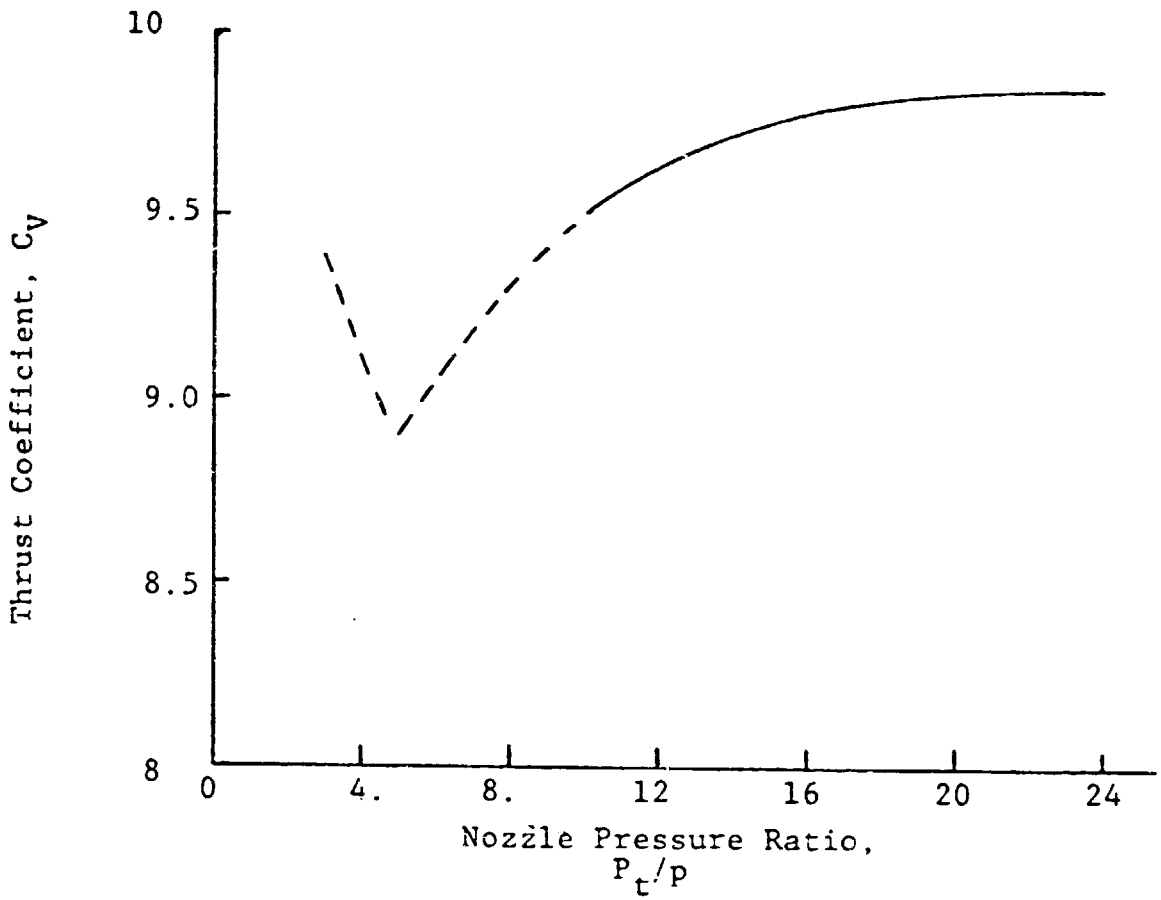


Figure 14. Nozzle Internal and External Performance Schedules.

expansion increases. Qualitatively, the plug nozzle displays performance which is superior to the convergent-divergent nozzle at all pressure ratios and provides the altitude compensation that is desired in a multi-mode nozzle. The data have been assumed to be invariant with nozzle throat-to-exit ratio, though QNEP can accept data in this format without program modification.

These internal and external nozzle performance data have been incorporated as data tables in the specifying data of the typical engine cycles. The results of applying these nozzle installation effects are typified by the augmented aft fan results shown in Figures 15 and 16. The performance is again compared on the basis of uninstalled and installed performance. Uninstalled data are based upon no spillage drag, standard inlet recovery [32], a flow deflection of 10° and expansion to ambient conditions assuming a constant thrust coefficient of 0.99. The installed performance incorporates the thrust coefficient and afterbody drag schedules discussed above. The impact of incorporating these nozzle losses is to lower the engine performance in the region of low nozzle pressure ratio. At higher pressure ratios (Ref. Figure 14), the negative drag results in an increase in engine performance. Again, it should be noted that these results reveal the importance of incorporating individual component losses in the cycle calculations.

The results of applying both the inlet and nozzle loss schedules to the augmented aft fan cycle are shown in Figures 17 and 18. The uninstalled performance is based upon no spillage drag, standard inlet recovery [32], a flow deflection of 10° and

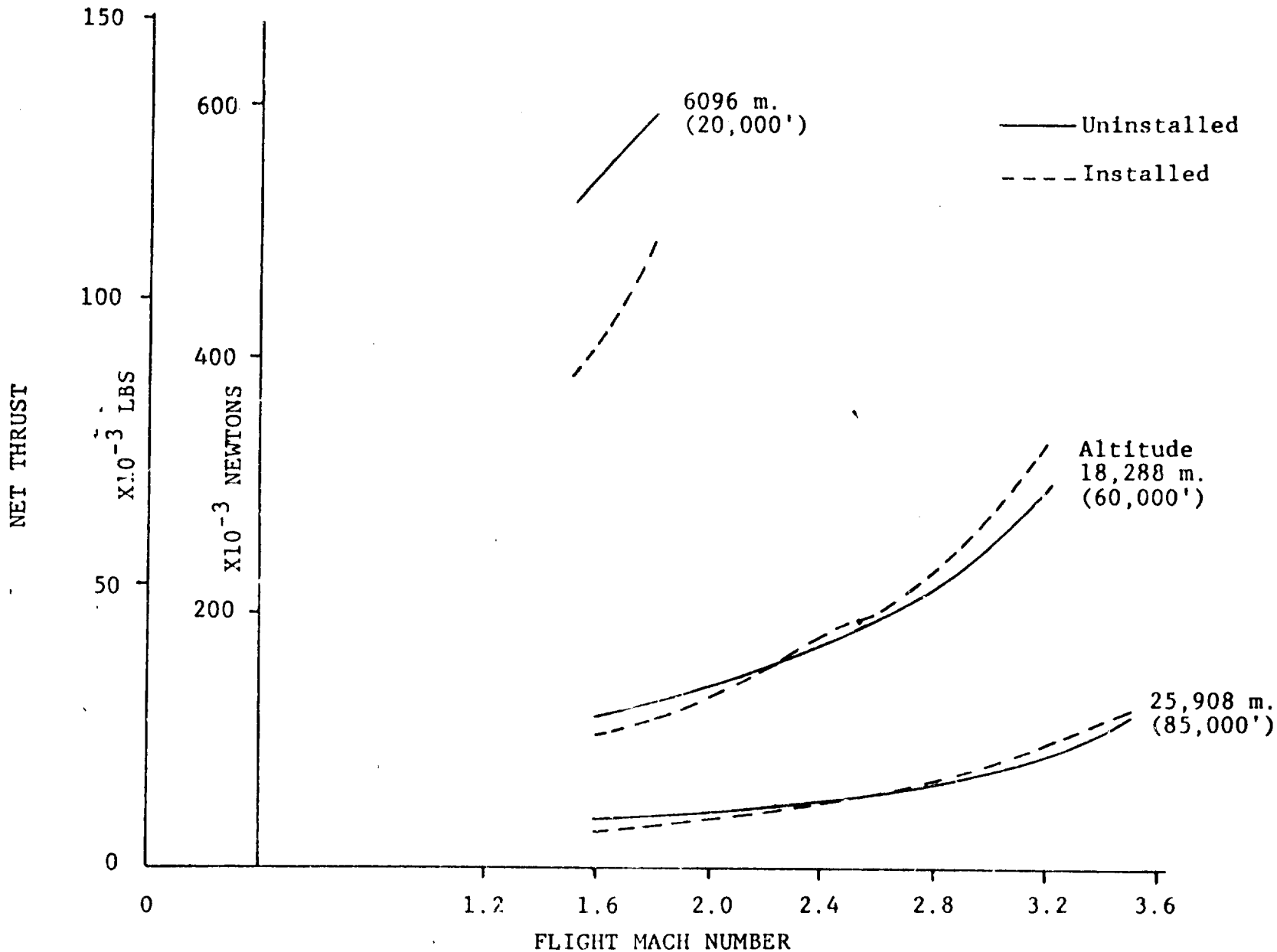


Figure 15. Nozzle Performance Effects on Augmented Turbofan Performance; $\delta = 10^{\circ}$.

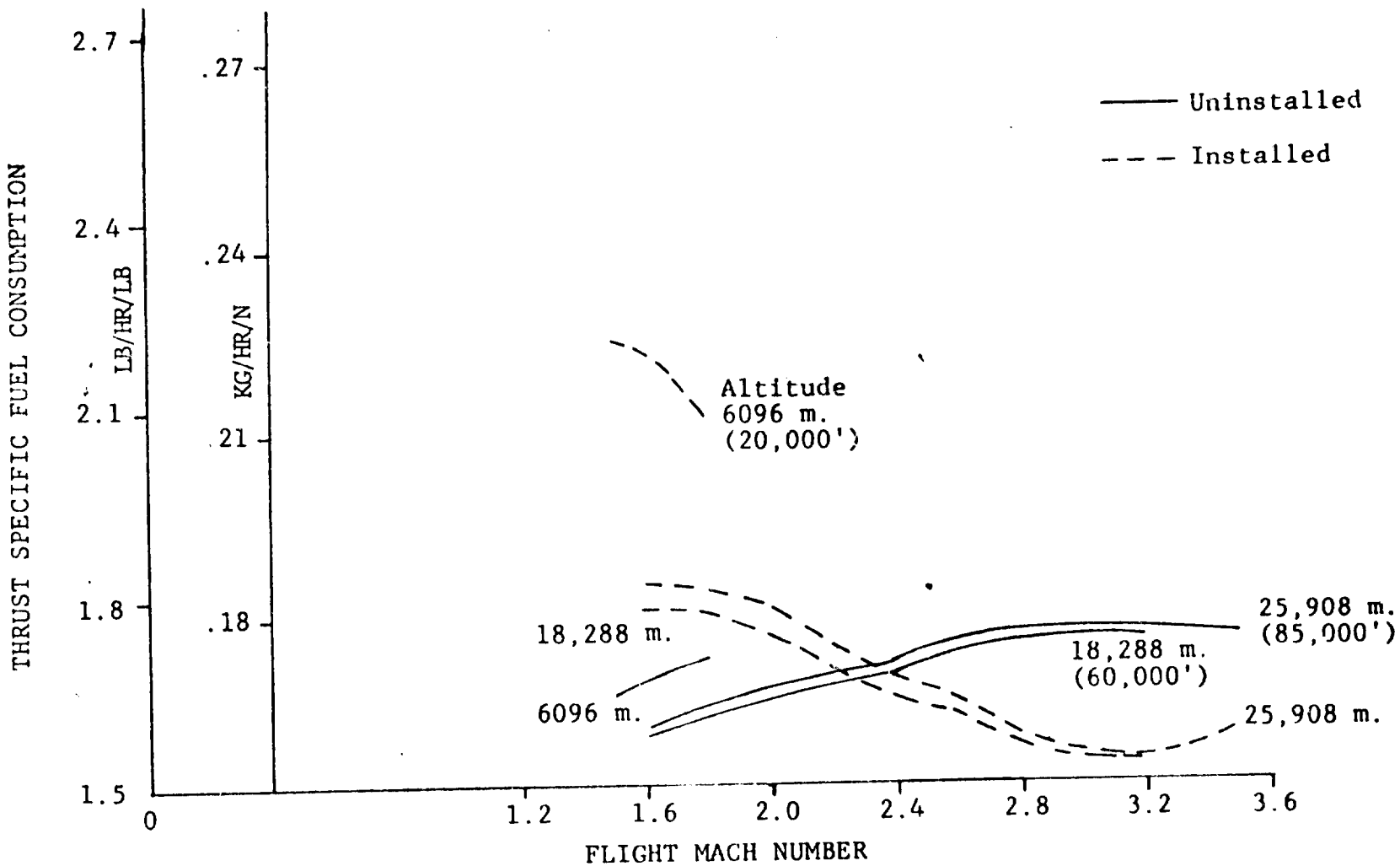


Figure 16. Nozzle Performance Effects on Augmented Turbofan Performance; $\delta = 10^{\circ}$.

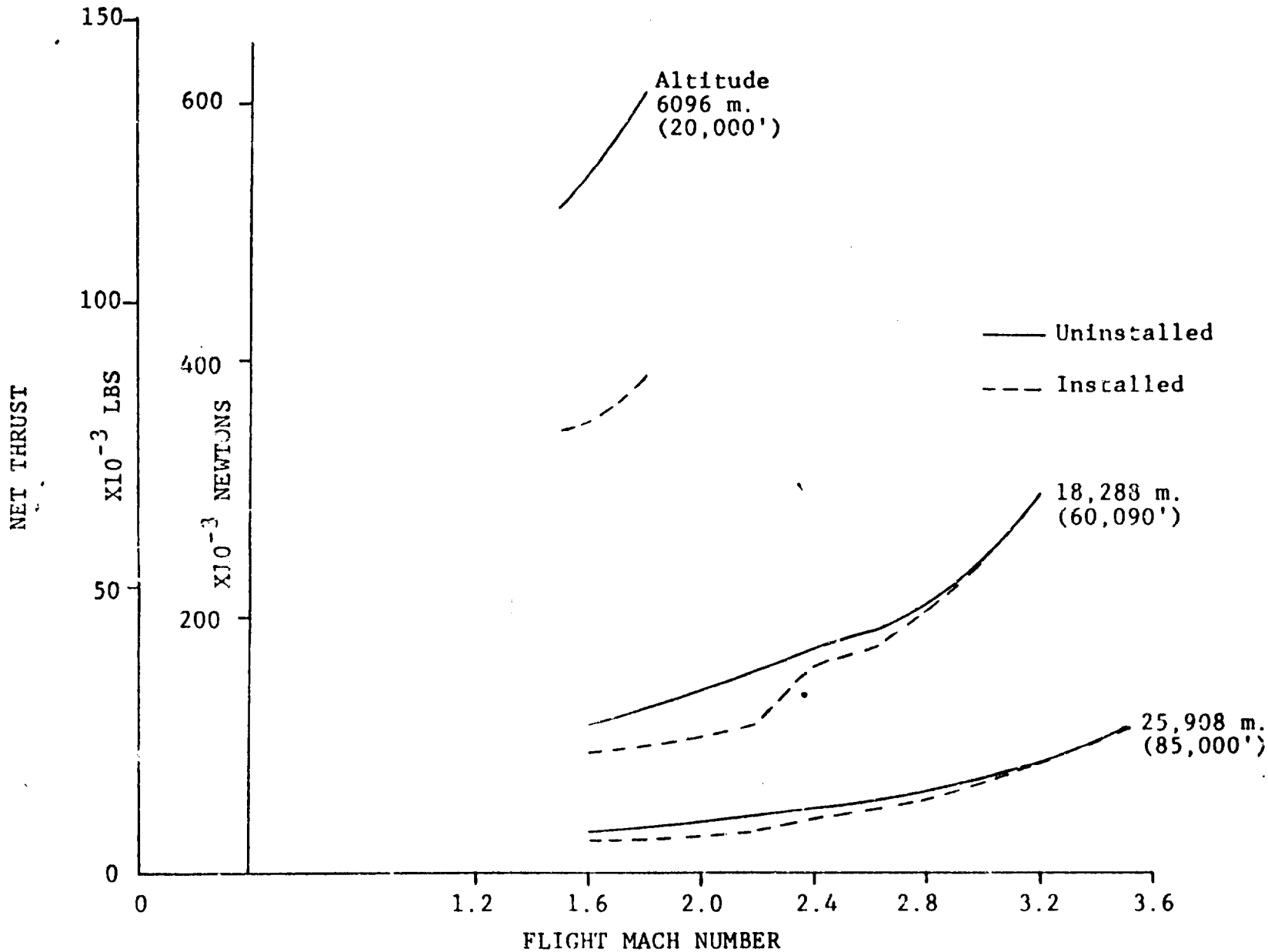


Figure 17. Combined Installational Effects on Augmented Turbofan Engine Performance; $\delta = 10^{o}$.

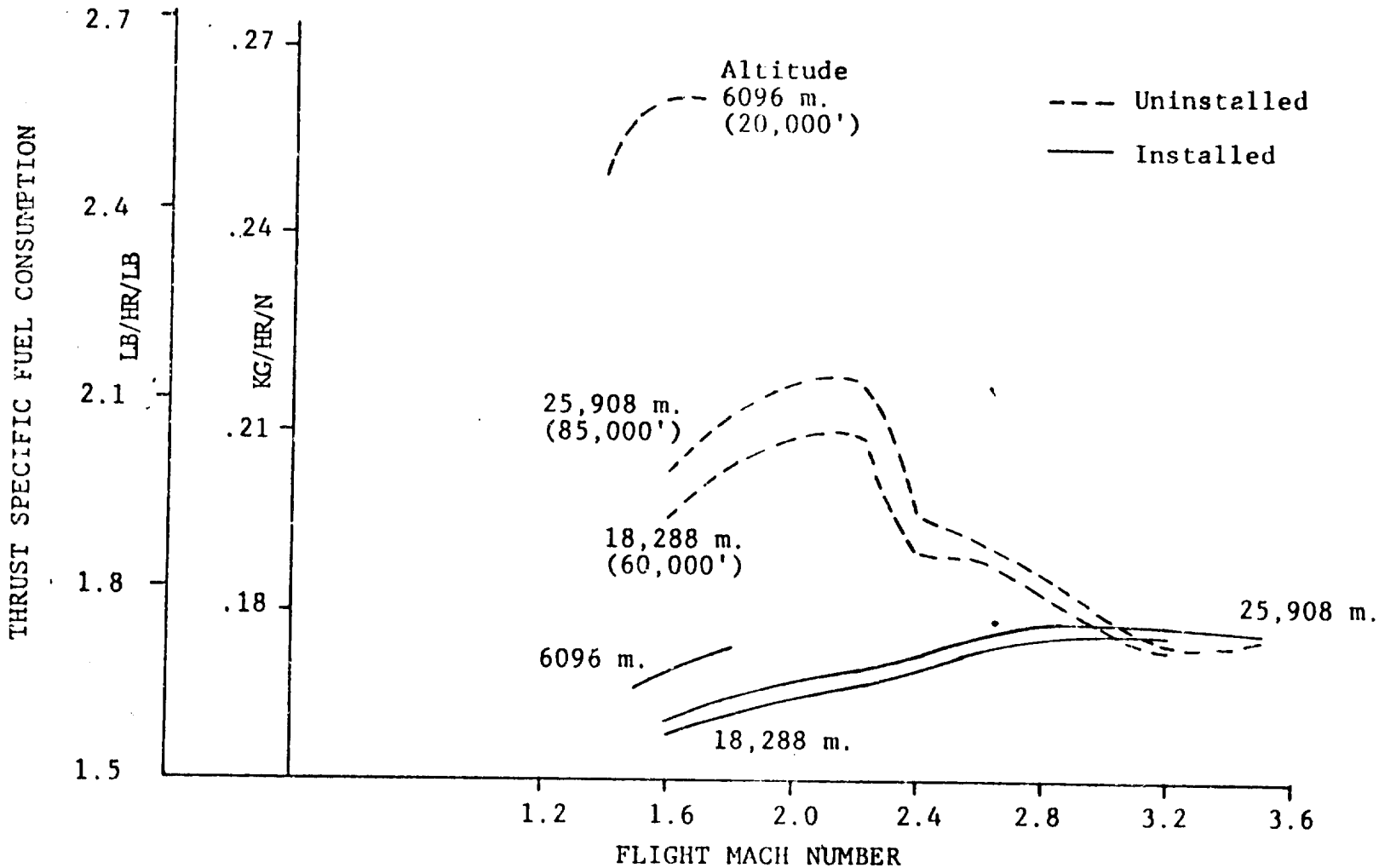


Figure 18. Combined Installational Effects on Augmented Turbofan Engine Performance; $\delta = 10^{o}$.

expansion to ambient conditions assuming a constant thrust coefficient of 0.99. The installed performance incorporates the inlet recovery, spillage drag, thrust coefficient and afterbody drag schedules. The optimistic performance provided by uninstalled assumptions is obvious.

The effect of these combined losses at part-power conditions is also significant. Figure 19 displays the installed and uninstalled performance for throttled operation of the unaugmented turbofan at M = 0.8 and an altitude of 10973 meters (36,000 feet). Again, large losses are demonstrated.

These results have used typical inlet and nozzle loss schedules chosen from the open literature to demonstrate the importance of incorporating their influence in calculations of engine performance. Selection of a specific inlet/engine/nozzle afterbody configuration for an orbital launch vehicle will provide inlet and nozzle data which can be utilized in QNEP in an identical manner.

D. Hydrogen Combustion Model. Because of the high energy content of hydrogen, its large heat capacity and its utility for both airbreathing and rocket cycles, most turboaccelerator cycle concepts utilize hydrogen as the fuel [8,9,10,11,12]. For this reason, the QNEP thermodynamic model has been modified to allow the user to make engine calculations with hydrogen fuel. The model has also been expanded to allow calculations with hydrocarbon fuels with a broad range of user-specified carbon-to-hydrogen ratios. The evaluation of various potential hydrogen combustion models comprised a major portion of this effort. The

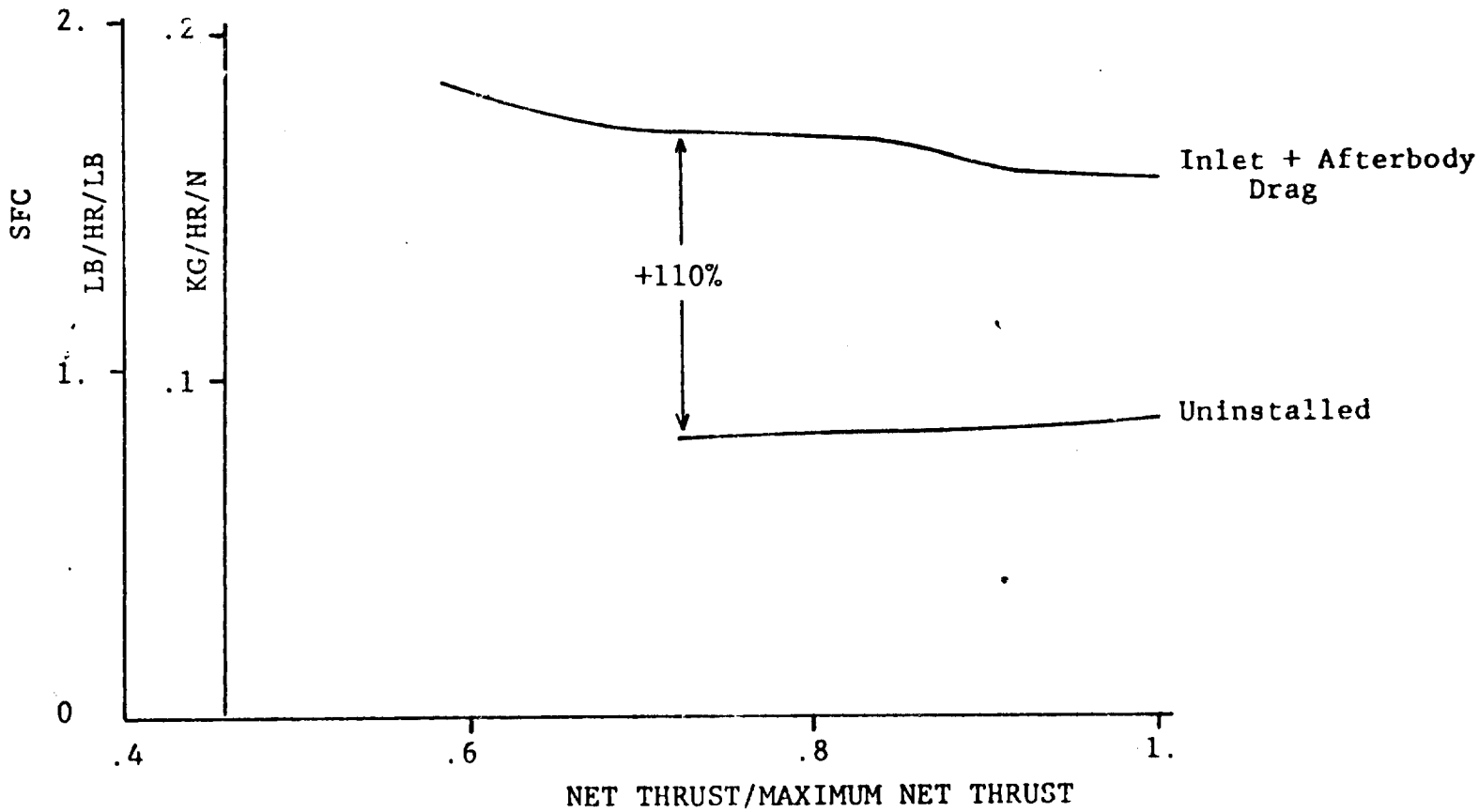


Figure 19. Part-Power Installation Losses For Unaugmented Turbofan, M = 0.8, Altitude = 10973 m. (36,000').

factors which were considered in this evaluation are detailed in the paragraphs below.

The operating environment of turboaccelerators implies both increased cycle temperatures and operating Mach numbers over those currently encountered by gas turbine engines. At these operating conditions, losses of 20 - 30% of the net thrust can occur due to the energy absorbed in dissociation. Hence, it becomes extremely important that the effects of chemical dissociation are incorporated in the cycle calculation. As the degree of dissociation is dependent upon the temperature and pressure of the combustion gases, the determination of the equilibrium composition, the mean molecular weight and the resulting thermodynamic properties must include consideration of this dependence. In addition, it is likely that the fuel will be utilized to cool the engine internal structure (turbine blades, duct walls, nozzle walls, etc.) and the external surfaces of the vehicle. During this use, the enthalpy of the fuel is increased, and it is desirable to incorporate provision in the thermodynamic model to treat this increased energy content.

The standard QNEP program provides thermodynamic calculations via FUNCTION THERM. The method is based on separate calculation of the thermodynamic properties of air and the products of combustion of a stoichiometric fuel-air mixture having the hydrogen-to-carbon ratio (0.16) that is typical of jet fuels; it is then assumed that the properties of the combustion products for any fuel-air ratio that is less than the stoichiometric value may be obtained by a linear interpolation between the two

extreme values. In the absence of dissociation, the results of this approach are highly accurate; however, application of this approach to cycles in which dissociation occurs will give only approximate results. Since the high operating temperatures of advanced turboaccelerator cycles will likely result in significant dissociation, large errors in engine calculated performance can result. For this reason, FUNCTION THERM is restricted to hydrocarbon fuel used for cycle temperatures below 4500°F, and processes where significant dissociation is absent. Hence, its calculated thermodynamic properties are functions only of temperature and fuel-air ratio. This factor led to the conclusion that, for the range of temperatures and pressures encountered by turboaccelerators, it would not be possible to merely substitute the hydrogen combustion product properties in the current FUNCTION THERM logic. Instead, it was necessary to modify the complete program logic for determining the thermodynamic properties.

A number of methods for computing thermodynamic properties of exhaust gases are available for computer use. They fall into two general categories: one contains tabulated combustion properties, while the other is a computer program which calculates the properties. Examples of the former data format include Keenan and Kaye [55], Banes, et al. [56], Powell, et al. [57], and Browne and Warlick [58]. Examples of the latter include Pinkel and Turner [59], Osgerby and Rhodes [60], Gordon and McBride [61], Pelton [62], and Mascitti [63]. The use of the

tabular form of pre-calculated data using some form of curve fitting was rejected because of the large data storage requirements; it is anticipated that approximately 4000 constants would be required in order to provide temperature, pressure and fuel-air ratio dependence for hydrogen fuel, sacrificing both computer storage and accuracy.

Combining the QNEP code with a highly generalized code like Gordon and McBride [61] could greatly hinder its usefulness because of the significant increase both in computer storage and operating requirements and in execution time. The basic double precision QNEP code requires approximately 256 kilobytes of storage for execution; incorporation of the NASA SP-273 code in the QNEP code would require approximately 500 kilobytes of storage for execution. In addition, the thermodynamic subroutine of QNEP is a function which is interrogated by every component subroutine in the program. Hence, it is used more often and can be more time consuming than any other subroutine in the engine model. Thus, its computational efficiency is a significant factor in program utility. Calculation of the thermodynamic properties at single values of pressure, temperature and fuel-air ratio using the thermodynamic model of Reference 61 requires approximately one second. In considering the numerous iterations of thermodynamic properties required in cycle calculations, this computational requirement is considered too excessive. Additionally, the Gordon and McBride code contains many capabilities which are not required for engine cycle calculations. Elimination of these

excess capabilities could prove very complex and time consuming. In contrast, the incorporation of an engine-specialized computer code for calculating the thermodynamic properties provides improved computational efficiency and convenience, and, in addition, retains the flexibility of orderly updating as compositions for fuel or air change, or as thermodynamic property data are improved.

These factors have led to the selection of the Mascitti model [63] for incorporation in the QNEP engine program. The code is a simplified combustion gas model which includes the effects of dissociation and which allows a wide range of fuel-air ratios and carbon-to-hydrogen ratios. The model allows treatment of hydrocarbon-air combustion, hydrogen-air combustion and dissociating air. The model is applicable over the pressure range of 0.001 - 100 atmospheres and up to 7000°F. The gas model is simplified by neglecting the formation of species containing atomic nitrogen, thereby enabling a considerable simplification of the composition equations and allowing a solution for the chemical composition to be obtained with a single-level iteration of these equations. This assumption was made since calculations for this temperature and pressure range indicate that the formation of nitrogen species, such as N, NH, NH_3 and NO, occurs in negligible amounts, and, therefore, has a very small effect on the thermodynamic properties of combustion gas mixtures [8,9]. The impact of this assumption was examined both in terms of the thermodynamic properties of stoichiometric kerosene-air and hydrogen-air combustion products and in terms of the performance

of an idealized subsonic combustion ramjet. Good agreement was demonstrated between the simplfied model and more comprehensive treatments in the range of temperatures applicable to hypersonic engine cycles [63].

Preliminary analysis of the model revealed that several errors in constituent properties were present in the program listing. These errors were eliminated using data from the latest JANAF tables [64]. In addition, routines for calculation of specific heat properties were added to the program, and entry routines to allow the program to make various cycle calculations were constructed and evaluated. Since the calculated thermodynamic properties are functions of temperature, pressure, fuel-air ratio and carbon-to-hydrogen ratio, each of the component subroutines required modification to allow interfacing with the thermodynamic function subroutine. This new thermodynamic subroutine, which was designated FUNCTION THERMO, demonstrated an average execution time of 0.07 seconds for calculation of the thermodynamic properties at single values of pressure, temperature and fuel-air ratio.

The results of these modifications to the QNEP code were evaluated by comparing typical engine cycle calculations using both calculator-based design computations and results from the standard QNEP engine code. Because FUNCTION THERMO has the capability for treating both hydrocarbon and hydrogen fuels, it was possible to execute typical engine cycles with hydrocarbon fuel (carbon-to-hydrogen ratio of 0.16) for the modified QNEP program and compare the resulting data with the standard

QNEP program (containing FUNCTION THERM). For cycle conditions for which no dissociation occurs, comparison of the outputs from the two programs provide an excellent check of the validity of the program modifications and the accuracy of the simplified model incorporated in THERMO.

Typical results of cycle calculation comparisions for an augmented aft fan engine are shown in Table 1. These data tabulate the percentage of error encountered in thrust and thrust specific fuel consumption for calculations using the QNEP code incorporating the two thermodynamic routines. The values of error are given by:

$$\% \text{ Error} = \frac{\text{THERM Value-THERMO Value}}{\text{THERM Value}}$$

(For simplicity, the thrust is tabulated in pounds, while the thrust specific fuel consumption is cited in pounds per hour per pound.) Excellent agreement is demonstrated between the values calculated from the two models, with a maximum discrepancy in thrust of approximately 3%. The maximum discrepancy in thrust specific fuel consumption is less than 1%.

By artificially restricting the dissociation calculation in FUNCTION THERMO, it was also possible to obtain data for comparable high altitude and Mach number conditions with the ramjet cycle. These data which are displayed in Table 2 also reveal excellent agreement for the performance parameters.

Comparable calculations were conducted for the front fan, unaugmented turbofan cycle for both maximum power and throttled

Table 1. Comparison of Thermodynamic Models for Augmented Aft Fan Performance Calculation

ALTITUDE = 0.0 m. (0.0 ft.)

	THERM.		THERMO.		% ERROR	
MACH	FN	TSFC	FN	TSFC	FN	TSFC
0.0	102901	1.625	102256.	1.636	.6268	-.6769
.05	101617	1.65	100964.	1.661	.6426	-.6667
.15	99861	1.696	99182.	1.708	.6799	-.7075
.25	99763	1.735	98986.	1.747	.7788	-.6916
.35	101912	1.759	100681.	1.776	1.2079	-.9665
.45	105144	1.779	103991.	1.794	1.0966	-.8432
.55	109105	1.796	108394.	1.808	.6516	-.6682

ALTITUDE = 3048 m. (10,000 ft.)

	THERM.		THERMO.		% ERROR	
MACH	FN	TSFC	FN	TSFC	FN	TSFC
.4	76124	1.761	75514	1.772	.801	-.624
.6	81664	1.8	80776	1.813	1.087	-.666
.8	94897	1.788	93344	1.805	1.636	-.9507
1.0	104067	1.818	102980	1.833	1.04	-.769
1.2	113181	1.856	117756	1.868	.817	-.646
1.4	121679	1.9	120541	1.913	.935	-.684
1.5	127899	1.916	126571	1.928	1.03	-.626

Table 1 (Continued)

ALTITUDE = 9144 m. (30,000 ft.)

	THERM.		THERMO.		% ERROR	
MACh	FN	TSFC	FN	TSFC	FN	TSFC
.6	41455	1.766	41026	1.778	1.034	-.679
.9	51859	1.754	51157	1.766	1.353	-.684
1.	56747	1.745	55819	1.757	1.635	-.687
1.2	68074	1.729	66516	1.745	2.288	-.925
1.4	79408	1.729	77885	1.742	1.917	-.751
1.6	87865	1.754	86362	1.766	1.71	-.684
1.8	95589	1.789	93940	1.8	1.725	-.614

ALTITUDE = 15,240 m. (50,000 ft.)

	THERM.		THERMO.		% ERROR	
MACH	FN	TSFC	FN	TSFC	FN	TSFC
.8	19243	1.7540	19119	1.763	.644	-.398
1.1	25313	1.724	25020	1.734	1.157	-.58
1.6	38638	1.708	37998	1.719	1.656	-.644
2.2	52463	1.785	51552	1.796	1.736	-.616
2.6	61845	1.856	61436	1.861	.661	-.269
3.	80276	1.893	78101	1.905	2.709	-.633
3.2	94423	1.898	91602	1.912	2.987	-.737

Table 2. Comparison of Thermodynamic Models for Ramjet Performance Calculation

ALTITUDE = 15240 m. (50,000 ft.)

	THERM.		THERMO.		% ERROR	
MACH	FN	TSFC	FN	TSFC	FN	TSFC
3.0	61094	2.275	60741	2.279	.5778	-.1758
3.5	110135	2.209	109652	2.22	.43855	-.498
4.	182485	2.186	181699	2.196	.4307	-.4575
5.	385113	2.232	383804	2.24	.3399	-.3584
6.	550176	2.414	547475	2.425	.491	-.4557
7.	442300	3.055	438807	3.082	.7897	-.884

ALTITUDE = 21,366 m. (70,000 ft.)

	THERM.		THERMO.		% ERROR	
MACH	FN	TSFC	FN	TSFC	FN	TSFC
3.0	23295	2.278	23140	2.282	.6654	-.1756
3.5	41973	2.212	41754	2.223	.522	-.497
4.	69514	2.189	69149	2.199	.525	-.457
5.	146427	2.236	145802	2.245	.427	-.4025
6.	208174	2.422	206959	2.434	.58365	-.4955
7.	163970	3.094	162472	3.122	.9136	-.905

Table 2 (Continued)

ALTITUDE = 27,432 m. (90,000 ft.)

	THERM.		THERMO.		% ERROR	
MACH	FN	TSFC	FN	TSFC	FN	TSFC
3.	8934	2.292	8854	2.298	.8955	-.262
3.5	16060	2.226	15942	2.238	.7347	-.539
4.	26500	2.204	26342	2.215	.746	-.499
5.	55418	2.256	55052	2.266	.6604	.443
6.	76969	2.460	76325	2.473	.837	-.5285
7.	54520	3.301	53795	3.339	1.33	-1.1512

ALTITUDE = 30,480 m. (100,000 ft.)

	THERM.		THERMO.		% ERROR	
MACH	FN	TSFC	FN	TSFC	FN	TSFC
3.	5586	2.99	5540	2.306	.8235	-.3045
3.5	10031	2.233	9964	2.245	.6679	-.537
4.	16557	2.212	16446	2.222	.6704	-.452
5.	34414	2.266	34709	2.276	.5957	-.441
6.	47207	2.480	46845	2.494	.7668	-.5645
7.	31404	3.433	30979	3.475	1.3533	-1.2234

power conditions. These data comparisons also revealed a maximum discrepancy in thrust of 3% for maximum power conditions. For throttling of the engine, this discrepancy typically increased, with a maximum discrepancy of 5% in thrust observed near the 10% thrust throttle setting. Comparable errors in thrust specific fuel consumption were also observed.

The excellent agreement between the THERMO and THERM models applied in QNEP for a hydrocarbon fuel gave high confidence for the validity of the program modifications and the accuracy of the simplified model incorporated in THERMO. In addition, the execution of the QNEP code for hydrogen fuel was evaluated by comparing the results from the code with calculator-based cycle computations. Again, excellent agreement was demonstrated. In addition, Mascitti [63] showed excellent agreement with the tabulated results of Brown and Warlick [58] in the usual operating ranges of turbo-accelerator cycles.

The previous experience with the code [12,63] and the author's evaluation led to the conclusion that the model was indeed performing well and that application to typical building block cycles should proceed.

E. Modified QNEP Code Application. Following verification of the THERMO subroutine and the individual thermodynamic modifications to the QNEP subroutines, the installational modifications and the thermodynamic modifications were combined. After check-out of the combination, the modified QNEP code, which is documented in Appendix B, was applied to typical turboaccelerator building

ORIGINAL PAGE IS
OF POOR QUALITY

block cycles. These cycles, which are depicted schematically in Figures 2 and 3, are typical turbofan, augmented turbofan and ramjet cycles. Each of the selected cycles are described by their QNEP data inputs in Appendix C. The modifications to these data inputs, which are required of a user in order to treat installational effects and to allow treatment of various fuels are described in Appendix A. Appendix C also contains sample output for each cycle type illustrating the use of the modified QNEP program.

Typical results from these applications of the modified QNEP code are depicted in Figures 20-26. The losses due to incorporating installational losses are evident in each figure, including the effect on part-power performance shown in Figure 22. These results again confirm the importance of incorporating "real world" installational losses in estimates of engine performance.

Figures 25 and 26 also display the importance of incorporating real gas losses in the engine model. The data depicted in symbols illustrate the additional losses in performance due to dissociation of the combustion gas products and resizing of the exhaust nozzle to handle the equilibrium flow. The cases labeled installed and uninstalled are based upon artificially precluding dissociation in the thermodynamic model and sizing the nozzle to handle the frozen flow. (This mechanism is controlled by varying in FUNCTION THERMO the temperature level considered to be the boundary for the onset of dissociation effects). Isentropic expansion to ambient conditions is assumed in both cases.

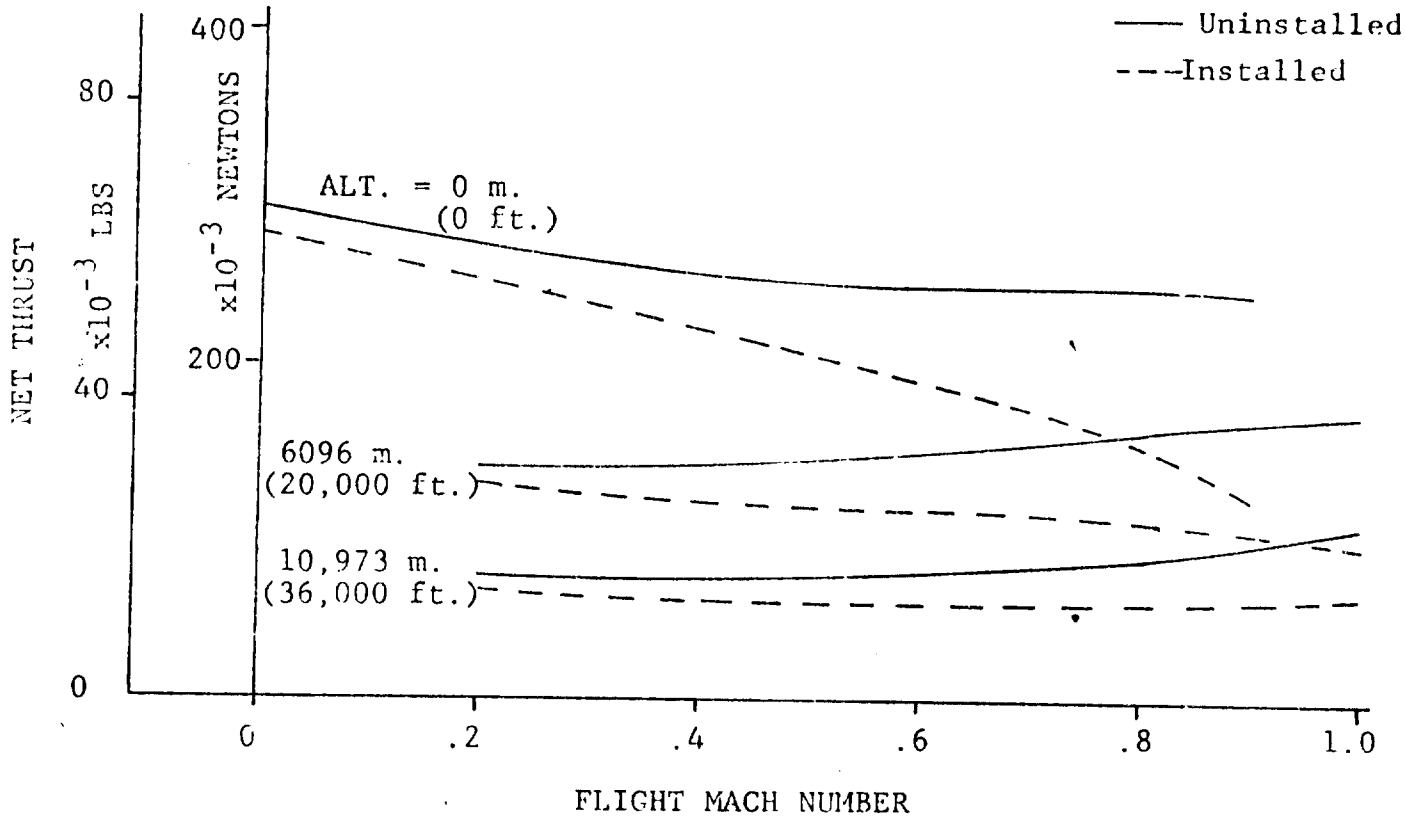


Figure 20. Unaugmented Aft Fan Engine, Uninstalled vs. Installed Performance, H_2 Fuel.

ORIGINAL PAGE IS
OF POOR QUALITY

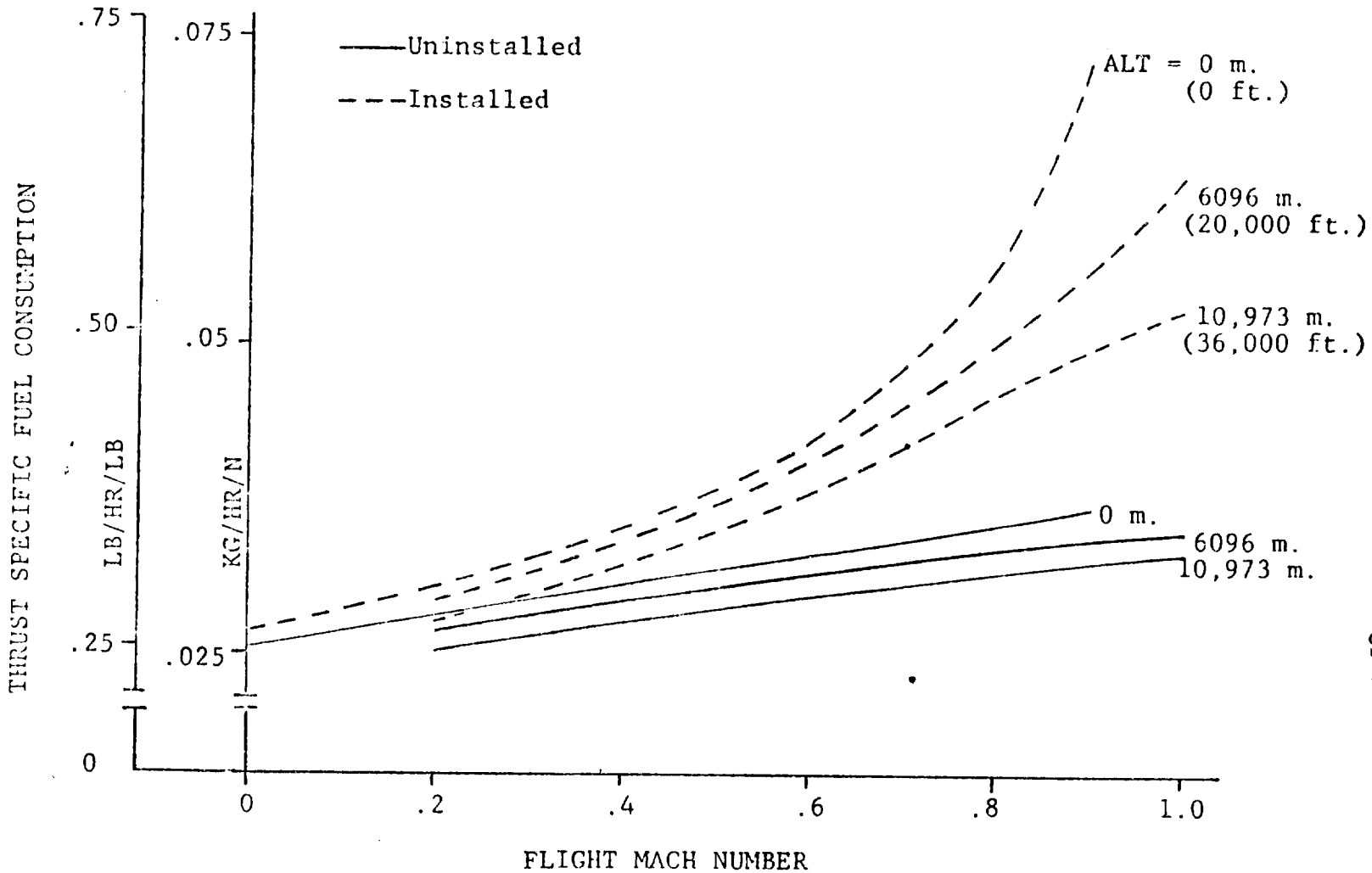


Figure 21. Unaugmented Aft Fan Engine, Uninstalled vs. Installed Performance, H_2 Fuel.

ORIGINAL PAGE IS
OF POOR QUALITY

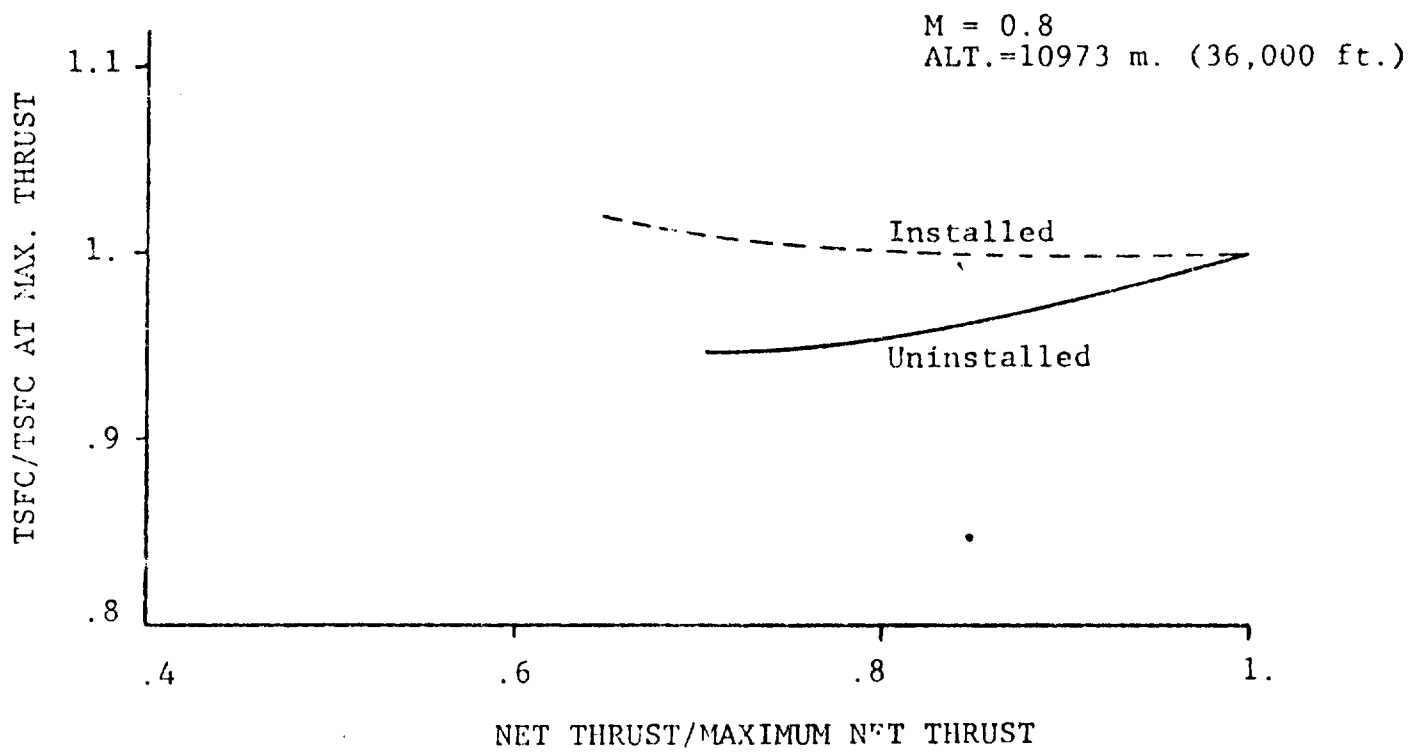


Figure 22. Unaugmented Aft Fan Engine, Part-power Performance for Installed vs. Uninstalled, H_2 Fuel.

ORIGINAL PAGE IS
OF POOR QUALITY

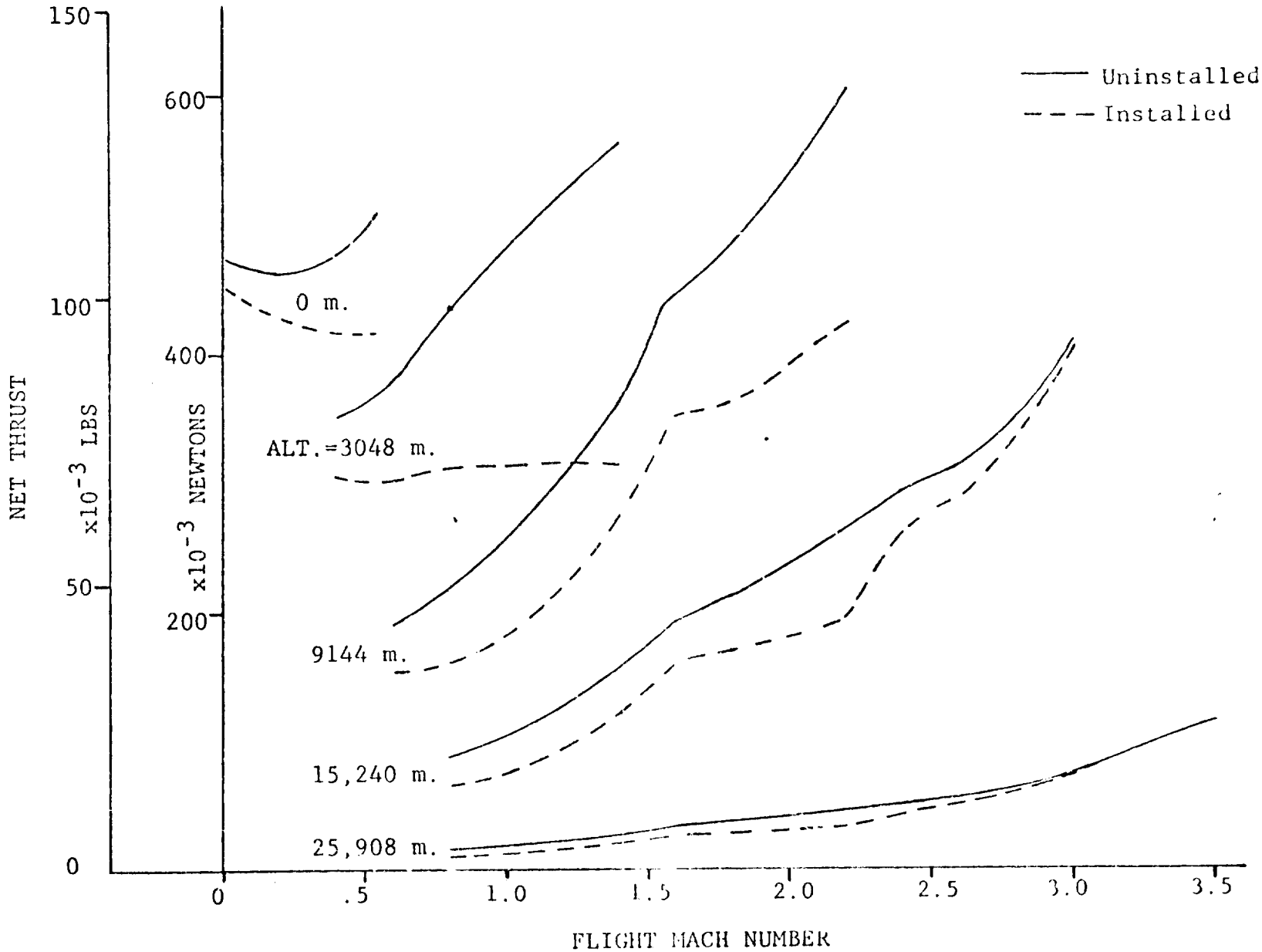


Figure 23. Augmented Aft Fan Engine, Uninstalled vs. Installed Performance, H_2 Fuel.

ORIGINAL PAGE IS
OF POOR QUALITY

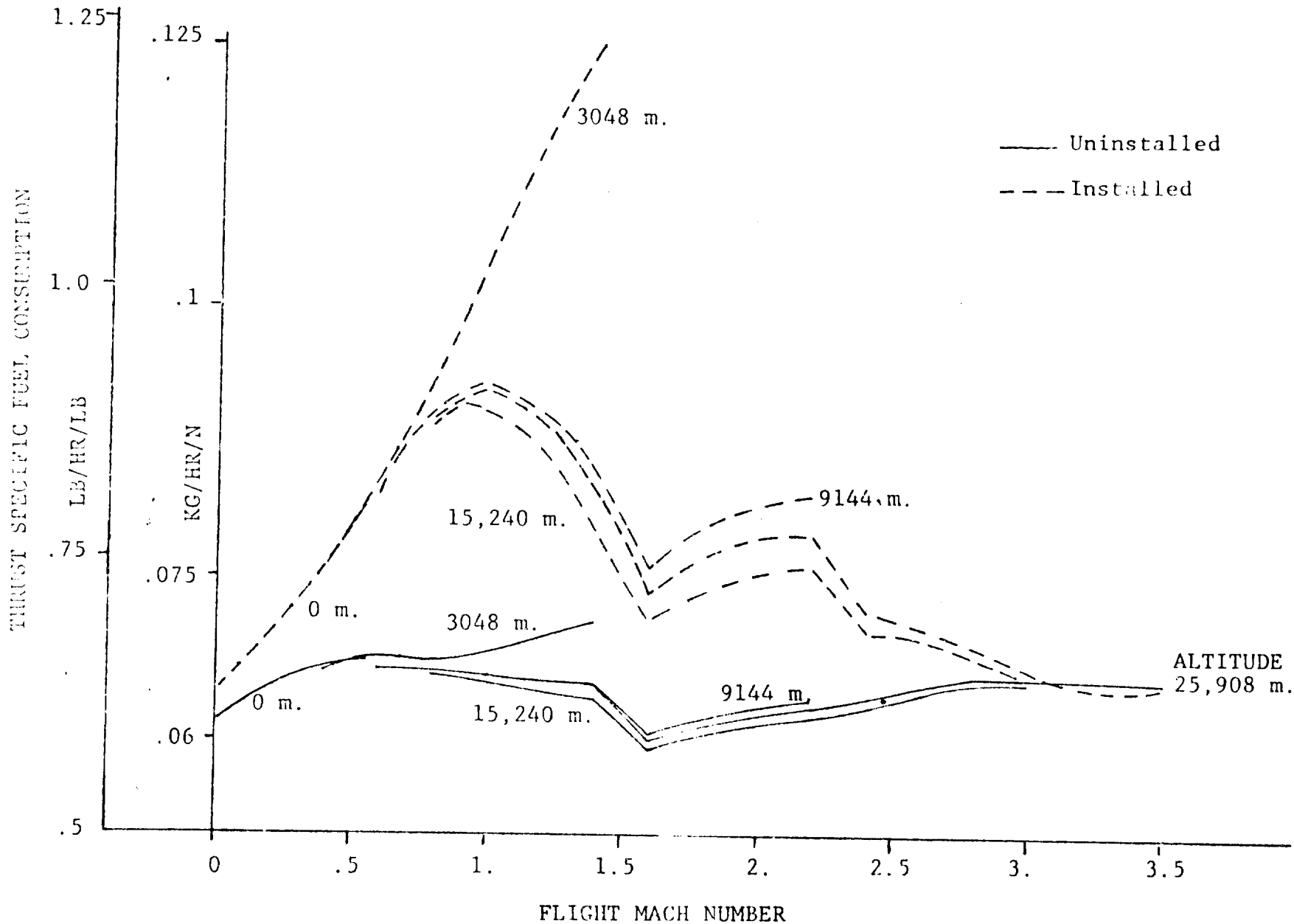


Figure 24. Augmented Aft Fan Engine, Uninstalled vs. Installed Performance, H_2 Fuel.

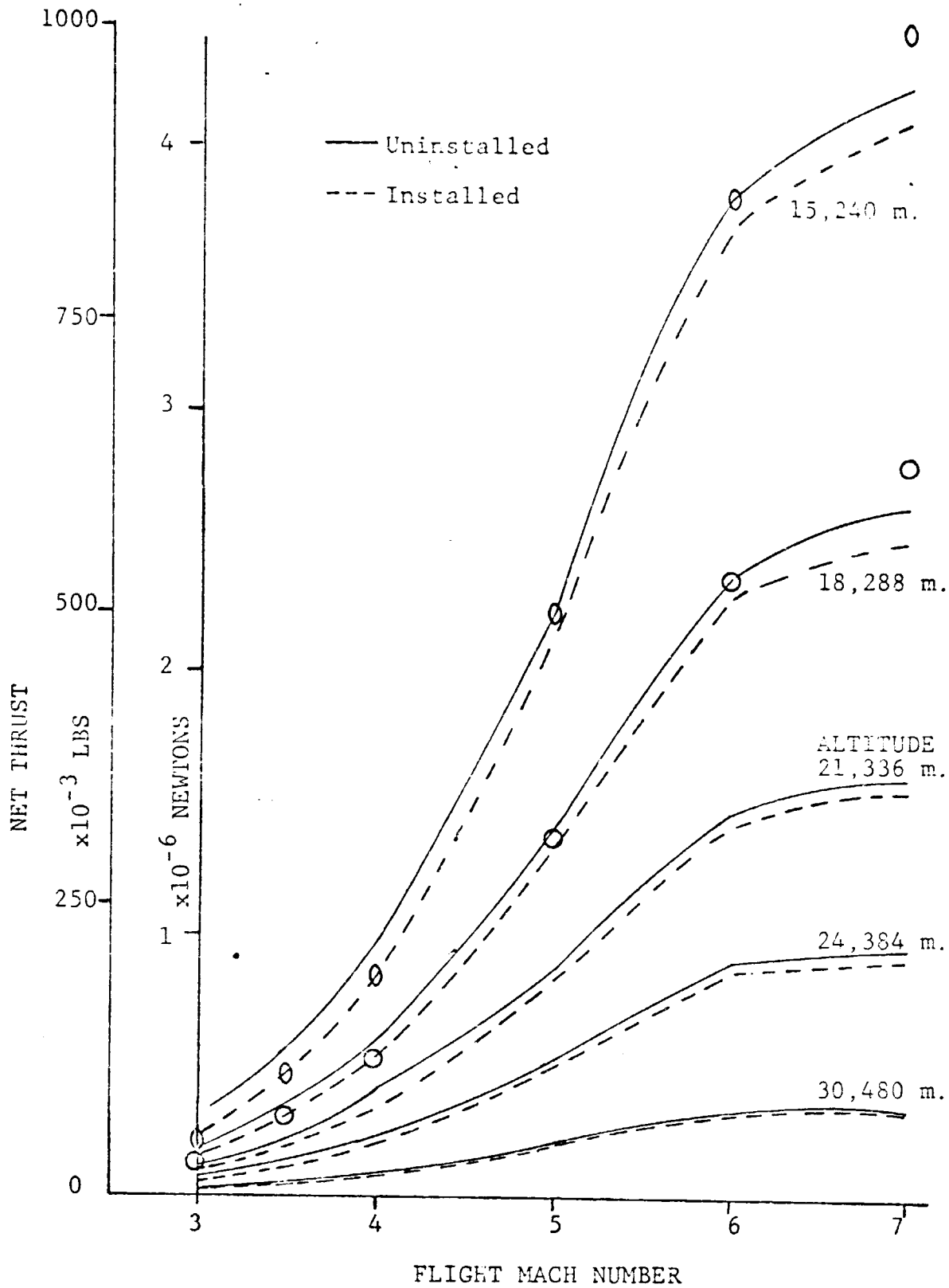


Figure 25. Ramjet Engine, Uninstalled vs. Installed Performance, H_2 Fuel.

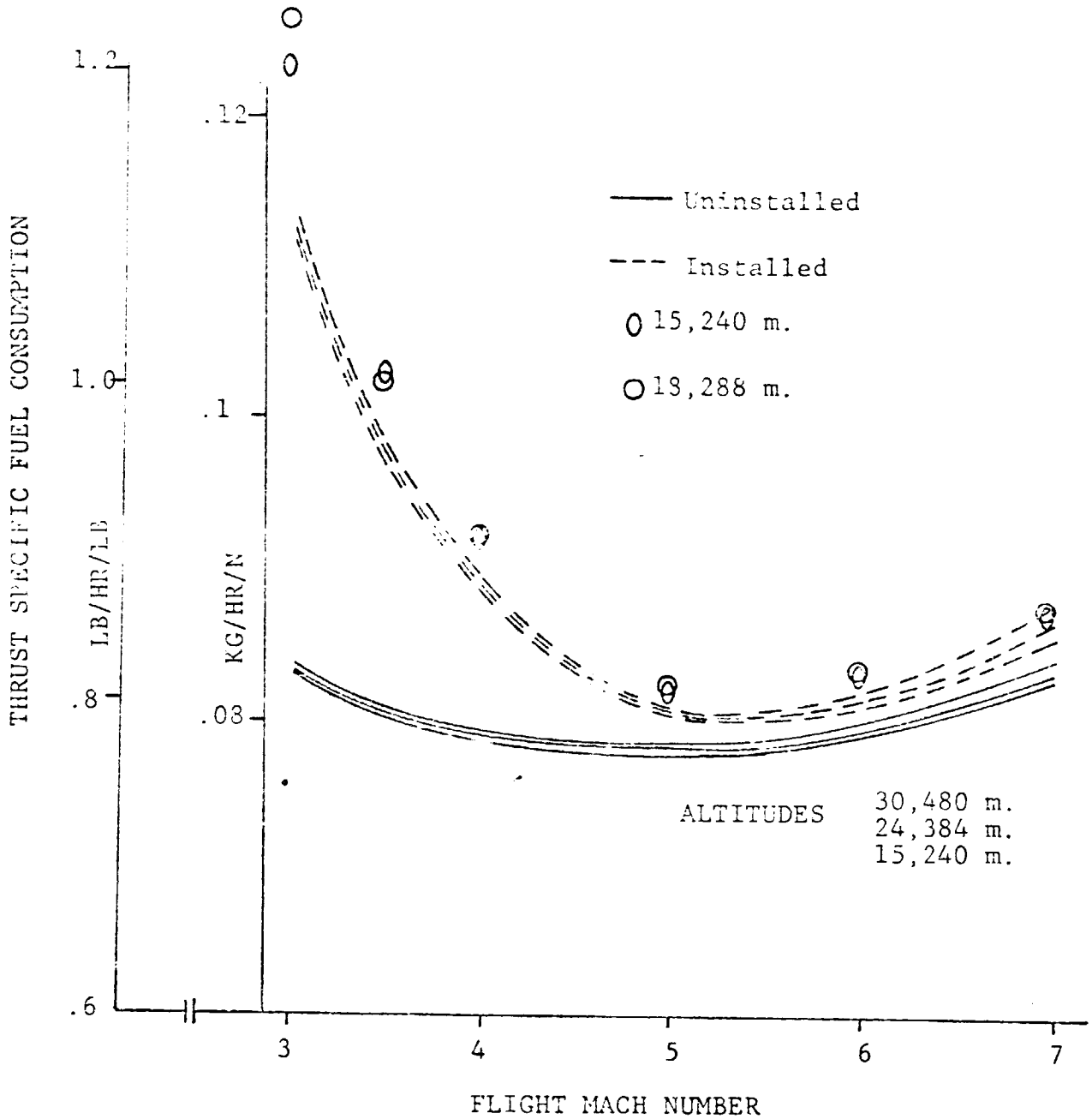


Figure 26. Ramjet Engine, Uninstalled vs. Installed Performance, H_2 Fuel.

The QNEP code offers great versatility and flexibility. The modified QNEP code extends its capabilities and utility for treating turboaccelerator cycles.

CONCLUSIONS AND RECOMMENDATIONS

The versatile QNEP code has been modified to give greater utility for treating advanced turboaccelerator concepts thereby providing an enhanced tool for conducting trajectory and payload optimization calculations. The inclusion of hydrogen fuel provides a major step toward exact modeling of turboaccelerator cycles. The capability to incorporate the effect of vehicle flowfield on the engine performance has been demonstrated to be significant for accurate cycle calculations. Finally, the inclusion of typical inlet and nozzle losses has been somewhat hindered by the lack of specifically applicable data in the open literature; however, selection and application of representative losses has demonstrated the importance of identifying their contribution to the overall propulsion system analysis.

It is important that other turboaccelerator features be modeled and incorporated in QNEP in order to increase confidence in the engine calculations. Chief among these currently neglected features are regeneratively cooled nozzles, pre-compressive cooling and turbo-expander energy extraction. In view of the importance of advanced orbital launch techniques to the further utilization of the orbital environment, it is recommended that timely development of the additional analysis capabilities be pursued.

REFERENCES

1. Love, E. S., "Advanced Technology and the Space Shuttle," AIAA Paper No. 73-31, January 1973.

2. Shelton, B. W., "Advanced Earth-to-Orbit Transportation Vehicles and Their Propulsion Systems," AIAA 78-1102, presented at the AIAA/SAE 14th Joint Propulsion Conference, Las Vegas, Nevada, July 25-27, 1978.

3. Jackson, L. R., J.A. Martin, and W. J. Small, "A Fully Reusable, Horizontal Takeoff Space Transport Concept with Two Small Turbojet Boosters," NASA TM 74087, October 1977.

4. Hanley, G. M., "Future Space Transportation Systems," presented at the Canaveral Council of Technical Societies, Fifteenth Space Congress, Cocoa Beach, Florida, April 26-28, 1978.

5. Hague, D. S. and H. L. Rozendaal, "NSEG-A Segmented Mission Analysis Program for Low and High-Speed Aircraft," Volume 1-Theoretical Development, NASA CR-2807; Volume 2-Program Users Manual, NASA CR-2808; August 1977.

6. Brauer, G. L., D. E. Cornick, and R. Stevenson, "Capabilities and Applications of the Program to Optimize Simulated Trajectories (POST), "NASA CR-2770, February 1977.

7. Rutowski, E. S., "Energy Approach to the General Aircraft Performance Problem," J. of the Aeronautical Sciences, March 1954, pp. 187-195.

8. Bendot, J. G., P. N. Brown, and T. G. Piercy, "Composite Engines for Application to a Single-State-to-Orbit Vehicle," NASA CR02613, December 1975.

9. "A Study of Composite Propulsion Systems for Advanced Launch Vehicle Applications," Vols. 3 and 6, Marquardt Report No. 25194, September 1966.

10. "Estimated Performance of a Mach 8.0 Hydrogen Fueled Turbofanramjet (STFRJ-230A) " Pratt & Whitney Aircraft Report, No. TDM-1905, 1-25-65.

11. "Supersonic - Hypersonic Propulsion System Study Data, Tandem Turboramjet (GE5/JZ1 - Study B)," General Electric Company, SS-63-5, April 15, 1963.

12. Waters, M. H., "Turboramjet Propulsion System for All-Body Hypersonic Aircraft," NASA TN D-5993, January 1971.

13. Smith, V. K., "Air Breathing Engine/Rocket Trajectory Optimization," in "Faculty Fellow Research Reports, 1978 NASA/ASEE Summer Faculty Fellowship Program," University of Alabama BER Report No. 224-94, September 1978.

14. Shapiro, S. R. and M. J. Caddy, "NEPCOMP - The Navy Engine Performance Program," ASME Paper 74-GT-83, March-April 1974.

15. Fishbach, L. H. and M. J. Caddy, "NNEP - The Navy NASA Engine Program," NASA TM X-71857, December 1975.

16. Zucrow, M. and J. Huffman, Gas Dynamics, John Wiley & Sons, 1976.

17. Johnson, J. E., "Variable Cycle Engines - The Next Step in Propulsion Evolution?," AIAA Paper 76-758, 1976.

18. Petersen, M. W. and G. C. Tamplin, "Experimental Review of Transonic Spillage Drag of Rectangular Inlets," USAF Report APL-TR-66-30, May 1966.

19. Hawkins, J. E., F. P. Kirkland and R. L. Turner, "Inlet Spillage Drag Tests and Numerical Flow-Field Analysis at Subsonic and Transonic Speeds of a 1/8-Scale, Two-Dimensional, External-Compression, Variable-Geometry, Supersonic Inlet Configuration," NASA CR-2680, April 1976.

20. Wasserbauer, J. F. and W. H. Gerstenmaier, "Inlet-Engine Matching for SCAR Including Application of A Bicone Variable Geometry Inlet," AIAA Paper 78-961, July 1978.

21. Woolett, R. R., E. T. Meleason, and D. A. Choby, "Transonic Off-Design Drag and Performance of Three Mixed Compression Axisymmetric Inlets," NASA TM X-3215, June 1975.

22. Woolett, R. R., E. T. Meleason, and D. A. Choby, "Transonic Off-Design Drag and Performance of an Axisymmetric Inlet With 40 Percent Internal Contraction on Design," NASA TM X-3042, August 1974.

23. Smeltzer, D. B. and N. E. Sorenson, "Tests of a Mixed Compression Axisymmetric Inlet With Large Transonic Flow at Mach Number 0.6 to 2.65," NASA TN D-6971, December 1972.

24. Smeltzer, D. B. and N. E. Sorenson, "Analytic and Experimental Performance of Two Isentropic Axisymmetric Inlets at Mach Number 0.8 to 2.65," NASA TN D-7302, June 1973.

25. Pearson, L. W. and L. F. Jilly, "Hypersonic Research Engine Project. Phase 2A, Inlet Program," Final Technical Data Report, 1 March 1967 - 28 February 1969, NASA CR 66797, March 1969.

26. Trexler, C. A., "Inlet Performance of the Integrated Langley Scramjet Module," AIAA Paper 75-1212.

27. Andrews, Earl H., J. W. Russell, E. A. Mackley, and A. L. Simmonds, "An Inlet Analysis for the NASA Hypersonic Research Engine Aerothermodynamic Integration Model," NASA TM X-3038, November 1974.

28. Hube, F. K. and P. J. Bontrager, "Wind Tunnel Tests of A Two-Thirds Scale NASA HRE Inlet at Mach Numbers 4,5,6, and 8," AEDC TR-69-9, February 1969.

29. Bencze, D. P. and N. E. Sorensen, "A Study of the Relative Merits of Three Axisymmetric Inlets for a Hypersonic Cruise Mission," AIAA Paper 70-687.

30. Marguet, R., M. Barrere, and R. Ceresuela, "Propulsion of Vehicules Hypersoniques," AGARD LS-42, Vol. 2, July 1972.

31. Little, F. K., "Internal Aerodynamics Manual," North American Rockwell Corporation, Columbus Division, Report NR68H-434, July 1968, (Available as AD 837501).

32. "General Specification for Engines, Aircraft, Turbojet and Turbofan," Military Specification Mil-E-5009D. November 1967.

33. Hanley, G. M. and R. Burgeron, "An Overview of the Satellite Power System Transportation System," AIAA 78-975, presented at the AIAA/SAE 14th Joint Propulsion Conference, Las Vegas, Nevada, July 25-27, 1978.

34. Drake, John A., "Hypersonic Ramjet Development," in Combustion and Propulsion, Fourth AGARD Colloquium, Milan, 1960, Pergamon Press, 1961, pp. 71-83.

35. Kirkham, F. S., J. M. Cubbage, W. A. Vahl, and W. J. Small, "Studies of Airframe-Propulsion-System Integration for Mach 6 Cruise Vehicles," NASA TN D-4128, October 1967.

36. Kuchemann, D., "Hypersonic Aircraft and Their Aerodynamic Problems," in Progress in Aeronautical Sciences, Vol. 6, Pergamon Press, 1965, pp. 271-353.

37. Dugger, G. L., "Comparison of Hypersonic Ramjet Engines with Subsonic and Supersonic Combustion," in Combustion and Propulsion, Fourth AGARD Colloquium, Milan 1960, Pergamon Press, 1961, pp. 84-119.

38. Johnston, P. J., J. M. Cubbage, and J. P. Weidner, "Studies of Engine-Airframe Integration on Hypersonic Aircraft," AIAA Paper No. 70-542, May 1970.

39. Bendot, J. G., P. N. Brown and T. G. Piercy, "Composite Engines for Application to a Single-Stage-to-Orbit Vehicle," NASA CR-2613, December 1975.

40. Calmon, J., C. Menioux, and J. Sharp, "Le Fonctionnement Mixte du Turbostatoreacteur," in AGARD CP-9-1, 1966, pp. 183-218.

41. Chansler, R. C. "Hypersonic Research Engine (HRE) Project, Phase 2A, Nozzle Program, Terminal Summary Report," NASA-CR-101532, December 1968.

42. Staid, P. S., "Wind Tunnel Performance Tests of Coannular Plug Nozzles," NASA CR 2990, April 1978.

43. Wasko, R. A., "Performance of Annular Plug and Expansion-Deflection Nozzles Including External Flow Effects at Transonic Mach Numbers," NASA TN D-4462, April 1968.

44. Head, V. L., "Flight Investigation of Installation Effects on a Plug Nozzle with a Series of Boattailed Primary Shrouds Installed on an Underwing Nacelle," NASA TM X-2983, February 1974.

45. Harrington, D. E., S. M. Nosek, and D. M. Straight," Cold-Flow Performance of Several Variations of a Ram-Air-Cooled Plug Nozzle for Supersonic-Cruise Aircraft," NASA TM X-3110, October 1974.

46. Berrier, B. L., and C. E. Mercer, "Off-Design Performance of Two Isentropic Plug Nozzles Designed for a Pressure Ratio of 16.5," NASA TN D-3852, March 1967.

47. Wasko, R. A. and D. E. Harrington, "Performance of a Collapsible Plug Nozzle Having Either Two-Position Cylindrical or Variable Angle Floating Shrouds at Mach Numbers from 0 to 2.0," NASA TM X-1657, October 1968.

48. Mercer, C. B. and L. B. Salters, "Performance of a Plug Nozzle Having a Concave Central Base With and Without Terminal Fairings at Transonic Speeds," NASA TN D-1804, May 1963.

49. Valerino, A. S., R. F. Zappa, and K. L. Abdalla, "Effects of External Stream on the Performance of Isentropic Plug-Type Nozzles at Mach Numbers of 2.0, 1.8, and 1.5," NASA MEMO 20-17-59E, March 1959.

50. Hearth, D. P. and G. C. Gorton, "Investigation of Thrust and Drag Characteristics of a Plug-Type Exhaust Nozzle," NASA RM E53L16, February 1954.

ORIGINAL PAGE IS
OF POOR QUALITY

51. Stoddard, J. A. P., "Jet Effects on Boattail Pressure Drag at Supersonic Speeds," in AGARD-CP-91-71, "Inlets and Nozzles for Aerospace Engines," December 1971, pp. 23/1-23/11.

52. Glasgow, E. R., J. S. Divita, P. C. Everling and J. A. Laughrey, "Analytical and Experimental Evaluation of Performance Prediction Methods Applicable to Exhaust Nozzles," AIAA Paper No. 71-719, June 1971.

53. Migdal, D., "Supersonic Annular Nozzles," AIAA Paper No. 71-43, January 1971.

54. Gaede, A. E. and J. J. Lopez, "Selection of Nozzle Contours for a Research Scramjet Engine," AIAA Paper No. 67-453, July 1967.

55. Keenan, Joseph H., and J. Kaye, Gas Tables, John Wiley and Sons, Inc., 1948.

56. Banes, B., R. W. McIntyre, and J. A. Sims, "Properties of Air and Combustion Products with Kerosine and Hydrogen Fuels," Bristol Siddeley Engines Limited, 1967.

57. Powell, H. N., and S. N. Suciu, E., Properties of Combustion Gases/System: C_nH_{2n}-Air, McGraw-Hill Company, Inc., 1955.

58. Brown, W. G. and D. L. Warlick, "Properties of Combustion Gases/System: H_2-Air," General Electric Report R62FPD-366, 1962.

59. Pinkel, B. and R. L. Turner, "Thermodynamic Data for the Computation of the Performance of Exhaust-Gas Turbines," ARR No. 4B25, October 1945.

60. Osgerby, I. T. and R. P. Rhodes, "An Efficient Numerical Method for the Calculation of Chemical Equilibrium in the H/C/O/N/A System," AEDC-TR-71-256, April 1972.

61. Gordon, S. and B. J. McBride, "Computer Program for Calculation of Complex Chemical Equilibrium Compositions, Rocket Performance, Incident and Reflected Shocks, and Chapman-Jouget Detonation," NASA SP 273, 1971.

62. Pelton, J. M., "A Computer Model for the Calculation of Thermodynamic Properties of Working Fluids of A Gas Turbine Engine," AEDC-TR-76-15, March 1976.

63. Mascitti, V. R., "A Simplified Equilibrium Hydrocarbon-Air Combustion Gas Model for Use in Air-Breathing Engine Cycle Computer Programs," NASA TN D-4747, 1968.

64. Stull, D. R. and H. Prophet, JANAF Thermochemical Tables, Second Edition, U. S. Government Printing Office, June 1971.

65. Caddy, M. J. and S. R. Shapiro, "NEPCOMP-The Navy Engine Performance Computer Program, Version I," Report No. NADC-74045-30, April 1975.

ORIGINAL PAGE IS OF POOR QUALITY

ORIGINAL PAGE IS
OF POOR QUALITY

PRECEDING PAGE BLANK NOT FILMED

APPENDICES

ORIGINAL PAGE IS
OF POOR QUALITY

APPENDIX A

MODIFIED QNEP ENGINE CODE

USERS' GUIDE

USERS' GUIDE

The increased capabilities of the modified QNEP engine code to treat hydrogen or hydrocarbon fuel, to model the effect of the forebody flowfield, and to incorporate typical installational losses require extension of the standard QNEP component data input 14,65 . The modification of the CDAT inputs for the inlet to allow treatment of the forebody effect are described in Section C1 of this report.

The eleventh and twelth CDAT inputs for the duct/burner/afterburner are used to control the choice and condition of the fuel. CDAT (11,JCX) is the input for the carbon-to-hydrogen ratio of the fuel; it is zero for H_2 fuel, and can take on various values for hydrocarbon fuels. A value of 0.52456 corresponds to the hydrocarbon fuel used in THERM. The eleventh CDAT input is the entry temperature of the H_2 fuel (^{o}R) and provides a means for specifying heating of the fuel before entry to the combustor.

The eleventh CDAT input for the nozzle is used to specify the ratio of maximum nacelle cross-sectional area to throat area (A_{max}/A_{throat}) at the design point. This factor was used in calculating the afterbody drag coefficient of the plug nozzle.

APPENDIX B

MODIFIED QNEP ENGINE CODE

PROGRAM LISTING

PRECEDING PAGE BLANK NOT FILMED

```
COMEP
C***  NON VARIABLE GEOMETERY                                          EP  0002
C***                                                                  EP  0003
      IMPLICIT REAL*8(A-H,O-Z)
      INTEGER AWD,BWD
      COMMON WTF(30),TOPRES(30),TOTERR(30),FAR(30),CORFLO(30),VMACH(30) EP  0005
      COMMON STATP(30),ERROR(30),DATINP(15,40),DATOUT(9,40)
      COMMON DEFV(15),DTOL(15),PERPF(12),TOL,TOLT,TOLTT
      COMMON JM1,JM2,JP1,JP2,JCX,LOCTBL(9,40)
      COMMON JFIG(5,40),JFLOW(50),IDEVAP(14),JCOMP(50),NIT,IWAY
      COMMON KKINDS(15,25),NCOMP,NOSTAT,NITER,NFINIS,NPASS,JCC,NCTS
      COMMON JCIND(15),JCDEP(15),JCVIND(15),JCVDEP(15),KDTYP(15)
      COMMON RCH
      DIMENSION SAVE(15,2)
      DIMENSION XMA(16),TDEL(7),ERR(15)                               EP  0012
      COMMON/NEPOPT/SELAST,DD,NDSET,NPARTS,IOPTP,NPASSD,NVOPT,NJOPT,  NEP20002
     1TOLOPT,NOPT
      COMMON/OUT/TDEL,XMA,ALT,WMAX,PUNCHD,TIT,JCB,JN1,JN2,IDESN,IPRINT,
     2 JCAB2,JCAB1,NP,NN
      DIMENSION THP(7),WFD(7)
      DATA IPS,ITT /0,.002D0/
      DATA AWD,BWD /'TSFC','BSFC'/
C                                                                     EP  0016
C***  TABLE 1 IS NON-DIMENSIONAL REFERRED FLOW LIMIT VS THETA2        EP  0017
C                                                                     EP  0018
C     DO 7 I=1,7
C  7  TDEL(I)=0.0D0
C     TIT=0.0D0
C     PUNCHD=0.0D0
      CALL NEPSUB                                                     EP  0020
      NPLUS=NCOMP+1                                                   EP  0021
      IDESN=1                                                         EP  0022
      SELAST=0.0D0
      RCH=DATINP(11,JCB)
      CALL GOMEP                                                      EP  0023
      WMAXD=CORFLO(2)/1.549695676D0
C*** SET PRESSURE DROPS AS FUNCTIONS OF C FLOW**2                     EP  0024
      N=KKINDS(2,1)                                                   EP  0025
      DO 10 I=1,N                                                     EP  0026
      JCX=KKINDS(2,I+1)                                               EP  0027
      IF(JCX.NE.JCB)  DATINP(5,JCX)=0.                                EP  0028
      JS=JFIG(2,JCX)                                                  EP  0029
      DATINP(3,JCX)=DATOUT(2,JCX)/CORFLO(JS)**2.0D0                     EP
      DATINP(1,JCX)=0.0D0                                             EP  0
      DATINP(2,JCX)= 0.0D0                                            EP  0
   10 CONTINUE                                                        EP  0033
C*** ACTIVATE ALL CONTROLS                                            EP  0034
      N=KKINDS(12,1)                                                  EP  0035
      DO 20 I=1,N                                                     EP  0036
      JCX=KKINDS(12,I+1)                                              EP  0037
   20 DATINP(1,JCX)=1.0D0                                             EP  0
C*** CALL IN THE INPUT PRINT                                          EP  0039
C*** SET TIT TO DESIGN INPUT VALUE                                    EP  0040
      TID=DATINP(4,JCB)
C*** SET UNUSED COMPONENTS TO ZERO FOR PRINTING PURPOSES              EP  0042
      IF(JN2.NE.0) GO TO 30                                           EP  0043
      JN2=NPLUS                                                       EP  0044
      JSN2=NOSTAT+1                                                   EP  0045
      IF(JBPR.EQ.0) JBPR=NPLUS                                        EP  0046
   30 JSN2=JFIG(2,JN2)                                                EP  0047
      JBPR=KKINDS(7,2)                                                EP  0048
      JSN1=JFIG(2,JN1)                                                EP  0049
      JSH=JFIG(4,JCB)                                                 EP  0050
```

```
      IA=0                                                              EP  0051
      CALL FINPRT                                                       EP  0052
      IDESN=0                                                           EP  0053
      PRINT 40,IDEDAP                                                   EP  0054
   40 FORMAT(1H1,20A4,/)
   50 CALL  NPREAD                                                      EP  0056
      IF(WMAX.LE.0.0D0) WMAX=1.0D10                                        EP
C     IF(DABS(WMAX-WMAXD).LE.1.0D-4) WMAXD=WMAX
      IF(WMAX.LT.WMAXD)  PRINT 51
   51 FORMAT(' WARNING INPUT VALUE WMAX IS LESS THAN DESIGN')
      IF(JCAB1.EQ.0) JCAB1=NPLUS                                        EP  0058
      IF(JCAB2.EQ.0) JCAB2=NPLUS                                        EP  0059
      EFF1=DATINP(   ,JCAB1)                                            EP  0060
      EFF2=DATINP(5,JCAB2)                                              EP  0061
      IF(TIT.LE.0.0D0) TIT=TID
      IPS=IPS+5                                                         EP  0062
      IF((IPS+NP+1).LT.40) GO TO 60                                     EP  0063
      IPS=0                                                             EP  0064
      PRINT 40,IDEDAP                                                   EP  0065
   60 IPS=IPS+NP+1                                                      EP  0066
      ISFC=BWD
      IF(PERPF(2).NE.0.0D0) ISFC=BWD
      PRINT 70,ISFC                                                     EP  0069
   70 FORMAT(T3,'ALTITUDE', T13,'MACH', T19,' FN ', T26,'BSHP', T34,    EP  0070
     1 'WF', T39,A4     , T45,'REF FLOW', T54,'BPR', T60,'BOT', T65,    EP  0071
     2 'T19', T72,'PR19', T78,'A19', T85,'T9', T91,'PR9', T97,'A9',     EP  0072
     3 T104,'RN', T109,'NIT')                                           EP  0073
      IA=IA+1
      IF(PUNCHU.EQ.0.0D0)  GO TO 72
      MP=NM
      IF(NM.GT.7) MP=7
      PUNCH 301  ,NM,(XMA(I),I=1,MP)
  301 FORMAT('MACH',4X, I2,7(1X,F9.4))
      IF(NM.GT.7) PUNCH 302,(XMA(I),I=8,NM)
  302 FORMAT(10X,7(1X,F9.4))
   72 DO 230 IM=1,NM                                                    EP  0075
      Td1=DATINP(4,JCAB1)                                               EP  0076
      Td2=DATINP(4,JCAB2)                                               EP  0077
      IF(IM*IA.EQ.1) GO TO 90                                           EP  0078
      DO 80 ISS=1,N
      JCX=KKINDS(12,ISS+1)
      IF(DFIG(4,JCX).EQ.1.AND.DATINP(4,JCX).EQ.1.0D0) JJJ=JCX
      ISV=1
      IF(IM.EQ.1.AND.IA.NE.1) ISV=2
   80 DATOUT(1,JCX)=SAVE(ISS,ISV)
            J41=1                                                       EP  0081
                  JP1=2                                                 EP  0081
      JCX=1                                                             EP  0081
      DATINP(9,1)=ALT                                                   EP  0082
      DATINP(5,1)=XMA(IM)                                               EP  0083
C*** SAVE SCALE FACTOR ON RECOVERY TABLE REFERRED FLOW                  EP  0084
      RFC=DATINP(4,1)                                                   EP  0085
      DATINP(4,1)=.00001D0                                                EP  00
      CALL INLET                                                        EP  0089
      DATINP(4,1)=RFC                                                   EP  0087
      DATOUT(1,JJJ)=CSAVE*TOPRES(2)/DSQRT(TOTEMP(2))
C*** RESET ALTITUDE AND SET MACH NO.                                    EP  0090
   90 DATINP(9,1)=ALT                                                   EP  0091
      DATINP(5,1)=XMA(IM)                                               EP  0092
      T=TIT                                                             EP  0093
C*** SET A/B EFF OFF....                                                EP  0094
      IT=1                                                              EP  0095
      DATINP(5,JCAB1)=0.0D0                                               EP  0
      DATINP(5,JCAB2)=0.0D0                                               EP  0
      NN=0                                                              EP  0098
  100 DATINP(4,JCB)=T                                                   EP  0099
```

B.2.

```
      DT=-100.0D0                                                       EP  0
      SELAST=0.0D0
  110 CALL GONEP                                                       EP  0101
      IF(NIT.EQ.50) GO TO 140
      THET2=DATOUT(8,1)                                                EP  0103
      IF(AMAX.EQ.1.0D10)  GO TO 160
      REFMAX=AMAX                                                      EP  0105
      IF(THET2.GE.1.0D0) GO TO 120                                       EP  01
      CALL TABLU(1,THET2,Y,0.0D0,RATIO)                                   EP  0
      REFMAX=REFMAX*RATIO                                              EP  0108
  120 REF =COMFLD(2)/1.549695676D0                                       EP  01
      IF(N.NE.0) GO TO 130                                             EP  0110
      IF(REF.LT.REFMAX) GO TO 140                                      EP  0111
  130 DY=(REF-REFMAX)/REFMAX                                           EP  0112
      CALL SNEST (N,DY,DATINP(4,JCB),DT,TTT,ABDS,DYL,ABB,XCK,          EP  0113
     1 IOMFLD# SCHED  )                                                EP  0114
      IF(N.NE.0) GO TO 110                                             EP  0115
  140 IF(IPRINT.EQ.1) CALL FINPRT                                      EP  0116
      IF(II.GE.1) GO TO 160                                            EP  0117
      CSAVE=COMFLD(2)                                                  EP  0118
      DO 150 ISS=1,N
      JCX=MAINDS(12,ISS+1)
      IF(IP.EQ.1) SAVE(ISS,2)=DATOUT(1,JCX)
  150 SAVE(ISS,1)=DATOUT(1,JCX)
      IF((EFF1+EFF2).GT.0.0D0) GO TO 190                                 EP  0
  160 T=DATINP(4,JCB)                                                  EP  0122
      T=T     =TOEL(IT)                                                EP  0123
  170 T9=TOTEMP(JSN1)                                                  EP  0124
      T19=TOTEMP(JSN2)                                                 EP  0125
      PR9=DATOUT(9,JN1)                                                EP  0126
      PR19=DATOUT(9,JN2)                                               EP  0127
      REF =COMFLD(2)/1.549695676D0                                       EP  01
      BPR     =DATOUT(1,JBPR)                                          EP  0129
      E4      =PERPF(1)                                                EP  0130
      SFC=PERPF(4)                                                     EP  0131
      IF(PERPF(2).NE.0.0D0) SFC=PERPF(5)                                 EP  0
      PRINT 180,DATOUT(9,1),DATINP(5,1),FN,PERPF(2),PERPF(6),SFC,REF,  EP  0133
     1 DATOUT(1,JBPR),TOTEMP(JSB),T19,PR19,DATOUT(5,JN2)               EP  0134
     2,T9,PR9,DATOUT(5,JN1),DATOUT(7,1),NIT                            EP  0135
  180 FORMAT(T3,F7.0, T12,F5.3, T18,F7.0, T25,F3.0, T32,F7.0, T39,F5.3, EP  0136
     1 T45,F6.1, T52,F6.3, T59,F5.0, T65,F5.0, T71,F6.3, T78,F5.0,     EP  0137
     2 T84,F5.0, T89,F7.2, T97,F5.0, T103,F5.3, T109,I3)               EP  0138
      IF(FN.LE.0.0D0.OR.NIT.EQ.50) GO TO 609
      THR(IT)=FN
      WFD(IT)=PERPF(6)
      IP=IT
  609 IT=IT+1                                                          EP  0139
      IF(IT.LE.NP.AND.NIT.NE.50.AND.FN.GT.0.0D0) GO TO 189
      IF(PUNCHU.EQ.0.0D0)  GO TO 230
      PUNCH 611       ,IP,(THR(I),I=1,IP)
  611 FORMAT('THR ',4X,I2, 7(1X,F9.1))
      PUNCH 621       ,IP,(WFD(I),I=1,IP)
  621 FORMAT('WFD ',4X,I2, 7(1X,F9.1))
      GO TO 230
  189 IF((EFF1+EFF2).LE.0.0D0) GO TO 100                                 EP  0
  190 JCAB=JCAB1                                                       EP  0142
      JN=JN1                                                           EP  0143
      EFF=EFF1                                                         EP  0144
      TB=TB1                                                           EP  0145
  200 IF(EFF.LE.0.0D0) GO TO 210                                         EP  0
      DATINP(5,JCAB)=EFF                                               EP  0147
      TBS=DATINP(4,JCAB)                                               EP  0148
      DATINP(4,JCAB)=TB                                                EP  0149
      DATINP(7,JN)=1.0D0                                                 EP  0
      CALL FLOCAL(JCAB,SS,ERR)                                         EP  0151
      IF(IPRINT.NE.0) CALL FINPRT
```

B.3.

```
      DATINP(7,JN)=0.0D0                                                EP  0
      DATINP(4,JCAB)=TBS                                              EP  0153
  210 IF(EFF.EQ.EFF2) GO TO 220                                       EP  0154
      EFF=EFF2                                                        EP  0155
      JCAB=JCAB2                                                      EP  0156
      JN=JN2                                                          EP  0157
      Io=Io2                                                          EP  0158
      GO TO 200                                                       EP  0159
  220 Io1=Io1-IDEL(IT)                                                EP  0160
      Io2=Io2-IDEL(IT)                                                EP  0161
      JSUB=JPIG(2,JCAB1)
      IF(EFF1.GT.0.0D0.AND.TB1.LT.TOTEMP(JSUB          ))GO TO 230      EP  0
      JSUB=JPIG(2,JCAB2)
      IF(EFF2.GT.0.0D0.AND.TB2.LT.TOTEMP(JSUB          ))GO TO 230      EP  0
      GO TO 170                                                       EP  0164
  230 CONTINUE                                                        EP  0165
      GO TO 50                                                        EP  0166
      END                                                             EP  0167
CBOTMX
      SUBROUTINE BOTMX(X,N,IPRINT,AC1)                                BOTX0001
      IMPLICIT REAL*8(A-H,O-Z)
      COMMON/NEPOPT/SELAST,DD,NDSET,NPARTS,IOPTP,NPASSO,NVOPT,NJOPT,  NEP20002
     1TOLOPT,NOPT
      DIMENSION X(1100)
      DIMENSION DIRECT(10,10),S(10),BEFORE(10),Y(10),XL(10),SMM(10)
      STEP=1.0D0                                                        BOTX0
      FL=1.0D35                                                        BOTX00
      SF=.05D0                                                         BOTX00
      SM=.0100                                                         BOTX00
      ITEM=-1                                                         BOTX0009
      M1=N-1                                                          BOTX0010
      DO 20 I=1,N                                                     BOTX0011
      DO 10 J=1,N                                                     BOTX0012
   10 DIRECT(J,I)=0.0D0                                                 BOTX0
      SMM(I)=1.0D0                                                        BOTX0
   20 DIRECT(I,I)=1.0D0                                               BOTX0015
      CALL FUN(X,FX)                                                  BOTX0016
   30 ITER=ITER+1                                                     BOTX0017
      IF(IPRINT.EQ.1) PRINT 40,ITER        ,FX,(X(I),I=1,N)           BOTX0018
   40 FORMAT(1X, I7,D16.8,(5D16.8))                                   BOTX0019
      F1=FX                                                           BOTX0020
      DO 50 I=1,N                                                     BOTX0021
   50 BEFORE(I)=X(I)                                                     BOTX0
      SUM=0.0D0                                                       BOTX0023
      DO 120 I=1,N                                                         BOTX0
      SMAX=0.0D0                                                      BOTX0025
      DO 60 J=1,N                                                     BOTX0026
      S(J)=DIRECT(J,I)*STEP
      IF(DABS(S(J)).GT.SMAX) SMAX=DABS(S(J))                          BOTX0028
   60 CONTINUE
      DD=0.0D0                                                             BOTX0
      DELX=1.0D0
      IF(SMAX.EQ.0.0D0) GO TO 120                                     BOTX0031
      IF(SMAX.GT.SF) DELX=SF/SMAX                                     BOTX0032
      IF(SMAX.LT.SM) DELX=SM/SMAX
      IF(SMM(I).LT.1.0D0) DELX=DELX*SMM(I)
      PRINT 666,DELX,SMM(I)
  666 FORMAT(' DELX=',D13.5,' SMM=',D13.5)
      II=0                                                            BOTX0033
      F1=FX                                                           BOTX0034
C**** MOD                                                             BOTX0035
      NDSET=0                                                         BOTX0036
      GO TO 90                                                        BOTX0037
   70 DO 80 K=1,N                                                     BOTX0038
   80 Y(K)=X(K)+DD*S(K)
      CALL FUN(Y,FY)                                                  BOTX0040
```

ORIGINAL PAGE IS
OF POOR QUALITY

OF POOR QUALITY

```
   90 CALL MIN4PT(IT,DD,FY,DELX,FMAX,AC1)
      IF(IT.NE.0) GO TO 70
      PRINT 777,SM,SMAX,FY,FX,FMAX                                    BOTX0042
  777 FORMAT(5D13.5)
      IF(FMAX.LT.(100.000*AC1+FY)) GO TO 91
C*** FUNCTION IS VERY STEEP ...DECREASE NEXT INTERVAL
      SMM(I)=SMM(I)*.500
   91 IF(FMAX.LT.(3.000*AC1+FY)) SMM(I)=SMM(I)*1.5000
C*** FUNCTION IS NEAR OR IN NOISE LEVEL INCREASE INTERVAL
      A=FX-FY
      IF(A.GE.SUM) GO TO 100                                          BOTX0043
      ISAVE=I                                                         BOTX0044
      SUM=A                                                           BOTX0045
  100 DO 110 J=1,N                                                    BOTX0046
  110 X(J)=Y(J)                                                       BOTX0047
  120 FX=FY                                                           BOTX0048
C****   ONE VARIABLE QUICK EXIT                                       BOTX0049
      IF(N.EQ.1)  RETURN
      F2=FY
      FC=FX                                                           BOTX0050
      IF(IFIRM.EQ.0) GO TO 220
      DO 130 I=1,N                                                    BOTX0051
  130 Y(I)=2.000*X(I)-BEFORE(I)                                       BOTX0052
C*** MOD                                                              BOTX0
      MODEI=-1                                                        BOTX0054
      CALL FUN(Y,F3)                                                  BOTX0055
      FC=F3                                                           BOTX0056
      A=F3-F1                                                         BOTX0057
      IF(A.GE.0.000) GO TO 220                                        BOTX0058
      A=2.000*(F1-2.000*F2+F3)*((F1-F2-SUM)/A)**2.000                 BOTX0
      IF(A.GE.SUM) GO TO 220
      IF(ISAVE.GE.N) GO TO 150                                        BOTX0061
      DO 140 I=ISAVE,N1                                               BOTX0062
      II=I+1                                                          BOTX0063
      DO 140 J=1,N                                                    BOTX0064
  140 DIRECT(J,I)=DIRECT(J,II)                                        BOTX0065
  150 A=0.000                                                         BOTX0066
      DO 160 J=1,N                                                    BOTX0
      DIRECT(J,N)=X(J)-BEFORE(J)                                      BOTX0068
  160 A=DIRECT(J,N)**2.000+A                                          BOTX0069
      IF(A.NE.0.000)  GO TO 161                                       BOTX
      PRINT 162
  162 FORMAT(' CONVERGENCE HAS TERMINATED-NOISE, OR TIGHT TOLERANCE')
      GO TO 260
  161 A=1.000/DSQRT(A)
      SMAX=0.000
      DO 170 J=1,N                                                    BOTX0
      DIRECT(J,N)=DIRECT(J,N)*A                                       BOTX0073
      S(J)=DIRECT(J,N)*STEP                                           BOTX0074
      IF(DABS(S(J)).GT.SMAX) SMAX=DABS(S(J))                          BOTX0075
  170 CONTINUE
      DU=0.000                                                        BOTX0077
      DELX=1.000
      IF(SMAX.GT.SF) DELX=SF/SMAX                                     BOTX0
      IF(SMAX.LT.SM) DELX=SM/SMAX                                     BOTX0080
C**** MOD                                                             BOTX0081
      MODEI=0                                                         BOTX0082
      GO TO 200                                                       BOTX0083
  180 DO 190 I=1,N                                                    BOTX0084
  190 Y(I)=X(I)+DELX*S(I)                                             BOTX0085
      CALL FUN(Y,FX)
  200 CALL MIN4PT(IT,DD,FX,DELX,FMAX,AC1)                             BOTX0087
      IF(IT.NE.0) GO TO 180
      FC=FX                                                           BOTX0089
      DO 210 I=1,N                                                    BOTX0090
  210 X(I)=Y(I)                                                       BOTX0091
                                                                      BOTX0092
```

ORIGINAL PAGE IS
OF POOR QUALITY

ORIGINAL PAGE IS

```
  220 FF=1.0D0                                                          BOTX0
      FB=FL                                                            BOTX0094
      IF(FX.GE.FL) GO TO 240                                           BOTX0095
      FL=FX                                                            BOTX0096
      DO 230 I=1,N                                                     BOTX0097
  230 XL(I)=X(I)                                                       BOTX0098
      GO TO 250                                                        BOTX0099
  240 NOSET=-1                                                         BOTX0100
C****   MOD  FOR NOISE                                                 BOTX0101
      FP=FL                                                            BOTX0102
      CALL FUN(XL,FL)                                                  BOTX0103
      IF(DABS(2.0D0*(FP-FL)/(FL+FP)).GT.AC1)  GO TO 260
      FB=FL                                                            BOTX0105
  250 IF(DABS(FB).GT.AC1) FF=FB
      IF(DABS((FB-FX)/FF).GT.AC1) GO TO 270
  260 CONTINUE                                                         BOTX0108
      IF(IPRINT.EQ.1) PRINT 40,ITER,FL,(XL(I),I=1,N)                   BOTX0109
      IF(FL.EQ.FC) RETURN                                              BOTX0110
      CALL FUN(XL,FL)                                                  BOTX0111
      RETURN                                                           BOTX0112
  270 STEP=.40D*DSQRT(DABS(FL-FX))
      IF(FL.LT.FX) STEP=-STEP                                          BOTX0114
      IF(STEP.GT.1.0D0) STEP=1.0D0                                         8
      SF=.025D0                                                         BOTX01
      GO TO 30                                                         BOTX0117
      END                                                              BOTX0118
CCOMPR
      SUBROUTINE COMPRS                                                COMP0001
      IMPLICIT REAL*8(A-H,O-Z)
      COMMON WIP(30),TOPRES(30),TOTEMP(30),FAR(30),CORFLO(30),VMACH(30) EP  0005
      COMMON STATP(30),FPROR(30),DATINP(15,40),DATOUT(9,40)
      COMMON DELY(15),DTOL(15),PERPF(12),TOL,TOLT,TOLTT
      COMMON JM1,JM2,JP1,JP2,JCX,LOCTBL(9,40)
      COMMON JFIG(5,40),JFLOW(50),IDECAP(14),JCOMP(50),NIT,IWAY
      COMMON KKINDS(15,25),NCOMP,NOSTAT,NITER,NFINIS,NPASS,JCC,NCTS
      COMMON JCIND(15),JCDEP(15),JCVIND(15),JCVDEP(15),KDTYP(15)
      COMMON RCH
      FAR1=FAR(JM1)                                                    COMP0006
      T1=TOTEMP(JM1)                                                   COMP0007
      TP1=TOPRES(JM1)                                                  COMP0008
      FAR(JP1)=FAR1                                                    COMP0009
      FAR(JP2)=FAR1                                                    COMP0010
      NCOR=LOCTBL(4,JCX)                                               COMP0011
      NEFF=LOCTBL(6,JCX)                                               COMP0012
      NPR=LOCTBL(8,JCX)                                                COMP0013
      RT=DATINP(1,JCX)                                                 COMP0014
      VGP=DATINP(10,JCX)                                               COMP0015
      SQT1=1.0D0/DSQRT(T1)
      CRPM=DATOUT(2,JCX)*22.77432765D0*SQT1                              COMP00
      IF(IWAY.EQ.0) GO TO 10                                           COMP0018
      CRPMT=DATINP(14,JCX)                                             COMP0019
      DATINP(3,JCX)=CRPM/CRPMT                                         COMP0020
      GO TO 20                                                         COMP0021
   10 CRPMT=CRPM/DATINP(3,JCX)                                         COMP0022
   20 CORFT=DATINP(4,JCX)                                              COMP0023
      IF(NCOR.GT.0) CALL TABLU(NCOR,RT,CRPMT,VGP,CORFT)                COMP0024
      CORFT=CORFT*1.5396956760D0                                         COMP00
      PRT=DATINP(8,JCX)                                                COMP0026
      IF(NPR.GT.0) CALL TABLU(NPR ,RT,CRPMT,VGP,PRT)                   COMP0027
      EFFT=DATINP(6,JCX)                                               COMP0028
      IF(NEFF.GT.0) CALL TABLU(NEFF,RT,CRPMT,VGP,EFFT)                 COMP0029
      IF(IWAY.EQ.0) GO TO 30                                           COMP0030
      CORFF=CORFLO(JM1)                                                COMP0031
      DATINP(5,JCX)=CORFF/CORFT                                        COMP0032
      EFF=DATINP(12,JCX)                                               COMP0033
      DATINP(7,JCX)=EFF/EFFT                                           COMP0034
```

ORIGINAL PAGE OF POOR QUALITY

B.6

```
      PR=DATINP(13,JCX)                                                 COMP0035
      DATINP(9,JCX)=(PR-1.0D0)/(PRT-1.0D0)                                    CO
      GO TO 40                                                          COMP0037
   30 PR=DATINP(9,JCX)*(PRT-1.0D0)+1.0D0                                      CO
      EFF=EFFT*DATINP(7,JCX)                                            COMP0039
      COREF=COREF*DATINP(5,JCX)                                         COMP0040
   40 WT1=COREF*TP1*SQT1                                                COMP0041
      WTF(JP2)=WT1*DATINP(2,JCX)                                        COMP0042
      WTF(JP1)=WT1-WTF(JP2)                                             COMP0043
      ER=1.0D0-DATINP(11,JCX)                                              COMP0
      P2=TP1*PR
      CALL THERMO (T1,TP1,H1,S1,1,RCH,FAR1,T2,H2,P2,0,GAM,RR)
      DH1=H2-H1                                                         COMP0050
      DHA=DH1/EFF                                                       COMP0051
      H3=H1+DHA                                                         COMP0052
      CALL THERMO (T2,P2,H3,SS,6,RCH,FAR1,ZERO,ZERO,ZERO,0,GAM,RR)
      TOTEMP(JP1)=T2
      IF(WTF(JP2).LE.0.0D0) GO TO 70                                       COMP0
      IF(ER.LT.1.0D0) GO TO 50                                             COMP0
      TB=TOTEMP(JP1)                                                    COMP0056
      DHBLD=DHA                                                         COMP0057
      PRB=PR*TP1
      GO TO 60                                                          COMP0059
   50 H4I=DH1*ER+H1                                                     COMP0060
      CALL THERMO (T1,TP1,H1,S1,4,RCH,FAR1,T4I,H4I,PRB,4,GAM,RR)
      DHBLD=DHA*ER                                                      COMP0064
      H4=H1+DHBLD                                                       COMP0065
      CALL THERMO (TB,PRB,H4,SS,6,RCH,FAR1,ZERO,ZERO,ZERO,0,GAM,RR)
   60 HPB=-1.415D0*WTF(JP2)*DHBLD                                         COMP00
      GO TO 80                                                          COMP0068
   70 HPB=0.0D0                                                            COMP0
      TB=0.0D0                                                             COMP0
      PRB=0.0D0                                                            COMP0
   80 HPC=-1.415D0*WTF(JP1)*DHA+HPB                                        COMP00
      TOTEMP(JP2)=TB                                                    COMP0073
      TOPRES(JP2)=PRB
      WTF(JP1)=WT1                                                      COMP0075
      CORFLO(JP1)=COREF                                                 COMP0076
      TOPRES(JP1)=TP1*PR
      CORFLO(JP1)=WTF(JP1)*DSQRT(TOTEMP(JP1))/TOPRES(JP1)
      DATOUT(1,JCX)=HPC                                                 COMP0079
      DATOUT(3,JCX)=VGP                                                 COMP0080
      DATOUT(4,JCX)=HI                                                  COMP0081
      DATOUT(5,JCX)=DATINP(3,JCX)                                       COMP0082
      DATOUT(6,JCX)=CRPMT                                               COMP0083
      DATOUT(7,JCX)=DATINP(5,JCX)                                       COMP0084
      DATOUT(8,JCX)=EFF                                                 COMP0085
      DATOUT(9,JCX)=PR                                                  COMP0086
      RETURN                                                            COMP0087
      END                                                               COMP0088
CCONFIG
      SUBROUTINE CONFIG                                                 CFIG0001
      IMPLICIT REAL*8(A-H,O-Z)
      COMMON WTF(30),TOPRES(30),TOTEMP(30),FAR(30),CORFLO(30),VMACH(30) EP  0005
      COMMON STATP(30),ERROR(30),DATINP(15,40),DATOUT(9,40)
      COMMON DEPV(15),DTOL(15),PERPF(12),TOL,TOLT,TOLTT
      COMMON JM1,JM2,JP1,JP2,JCX,LOCTBL(9,40)
      COMMON JFIG(5,40),JFLOW(50),IDEDAP(14),JCOMP(50),NIT,IWAY
      COMMON KKINDS(15,25),NCOMP,NOSTAT,NITER,NFINIS,NPASS,JCC,NCTS
      COMMON JCIND(15),JCDEP(15),JCVIND(15),JCVDEP(15),KDTYP(15)
      DIMENSION JCOS(30),JCCS(30),JPASS(25),JPASS1(25),JHEATX(25)       CFIG0007
C     ASSEMBLE NUMBERS AND KINDS OF COMPONENTS                          CFIG0008
      DO 10 IC=1,15
      DO 10 JC=1,25
   10 KKINDS(IC,JC)=0
      DO 30 IC=1,NCOMP                                                  CFIG0011
```

```
      JT=JFIG(1,IC)                                                     CFIG0012
      IF(JT.GT.15.OR.JT.LT.1) PRINT 20,IC
   20 FORMAT(' CONFIGURATION DATA, JFIG(1,',I2,') IS IN ERROR')         CFIG0014
      JNO=KKINDS(JT,1)                                                  CFIG0015
      KKINDS(JT,1)=JNO+1                                                CFIG0016
      JNO=JNO+                                                          CFIG0017
   30 KKINDS(JT,JNO)=IC                                                 CFIG0018
C     OBTAIN ARRAY OF ALL COMPONENTS WHICH ARE IN FLOW                  CFIG0019
      JCC=0                                                             CFIG0020
      NS=KKINDS(11,1)                                                   CFIG0021
      DO 80 I=1,NCOMP                                                   CFIG0022
C*** CHECK FOR SHAFT CONNECTION TO ALL ROTATING COMPONENTS              CFIG0023
      JT=JFIG(1,I)                                                      CFIG0024
      IF(JT.NE.4.AND.JT.NE.5.AND.JT.NE.10) GO TO 70                     CFIG0025
      IF(NS.EQ.0) GO TO 50                                              CFIG0026
      DO 40 J=1,NS                                                      CFIG0027
      JCX=KKINDS(11,J+1)                                                CFIG0028
      DO 40 K=2,5                                                       CFIG0029
      IF(JFIG(K,JCX).EQ.I) GO TO 70                                     CFIG0030
   40 CONTINUE                                                          CFIG0031
   50 PRINT 60,I,(KKINDS(11,K+1),K=1,NS)                                CFIG0032
   60 FORMAT(' WARNING COMPONENT ',I3,' MUST HAVE A CONNECTION TO ONE OFCFIG0033
     1 THE FOLLOWING SHAFTS ',10(I2,' OR '))                            CFIG0034
   70 IF(JT.GT.4.OR.JT.EQ.0) GO TO 80                                   CFIG0035
      JCC=JCC+1                                                         CFIG0036
      JCOMP(JCC)=I                                                      CFIG0037
   80 CONTINUE                                                          CFIG0038
C     GET ALL COMPONENTS IN TERMS OF THEIR STATION                      CFIG0039
      DO 110 I=1,NOSTAT                                                 CFIG0040
      JCUS(I)=0                                                         CFIG0041
      JCDS(I)=0                                                         CFIG0042
      DO 90 J=1,JCC                                                     CFIG0043
      JJ=JCOMP(J)                                                       CFIG0044
      IF(JFIG(4,JJ).EQ.I.OR.JFIG(5,JJ).EQ.I) JCUS(I) = JJ               CFIG0045
      IF(JFIG(2,JJ).NE.I.AND.JFIG(3,JJ).NE.I) GO TO 90                  CFIG0046
      JCDS(I)=JJ                                                        CFIG0047
      IF(JCUS(I).NE.0) GO TO 110                                        CFIG0048
   90 CONTINUE                                                          CFIG0049
      IF((JCDS(I)+JCUS(I)).EQ.0) PRINT 100,I                            CFIG0050
  100 FORMAT(' WARNING, FLOW STATION ',I3,' HAS NO CONNECTION')         CFIG0051
  110 CONTINUE                                                          CFIG0052
C     BEGIN AT FIRST INLET IN CONFIGURATION                             CFIG0053
      JINLET=1                                                          CFIG0054
      JC=0                                                              CFIG0055
C     INITIALIZE COUNTERS                                               CFIG0056
      JSEP=0                                                            CFIG0057
      JSEPI=0                                                           CFIG0058
      JHEAT=0                                                           CFIG0059
      JH=0                                                              CFIG0060
      GO TO 240                                                         CFIG0061
C     STORE COMPONENT IN FLOW ARRAY                                     CFIG0062
  120 IF(JCX.EQ.0) GO TO 280                                            CFIG0063
      JC =JC+1                                                          CFIG0064
C*** CHECK FOR OVERFLOW ** LOOPING AROUND IN CONFIG DATA                CFIG0065
      IF(JC.GT.50) GO TO 290                                            CFIG0066
      JFLOW(JC)=JCX                                                     CFIG0067
C     GET MAIN DOWNSTREAM STATION                                       CFIG0068
      JP1=JFIG(JH+4,JCX)                                                CFIG0069
      IF(JP1.LE.NOSTAT) GO TO 140                                       CFIG0070
      PRINT 130,JCX,JCX                                                 CFIG0071
  130 FORMAT(' CONFIGURATION DATA, JFIG(4,',I2,') OR JFIG(5,',I2,') IS ICFIG0072
     IN ERROR')                                                         CFIG0073
      GO TO 290                                                         CFIG0074
  140 JH=0                                                              CFIG0075
C     GET NEXT COMPONENT JCX DOWN STREAM OF STATION JP1  NOW JM1        CFIG0076
      JCX=JCDS(JP1)                                                     CFIG0077
```

```
C     CHECK TO SEE IF THIS IS THE END OF A FLOW PATH                    CFIG0078
      IF (JCX.EQ.0) GO TO 260                                           CFIG0079
  150 JT=JFIG(1,JCX)                                                    CFIG0080
C     CHECK COMPONENT TYPE FOR SPLITTER OR MIXER                        CFIG0081
C *** AND HEAT EXCHANGER                                                CFIG0082
      IF(JT-6)120,160,200                                               CFIG0083
C *** PROCESS FIRST PASS IN HEAT EXCHANGER                              CFIG0084
  160 IF(JHEAT.EQ.0) GO TO 180                                          CFIG0085
      DO 170 JX=1,JHEAT                                                 CFIG0086
      IF(JCX.EQ.JHEATX(JX)) GO TO 190                                   CFIG0087
  170 CONTINUE                                                          CFIG0088
  180 JHEAT=JHEAT+1                                                     CFIG0089
      JHEATX(JHEAT)=JCX                                                 CFIG0090
      GO TO 120                                                         CFIG0091
  190 JX=1                                                              CFIG0092
      JHEATX(JX)=JHEATX(JHEAT)                                          CFIG0093
      JHEAT=JHEAT-1                                                     CFIG0094
      GO TO 120                                                         CFIG0095
C     CHECK FOR SPLITTER                                                CFIG0096
  200 IF (JT.EQ.7) GO TO 250                                            CFIG0097
      IF (JT.NE.8) GO TO 120                                            CFIG0098
C     HAS THIS MIXER ALREADY BEEN PROCESSED                             CFIG0099
      IF (JSET.EQ.0) GO TO 230                                          CFIG0100
      DO 210 JX=1,JSET                                                  CFIG0101
      IF (JCX.EQ.JPASS(JX)) GO TO 220                                   CFIG0102
  210 CONTINUE                                                          CFIG0103
      GO TO 230                                                         CFIG0104
  220 JPASS(JX)=JPASS(JSET)                                             CFIG0105
      JSET=JSET-1                                                       CFIG0106
      GO TO 120                                                         CFIG0107
  230 JSET=JSET+1                                                       CFIG0108
      JPASS(JSET)=JCX                                                   CFIG0109
      IF(JSET1.NE.0) GO TO 270                                          CFIG0110
C     CHECK FOR MORE INLETS                                             CFIG0111
  240 IF(JINLET.GE.KKINDS(1,1)) GO TO 280                               CFIG0112
      JINLET=JINLET+1                                                   CFIG0113
      JCX=KKINDS(1,JINLET)                                              CFIG0114
      GO TO 120                                                         CFIG0115
  250 JSET1=JSET1+1                                                     CFIG0116
      JSPT=JFIG(5,JCX)                                                  CFIG0117
      JPASS1(JSET1)=JCDS(JSPT)                                          CFIG0118
      GO TO 120                                                         CFIG0119
  260 IF (JSET1.EQ.0) GO TO 240                                         CFIG0120
C     ARE THERE ANYMORE FLOW PATHS FROM SPLITTERS NOT PROCESSED YET     CFIG0121
  270 JCX=JPASS1(JSET1)                                                 CFIG0122
C     YES CHECKER OFF                                                   CFIG0123
      JSET1=JSET1-1                                                     CFIG0124
      GO TO 150                                                         CFIG0125
  280 IF(JC.GE.JCC) GO TO 340                                           CFIG0126
  290 PRINT 300                                                         CFIG0127
  300 FORMAT(//,39H WARNING * CHECK LOGIC IN CONFIGURATION,/,           CFIG0128
     1 40H THE FOLLOWING FLOW COMPONENTS DO NOT LIE IN ANY FLOW STREAM ) CFIG0129
      DO 330 I=1,JCC                                                    CFIG0130
      L=JCOMP(I)                                                        CFIG0131
      DO 310 J=1,JC                                                     CFIG0132
      IF(L.EQ.JCOM(J)) GO TO 330                                        CFIG0133
  310 CONTINUE                                                          CFIG0134
      PRINT 320,L                                                       CFIG0135
  320 FORMAT(I4,I3)                                                     CFIG0136
  330 CONTINUE                                                          CFIG0137
  340 CONTINUE                                                          CFIG0138
      DO 350 KJ=1,50                                                    CFIG0139
  350 JCOMP(KJ)=0                                                       CFIG0140
      DO 360 K=1,JC                                                     CFIG0141
      L=JC+1-K                                                          CFIG0142
      JCX=JCOM(L)                                                       CFIG0143
```

ORIGINAL PAGE IS OF POOR QUALITY

```
  360 JCOMP(JCX)=L                                                      CFIG0144
      JCC=JC                                                            CFIG0145
C     SET CONTROL ORDER FOR OPTIMUM PASS MODE                           CFIG0146
      NCTS=KKINDS(12,1)                                                 CFIG0147
      NPI=NCTS-1                                                        CFIG0148
      IF(NCTS.LE.1) GO TO 390                                           CFIG0149
  370 NOTFLT=0                                                          CFIG0150
      DO 380 I=1,NPI                                                    CFIG0151
      JCX1=KKINDS(12,I+1)                                               CFIG0152
      JCX2=KKINDS(12,I+2)                                               CFIG0153
      JI+1=JFIG(4,JCX1)                                                 CFIG0154
      JI++=JFIG(4,JCX2)                                                 CFIG0155
      IC1=JCOMP(JI+1)                                                   CFIG0156
      IC2=JCOMP(JI++)                                                   CFIG0157
      IF (IC1.GE.IC2) GO TO 380                                         CFIG0158
      NOTFLT=1                                                          CFIG0159
      JCXS=JCX1                                                         CFIG0160
      KKINDS(12,I+1)=JCX2                                               CFIG0161
      KKINDS(12,I+2)=JCXS                                               CFIG0162
  380 CONTINUE                                                          CFIG0163
      IF (NOTFLT.EQ.1) GO TO 370                                        CFIG0164
  390 CALL INPMT                                                        CFIG0165
      RETURN                                                            CFIG0166
      END                                                               CFIG0167
CDUCTB
      SUBROUTINE DBURNR                                                 DBNR0001
      IMPLICIT REAL*8(A-H,O-Z)
      COMMON ATP(30),TOPRES(30),TOTEMP(30),FAR(30),CORFLO(30),VMACH(30) EP  0005
      COMMON STATP(30),ERROR(30),DATINP(15,40),DATOUT(9,40)
      COMMON DERV(15),DTOL(15),PERPE(12),TOL,TOLY,TOLTT
      COMMON J+1,J+2,JP1,JP2,JCX,LOCTBL(9,40)
      COMMON JFIG(5,40),JFLO+(50),IDEDAP(14),JCOMP(50),NIT,IWAY
      COMMON KKINDS(15,25),NCOMP,NOSTAT,NITER,NFINIS,NPASS,JCC,NCTS
      COMMON JCINDU(15),JCDEP(15),JCVINU(15),JCVDEP(15),KDEIP(15)
      COMMON RCH
      FAR1=FAR(JM1)                                                     DBNR0005
      TP1=TOPRES(JM1)                                                   DBNR0006
      T1=TOTEMP(JM1)                                                    DBNR0007
      T2=DATINP(4,JCX)                                                  DBNR0008
      HCP=DATINP(6,JCX)                                                 DBNR0009
      EFF=DATINP(5,JCX)                                                 DBNR0010
      HCE=LOCTBL(5,JCX)                                                 DBNR0011
      HCP=LOCTBL(6,JCX)                                                 DBNR0012
      HCP=LOCTBL(1,JCX)                                                 DBNR0013
      G=CORFLO(JM1)                                                     DBNR0014
      MT1=ATP(JM1)                                                      DBNR0015
C***                                                                    DBNR0016
C***DRY PRESSURE DROP CALCULATIONS                                      DBNR0017
C***                                                                    DBNR0018
      DELP=  DATINP(1,JCX)+DATINP(3,JCX)*G*G                            DBNR0019
      CALL TABLU (NDP,G,0.0D0,0.0D0,DELP)                                  DB
      IF (DELP.GT..800) DELP=.800                                        DBNR
      TP2=TP1*(1.0D0-DELP)                                               DBNR0
      IF (EFF.GT.0.000) GO TO 30                                         DBNR0
      FAR=0.000                                                          DBNR0
      FJEC=0.000                                                         DBNR0
      DELNP=0.000                                                        DBNR0
      XM1=0.000                                                          DBNR0
      T2=T1                                                             DBNR0028
      MT2=MT1                                                           DBNR0029
      FAR2=FAR1                                                         DBNR0030
      IF(JM2.GE.30) GO TO 10                                            DBNR0031
      FAR1=FAR(JM2)                                                     DBNR0032
      MT1=ATP(8,JCX)*MTF(JM2)                                           DBNR0033
      IF(MT1.GE.0.000) GO TO 10                                          DBNR0
      A1=MT1/(1.0D0+FAR1)                                                DBNR0
```

ORIGINAL PAGE IS OF POOR QUALITY

```
      CALL THERMO (T1,TP1,HIN,S1,5,RCH,FAR1,ZERO,ZERO,ZERO,0,
     1ZERO,ZERO)                                                        DBNR0
      A2=WB14/(1.0D0+FAR1B)
      CALL THERMO (TOTEMP(JM2),TOPRES(JM2),H2M,S1,5,RCH,FAR1B,ZERO,
     1ZERO,ZERO,0,ZERO,ZERO)                                            DBNR0039
      WT2=WT1+WIN                                                       DBNR0040
      FARG=(FAR1*A1+FAR1B*A2)/(A1+A2)                                   DBNR0041
      HT2=(WT1*H1M+WIN*H2M)/WT2
      CALL THERMO (T2,TP2,HMT2,S1,6,RCH,FARG,ZERO,ZERO,ZERO,0,
     1ZERO,ZERO)                                                        DBNR0043
   10 IF(JM2.GE.30) GO TO 20                                            DBNR0044
      WIRO=WT2*DATINP(9,JCX)                                            DBNR0045
      WTF=WT2-WIRO                                                      DBNR0046
      WTF(JM2)=WTF0                                                     DBNR0047
      TOTEMP(JM2)=T2                                                    DBNR0048
      FAR(JM2)=FARG                                                     DBNR0049
   20 IF(IARY.NE.0) GO TO 70                                            DBNR0050
      GO TO 290                                                         DBNR0
   30 CALL TABLU (NCE,G,FAR1,0,0D0,EFF)                                 DBNR0
      CALL TABLU (NHCF,T2,TP1,0,0D0,HCF)
      CALL THERMO (T1,TP1,HIN,S1,5,RCH,FAR1,ZERO,ZERO,ZERO,0,
     1ZERO,ZERO)                                                        DBNR00
      FARG=.1200                                                        DBNR0
      IF (WT1.LE.0.0D0) GO TO 50                                        DBNR0
      AIRW=(1.0D0+FAR1)/WT1
      IF(HCF.GT.25000.D0) GO TO 35                                      DBNR00
      EFFHCF=EFF*HCF+178.27D0
      GO TO 40
   35 EFFHCF=EFF*(HCF+1.7500*(DATINP(10,JCX)-37.0D0))                   DBNR0058
   40 FAR2=FARG
      CALL THERMO (T2,TP2,HOUT,S1,5,RCH,FAR2,ZERO,ZERO,ZERO,0,
     1ZERO,ZERO)                                                        DBNR0060
      FAR=(HOUT-HIN)/(EFFHCF-HOUT)                                      DBNR0061
      FARG=FAR1+WT1*FWR*AIRR
      IF (DABS((FAR2-FARG)/FARG).GT..0001D0) GO TO 40
      CALL THERMO (T2,TP2,HOUT,S1,5,RCH,FARG,ZERO,ZERO,ZERO,0,
     1ZERO,ZERO)                                                        DBNR0064
   50 FUEL=FAR*WT1                                                      DBNR0065
      WTF=WT1*FUEL                                                      DBNR0
      DELPR=0.0D0                                                       DBNR0
      VM1=0.0D0                                                         DBNR0068
C ***                                                                   DBNR0069
C *** MOMENTUM PRESSURE DROP CALCULATION                                DBNR0070
C ***                                                                   DBNR0071
      MDESN=0                                                           DBNR0072
      IF(IARY.NE.0) GO TO 70                                            DBNR0073
   60 AREA=DATINP(7,JCX)                                                DBNR0
      IF(AREA*EFF.EQ.0.0D0) GO TO 290                                   DBNR0075
C***                                                                    DBNR0076
C*** CHECK FOR LOW FLOW CONDITIONS,  IF MACH IS GREATER THAN .0001 GO  DBNR0077
C***                                                                    DBNR0
      IF(G/AREA.LT..0001D0) GO TO 290                                   DBNR0079
      GO TO 80                                                          DBNR0080
   70 VM1S=DATINP(2,JCX)                                                DBNR0
      IF(VM1S.LE.0.0D0) GO TO 60                                        DBNR0082
      VM1S=VM1S*VM1S                                                    DBNR0083
      MDESN=1
   80 CALL THERMO (T1,TP1,HIN,S1,5,RCH,FARG,ZERO,ZERO,ZERO,0,
     1GAM1,HIM)                                                         DBNR0
      DELH=0.0D0                                                        DBNR0088
      TP1=TP2                                                           DBNR0089
      IF(MDESN.NE.1) GO TO 100                                          DBN
      T2=T1/(1.0D0+.2D0*VM1S)
   90 CALL THERMO (T1,TP1,ZERO,ZERO ),RCH,FARG,T2M,H2M,ZERO,
     1D,GAM,HIM)                                                        DBNR0
      VMSC=2.0D0*(HIN-H2M)/(GAM*RIN*T2M)
```

ORIGINAL PAGE IS OF POOR QUALITY

B.11.

```
      DM=VM1S-VMSC                                                      DBNR0094
      T2M=T2M*(1.0D0-.5D0*(GAM-1.0D0)*DM/(1.0D0+.5D0*(GAM-1.0D0)*VMSC))
      IF(DABS(DM/VM1S).GT..00001D0) GO TO 90
      GO TO 110                                                         DBNR0097
  100 CONI=AREA/(R1M*778.161D0)                                           DBNR00
      CONST=CONI*TP2/TP1
C***                                                                    DBNR0100
C *** COMPUTE INLET MACH NO. BASED ON FLOW AFTER DRY PRESSURE LOSS      DBNR0101
C *** MACH NO. IS COMPUTED WITH FUEL ADDED INTO FLOW                    DBNR0102
C***                                                                    DBNR0103
      NM=0                                                              DBNR0104
C***                                                                    DBNR0105
C*** FIRST GUESS AT STATIC TEMPERATURE - DUCT ENTRANCE                  DBNR0106
C***                                                                    DBNR0107
      FLOWG=WT2*DSQRT(R1M*778.161D0*T1)/(AREA*TP2)
        GAM=GAM)
      FDUMAC=4.0D0*FLOWG/32.174D0*FLOWG/GAM                                DBN
      RDUT=0.0D0                                                         DBNR0
      IF(FDUMAC.LT.1.0D0) RDUT=DSQRT(1.0D0-FDUMAC)
      TDEL=(1.0D0-RDUT)*.25D0*(GAM-1.0D0)
      T2M=T1*(1.0D0-TDEL)                                                DBNR0
      CA=0.0D0                                                           DBNR0
  110 CALL THERMO (T1,TP1,ZERO,S1,3,HCH,FARG,T2M,H2M,P2,0,
     1GAM,R1M)
      V1=223.770200*DSQRT(HIN-H2M)
      IF(MODE.EQ.0) GO TO 120                                           DBNR0119
      CONI=WT2/P2*T2M/V1*TP1/TP2
      AREA=CONI*R1M*778.161D0                                            DBNR01
      DATIOV(7,JCK)=AREA                                                DBNR0122
      IF(EFF.LE.0.0D0) GO TO 290                                         DBNR0
      GO TO 140                                                         DBNR0124
C***                                                                    DBNR0125
C*** COMPUTE  FLOW FOR CHECK WITH INCOMING FLOW                         DBNR0126
C***                                                                    DBNR0127
  120 WT2G=P2*CONST*V1/T2M                                              DBNR0128
      VM1S=2.0D0*(HIN-H2M)/(GAM*R1M*T2M)                                 DBNR0
      IF(VM1S.LE.1.0D0) GO TO 140                                        DBNR0
C***                                                                    DBNR0132
C***  ITERATION HAS GONE SONIC -FIND STATIC TEMP FOR MACH=1.            DBNR0133
C***                                                                    DBNR0134
      TSMIN=.8333D0*T1                                                   DBNR01
  130 TS=TSMIN                                                          DBNR0136
      CALL THERMO (T1,TP1,ZERO,S1,3,HCH,FARG,TS,HCRIT,PS,0,
     1GAM,R1M)
      VM1S=2.0D0*(HIN-HCRIT)/(GAM*R1M*TS)                                DBNR0
      Z=.5D0*(GAM-1.0D0)*VM1S                                             DBN
      DM=1.0D0-VM1S                                                      DBNR0
      TSMIN=TSMIN*(1.0D0-Z/(1.0D0+Z)*DM/VM1S)                              DB
      IF(DABS(DM).GT..00001D0 ) GO TO 130
      T2M=TSMIN+.005D0                                                   DBNR01
      CA=1.0D0                                                           DBNR0
      GO TO 110                                                         DBNR0146
  140 WTERR=(WT2-WT2G)/WT2                                              DBNR0147
      NM=NM+1                                                           DBNR0148
      IF(NM.GT.25) GO TO 160                                            DBNR0149
      IF(DABS(WTERR).LT..0001D0) GO TO 180
C***                                                                    DBNR0151
C*** UPDATE STATIC TEMP USING INFLUENCE COEFFICIENT                     DBNR0152
C***                                                                    DBNR0153
      FAC=-WTERR*  (GAM-1.0D0)*VM1S/(1.0D0-VM1S)                           DB
      IF(CA*TERR.GT.0.0D0) GO TO 200                                     DBNR0
      CA=0.0D0                                                           DBNR0
      AFAC=DABS(FAC)
      IF(AFAC.GT..01D0) FAC=.01D0*FAC/AFAC                                 DBNR
      TOLD=T2M                                                          DBNR0159
      T2M=T2M*(1.0D0+FAC)                                                DBNR0
```

ORIGINAL PAGE IS
OF POOR QUALITY

```
      IF(T2M.GT.TSMIN) GO TO 150                                        DBNR0161
      T2M=.5D0*(TSMIN+TOLD)                                               DBNR01
      GO TO 110                                                         DBNR0163
  150 IF(T2M.GT.T1) T2M=.99D0*T1+.01D0*TOLD                                 DBNR
      GO TO 110                                                         DBNR0165
  160 PRINT 170,JCK                                                     DBNR0166
  170 FORMAT(' MACH NUMBER ITERATION HAS FAILED  ** COMPONENT ',I2)     DBNR0167
      GO TO 290                                                         DBNR0168
C***                                                                    DBNR0169
C*** COMPUTE MAX ALLOWABLE TEMP RATIO FOR THERMAL CHOKING               DBNR0170
C***                                                                    DBNR0171
  180 TOTM=((1.0D0+GAM*VM1S)**2.0D0)/((GAM+1.0D0)*VM1S*(2.0D0+(GAM-1.0D0
     1)*VM1S))
      IF(T2/T1.LT.TOTM) GO TO 220                                       DBNR0173
C***                                                                    DBNR0174
C***  FLOW AT EXIT IS SONIC SET DROP TO MAX                             DBNR0175
C***                                                                    DBNR0176
  190 PDTM=((GAM+1.0D0)/(1.0D0+GAM*VM1S))*((2.0D0+(GAM-1.0D0)*VM1S)/(GAM
     1+1.0D0))**(GAM/(GAM-1.0D0))
      TP2=TP2/PDTM                                                      DBNR0179
  200 WRITE(6,210,JCK                                                   DBNR0180
  210 FORMAT(10X,46HWARNING *** EXIT VELOCITY IS SONIC *COMPONENT ,I2)  DBNR0181
      GO TO 290                                                         DBNR0182
  220 IF(T2.LT.T1) GO TO 290                                            DBNR0183
C***                                                                    DBNR0184
C*** LOOP FOR COMPUTING EXIT STATIC TEMP,P TOTAL ,MACH NO, AND FLOW     DBNR0185
C***                                                                    DBNR0186
      TSMIN=0.0D0                                                         DBNR0
      PS1=TP2*P2/TP1                                                      DBNR01
      CDA=WT2/(32.17400*AREA)                                           DBNR0191
      TS2=T2**T2/T1                                                       DBNR0
      CK=0.0D0
  230 CALL THERMO (T2,TP2,ZERO,S1,3,NCH,FARG,TS2,HS2,PS,0,
     1GAM,R1M)
      V2=223.770200*DSQRT(HOUT-HS2)
C***                                                                    DBNR0195
C*** STATIC PRESSURE CALCULATION CONSIDERING MOMENTUM CONSERVATION       DBNR0196
C***                                                                    DBNR0197
      PS2=PS1-(V2-V1)*CON
      WT2G=PS2*CDA*V2/TS2                                                 DBNR0
      VM2S=2.0D0*(HOUT-HS2)/(GAM*R1M*TS2)                                 DBNR0
      IF(VM2S.LE.1.0D0) GO TO 250                                        DBNR02
      TSMIN=.8333D0*T2                                                  DBNR0204
  240 TS=TSMIN
      CALL THERMO (T2,TP2,ZERO,S1,3,NCH,FARG,TS,HCRIT,PS,0,
     1GAM,R1M)
      VM3S=2.0D0*(HOUT-HCRIT)/(GAM*R1M*TS)                                DBNR0
      Z=.5D0*(GAM-1.0D0)*VM3S                                             DBN
      DM=1.0D0-VM3S                                                     DBNR0
      TSMIN=TSMIN*(1.0D0-Z/(1.0D0+Z)*DM/VM3S)                             DB
      IF(DABS(DM).GT.1.0D-5) GO TO 240
      TS2=TSMIN+.00500                                                   DBNR02
      CK=1.0D0                                                            DBNR0
      GO TO 230                                                         DBNR0214
  250 WTERR=(WT2-WT2G)/WT2                                              DBNR0215
      IF(WTERR*CK.GT.0.0D0) GO TO 190                                     DBNR0
      IF(DABS(WTERR).LT..00010D0) GO TO 270
      FAC=WTERR*  (GAM-1.0D0)*VM2S/(1.0D0-VM2S)                           DB
      AFAC=DABS(FAC)
      IF(AFAC.GT..01D0) FAC=.01D0*FAC/AFAC                               DBNR
      TS2=TS2*(1.0D0+FAC)                                                DBNR0
      IF(TS2.GT.TSMIN) GO TO 260                                        DBNR0222
      TS=TSMIN+.0500                                                     DBNR02
      GO TO 230                                                         DBNR0224
  260 IF(TS2.GT.T2) TS2=.5D0*(T2+TS2/(1.0D0+FAC))                         DBN
      GO TO 230                                                         DBNR0226
```

B.13.

```
  270 CALL THERMO (T2,TP2,ZERO,S1,3,RCH,FARG,TS2,ZERO,PS,0
     1,ZERO,ZERO)
      TP2=PS2*TP2/PS
C***                                                                DBNR0229
C*** MOMENTUM PRESSURE DROP                                         DBNR0230
C***                                                                DBNR0231
  280 DELMP=(TPM-TP2)/TPM                                           DBNR0232
      VM1=DSQRT(VM1S)
  290 FAR(JP1)=FARG                                                 DBNR0234
      CORFLO(JP1)=WT2*DSQRT(T2)/TP2
      TOTEMP(JP1)=T2                                                DBNR0236
      TOPRES(JP1)=TP2
      WTF(JP1)=WT2                                                  DBNR0238
      DATOUT(1,JCX)=DELMP                                           DBNR0239
      DATOUT(2,JCX)=DELP                                            DBNR0240
      DATOUT(3,JCX)=DATINP(2,JCX)                                   DBNR0241
      DATOUT(5,JCX)=DATINP(7,JCX)                                   DBNR0242
      DATOUT(4,JCX)=FAR                                             DBNR0243
      DATOUT(6,JCX)=FUEL*3600.0D0                                   DBNR0
      DATOUT(7,JCX)=VM1                                             DBNR0245
      DATOUT(8,JCX)=HCF                                             DBNR0246
      DATOUT(9,JCX)=FFF                                             DBNR0247
      RETURN                                                        DBNR0248
      END                                                           DBNR0249
CFLOCAL
      SUBROUTINE FLOCAL(IGET,SS,EROR)                               FCAL0001
      IMPLICIT REAL*8(A-H,O-Z)
      COMMON WTF(30),TOPRES(30),TOTEMP(30),FAR(30),CORFLO(30),VMACH(30) EP  0005
      COMMON STAGP(30),ERROR(30),DATINP(15,40),DATOUT(9,40)
      COMMON DEPV(15),DTOL(15),PERMP(12),TOL,TOLT,TOLTT
      COMMON JM1,JM2,JP1,JP2,JCX,LOCTBL(9,40)
      COMMON JFIG(5,40),JFLOW(50),IDEDAP(14),JCOMP(50),NIT,IWAY
      COMMON KNINDS(15,25),NCOMP,NOSTAT,NITER,NFINIS,NPASS,JCC,NCYS
      COMMON JCIND(15),JCDEP(15),JCVIND(15),JCVDEP(15),KDTYP(15)
      DIMENSION SPROP(30,8),EROR(15)                                FCAL0009
      EQUIVALENCE(SPROP,WTF)                                        FCAL0010
      JMAT=IMAT                                                     FCAL0011
      IF (IPASS) 10,10,20                                           FCAL0012
   10 NI=KNINDS(1,1)                                                FCAL0013
      NZ=KNINDS(9,1)                                                FCAL0014
      NJ=KNINDS(2,1)                                                FCAL0015
      NIP=KNINDS(10,1)                                              FCAL0016
      NSHAFT=KNINDS(11,1)                                           FCAL0017
C                                                                   FCAL0018
C     SET SHAFT RPMS                                                FCAL0019
   20 IF (NSHAFT) 90,90,30                                          FCAL0020
   30 DO 80 IS=1,NSHAFT                                             FCAL0021
      JSC=KNINDS(11,IS+1)                                           FCAL0022
      RPM=DATINP(1,JSC)                                             FCAL0023
      DATOUT(2,JSC)=RPM                                             FCAL0024
      DO 40 KJ=2,5                                                  FCAL0025
      JCX=JFIG(KJ,JSC)                                              FCAL0026
      IF (JCX.EQ.0) GO TO 80                                        FCAL0027
C*** CHECK FOR A ZERO SHAFT GEAR RATIO                              FCAL0028
      KL=2*(KJ-2)+2                                                 FCAL0029
      GR=DATINP(KL,JSC)                                             FCAL0030
      IF(GR.EQ.0.0D0) GR=1.0D0                                      FC
      RPMS=RPM*GR                                                   FCAL0032
      DATOUT(2,JCX)=RPMS                                            FCAL0033
C***** SHAFT MOD ..IF  SHAFT THEN SET SHAFT INPUT..NJC 6/9/78
      IF(JFIG(1,JCX).EQ.11) DATINP(1,JCX)=RPMS
      DATOUT(KJ+1,JSC)=RPMS                                         FCAL0034
C *** SET LOAD OR MOTOR HORSEPOWER                                  FCAL0035
      IF(JFIG(1,JCX).NE.10) GO TO 80                                FCAL0036
   40 HHP=LOCTBL(1,JCX)                                             FCAL0037
      IF(HHP)60,60,50                                               FCAL0038
```

B.14.

```
   50 CALL TABLU(NHP,DATOUT(2,JCX),0.0D0,0.0D0,HP)                    FC
      GO TO 70                                                       FCAL0040
   60 HP=DATINP(1,JCX)                                               FCAL0041
   70 DATOUT(1,JCX)=HP                                               FCAL0042
   80 CONTINUE                                                       FCAL0043
   90 JSPLIT=0                                                       FCAL0044
      JHP=0
      NPASS=NPASS+1                                                  FCAL0045
      IF(IGET.GE.0 ) GO TO 100                                       FCAL0046
      I=JCOMP(IGET)                                                  FCAL0047
      IF(I.GT.0) GO TO 110                                           FCAL0048
  100 I=1                                                            FCAL0049
      INLAST=JCC
  110 I=I                                                            FCAL0051
  120 JCX=JFLO*(I)                                                   FCAL0052
      JT=JFIG(1,JCX)                                                 FCAL0053
      JM1=JFIG(2,JCX)                                                FCAL0054
      JM2=JFIG(3,JCX)                                                FCAL0055
      JP1=JFIG(4,JCX)                                                FCAL0056
      JP2=JFIG(5,JCX)                                                FCAL0057
      IF(JM2.LE.0) JM2=30                                            FCAL0058
      IF(JP2.LE.0) JP2=30                                            FCAL0059
      CONJM1=COMFLO(JM1)                                             FCAL0060
      GO TO (130,140,150,160,180,190,200,210,220), JT                FCAL0061
C     COMPONENT TYPE 1                                               FCAL0062
  130 CALL INLET                                                     FCAL0063
      CONJM1=COMFLO(JM1)                                             FCAL0064
      GO TO 240                                                      FCAL0065
C     COMPONENT TYPE 2                                               FCAL0066
  140 CALL DOUBHR                                                    FCAL0067
      GO TO 240                                                      FCAL0068
C     COMPONENT TYPE 3                                               FCAL0069
  150 CONTINUE                                                       FCAL0070
      GO TO 240                                                      FCAL0071
C     COMPONENT TYPE 4                                               FCAL0072
  160 CALL COMPRS                                                    FCAL0073
C*** QUICK EXIT DESIGN POINT MODE 1ST PASS                           FCAL0074
      IF(IGET.GT.0) GO TO 170                                        FCAL0075
      IMAXE=I                                                        FCAL0076
      GO TO 240                                                      FCAL0077
  170 IF(I*MAX.GE.0) GO TO 240                                       FCAL0078
      IF(I[illegible] .1)GO TO 250                                   FCAL0079
      GO TO 240
C     COMPONENT TYPE 5                                               FCAL0080
  180 CALL TURBIN                                                    FCAL0081
      GO TO 240                                                      FCAL0082
C     COMPONENT TYPE 6                                               FCAL0083
  190 CONTINUE                                                       FCAL0084
      CALL HEATXC(I)                                                 FCAL0085
      JCXL=JFLO*(I-1)
      JHP=JHP-1
      IF(JFIG(4,JCXL).EQ.JM1.OR.JFIG(5,JCXL).EQ.JM1) JHP=JHP+2
      GO TO 240                                                      FCAL0086
C     COMPONENT TYPE 7                                               FCAL0087
  200 CALL SPLITR                                                    FCAL0088
      JSPLIT=JSPLIT+1                                                FCAL0089
      GO TO 240                                                      FCAL0090
C     COMPONENT TYPE 8                                               FCAL0091
  210 CONTINUE                                                       FCAL0092
      CALL MIXER                                                     FCAL0093
      JSPLIT=JSPLIT-1                                                FCAL0094
      GO TO 240                                                      FCAL0095
C     COMPONENT TYPE 9                                               FCAL0096
  220 CALL NOZZLE                                                    FCAL0097
      DEMO=.5000*DATOUT(5,JCX)
      GO TO 241
```

```
  240 DENO=.5D0*(CORJM1+CORFLO(JM1))
  241 ERROR(JM1)=(CORJM1-CORFLO(JM1))/DENO
      CORFLO(JM1)=CORJM1
      IF(JT.NE.9) GO TO 243
      IF(JSPLIT.LE.0) GO TO 242
      JSPLIT=JSPLIT-1
      GO TO 243
  242 IF(JHP.GE.0) GO TO 243
      IF(I.EQ.JCC.OR.I.GT.INLAST) GO TO 250
  243 I=I+1
      GO TO 120
  250 CONTINUE                                                    FCAL0106
C     COMPUTE SHAFT HORSEPOWERS                                   FCAL0107
      HPI=0.0D0                                                      FCAL0
      IF(NSHAFT.LE.0) GO TO 340                                   FCAL0109
C**** ADD TO REVERSE HP SUM ON SHAFTS TO PERMIT SHAFTS CONNECTED TO
C**** SHAFTS    MJC    6/8/78
      NSH=NSHAFT+2
      DO 340 IS=1,NSHAFT                                          FCAL0110
      JSC=KKINDS(11,NSH-IS)
      HP=0.0D0                                                       FCAL0
      HPA=0.0D0                                                      FCAL0
      DO 300 KJ=2,5                                               FCAL0114
      JCX=JFIG(KJ,JSC)                                            FCAL0115
      IF (JCX) 300,300,260                                        FCAL0116
  260 HPC=DATOUT(1,JCX)                                           FCAL0117
      KL=3+(KJ-2)*2                                               FCAL0118
      FAC=DATINP(KL,JSC)                                          FCAL0119
      IF (HPC) 280,300,270                                        FCAL0120
  270 IF (IWAY.GE.0) GO TO 290                                    FCAL0121
      IF(JFIG(1,JCX).EQ.5) GO TO 300                              FCAL0122
      GO TO 280                                                   FCAL0123
  280 FAC=1.0D0/FAC                                                  FCAL0
  290 HPFAC=HPC*FAC                                               FCAL0125
      HP=HP+HPFAC                                                 FCAL0126
      HPA=HPA+DABS(HPFAC)
  300 CONTINUE                                                    FCAL0128
      IF(IWAY.GE.0) GO TO 320                                     FCAL0129
      DO 310 KJ=2,5                                               FCAL0130
      JCX=JFIG(KJ,JSC)                                            FCAL0131
      IF(JCX.GE.0) GO TO 310                                      FCAL0132
      IF(JFIG(1,JCX).NE.5) GO TO 310                              FCAL0133
      KL=3+(KJ-2)*2                                               FCAL0134
      DATOUT(1,JCX)=-HP*DATINP(13,JCX)/DATINP(KL,JSC)             FCAL0135
  310 CONTINUE                                                    FCAL0136
C**** HP=0.        ********DELETE THIS CARD FOR SHAFT MOD
  320 DATOUT(1,JSC)=HP                                            FCAL0138
      DATOUT(8,JSC)=HP*2.0D0/HPA                                     FCAL0
      HPT=HPI+HP                                                  FCAL0140
  330 CONTINUE                                                    FCAL0141
  340 IF(IWAY.GE.0) GO TO 350                                     FCAL0142
      IWAY=1                                                      FCAL0143
      GO TO 90                                                    FCAL0144
C     SET AIR FLOW AND DRAG                                       FCAL0145
  350 AIR=0.0D0                                                      FCAL0
      DRAG=0.0D0                                                     FCAL0
      DO 360 I1=1,N1                                              FCAL0148
      JCX=KKINDS(1,I1+1)                                          FCAL0149
      DRAG=DRAG+DATOUT(1,JCX)                                     FCAL0150
  360 AIR=AIR+DATINP(1,JCX)                                       FCAL0151
C     SET NOZZLE NET THRUST                                       FCAL0152
      FG=0.0D0                                                       FCAL0
      DO 370 I2=1,N2                                              FCAL0154
      JCX=KKINDS(9,I2+1)                                          FCAL0155
      DRAG=DRAG+DATOUT(8,JCX)
  370 FG=FG+DATOUT(1,JCX)
```

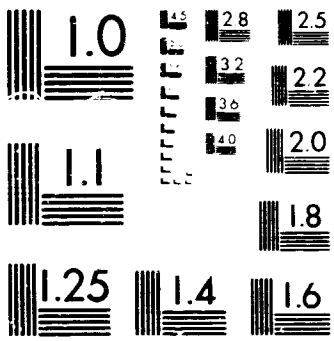
B.16.

```
      FNET=FG-DRAG
C     SET FUEL USED                                                     FCAL0157
      FUEL=0.0D0                                                        FCAL0158
      IF (N3.EQ.0) GO TO 390                                              FCAL0
      DO 380 I3=1,N3                                                    FCAL0160
      JCX=KKINDS(2,I3+1)                                                FCAL0161
  380 FUEL=FUEL+DATOUT(6,JCX)                                           FCAL0162
C     SET BSHP                                                          FCAL0163
  390 BSHP=0.0D0                                                        FCAL0164
      IF (N10.EQ.0) GO TO 410                                             FCAL0
      DO 400 I4=1,N10                                                   FCAL0166
      JCX=KKINDS(10,I4+1)                                               FCAL0167
      IF(DATINP(2,JCX).NE.0.0D0) BSHP=BSHP-DATOUT(1,JCX)                FCAL0168
  400 CONTINUE                                                            FCAL0
  410 BSFC=0.0D0                                                        FCAL0170
      IF(BSHP.NE.0.0D0) BSFC=FUEL/BSHP                                    FCAL0
      PERPF(1)=FNET                                                       FCAL0
      PERPF(2)=BSHP                                                     FCAL0173
      PERPF(3)=AIR                                                      FCAL0174
      PERPF(4)=FUEL/FNET                                                FCAL0175
      PERPF(5)=BSFC                                                     FCAL0176
      PERPF(6)=FUEL                                                     FCAL0177
      PERPF(7)=FNET/AIR                                                 FCAL0178
      PERPF(8)=BSHP/AIR                                                 FCAL0179
      PERPF(9)=DRAG                                                     FCAL0180
      IMAI=JMAY                                                         FCAL0181
C *** COMPUTE CONTROL ERRORS                                            FCAL0182
      S=0.0D0                                                           FCAL0183
      NFINIS=0                                                            FCAL0
      IF(NCTS.EQ.0) GO TO 470                                           FCAL0185
      DO 460 I=1,NCTS                                                   FCAL0186
      NJCXD=JCDEP(I)                                                    FCAL0187
      NDEP=JCVDEP(I)                                                    FCAL0188
      IF (KDTYP(I))430,420,440                                          FCAL0189
  420 VCAL=DATOUT(NDEP,NJCXD)                                           FCAL0190
      GO TO 450                                                         FCAL0191
  430 VCAL=DERIVP(NJCXD,NDEP)                                           FCAL0192
      GO TO 450                                                         FCAL0193
  440 VCAL=PERPF(NDEP)                                                  FCAL0194
  450 ER=DERV(I)-VCAL                                                   FCAL0195
      S=S+ER*ER                                                         FCAL0196
      ERROR(I)=ER                                                       FCAL0197
      IF(DABS(ER).GT.DTOL(I)) NFINIS=1                                  FCAL0198
  460 CONTINUE
  470 SS=S                                                              FCAL0200
      INLAST=IN                                                         FCAL0201
      RETURN                                                            FCAL0202
      END                                                               FCAL0203
CFUN                                                                    FCAL0204
      SUBROUTINE FUN(X,DEP)
      IMPLICIT REAL*8(A-H,O-Z)                                          FUN 0001
      COMMON WTF(30),TOPRES(30),TOTEMP(30),FAR(30),CORFLO(30),VMACH(30) EP  0005
      COMMON STATP(30),ERROR(30),DATINP(15,40),DATOUT(9,40)
      COMMON DERV(15),DTOL(15),PERPF(12),TOL,TOLT,TOLTT
      COMMON JM1,JM2,JP1,JP2,JCX,LOCTBL(9,40)
      COMMON JFIG(5,40),JFLOW(50),IDEDAP(14),JCOMP(50),NIT,IMAY
      COMMON KKINDS(15,25),NCOMP,NOSTAT,NITER,NFINIS,NPASS,JCC,NCTS
      COMMON JCIND(15),JCDEP(15),JCVIND(15),JCVDEP(15),KDTYP(15)
      COMMON/REPORT/SELAST,DD,NDSET,NPARTS,IOPTP,NPASSO,NVOPT,NJOPT,
     1IDLOPT,NOPT                                                       FUN 0009
      DIMENSION X(1100),XINIT(20),XOPTL(20)                             FUN 0010
      DIMENSION STAPAY(30,1)
      DIMENSION SDATA(660)                                              FUN 0012
      EQUIVALENCE (WTF(1),STAPAY(1))                                    FUN 0013
C***                                                                    FUN 0014
C*** DD = MAGNITUDE OF CHANGE ALONG A GIVEN SEARCH VECTOR               FUN 0015
                                                                        FUN 0016
```

```
C*** NPARTS=0, NO PARTIALS SAVED YET                                    FUN 0017
C*** NDSET=0  DO NOT UPDATE CONVERGENCE VARIABLES, =-1  DO NOT STORE    FUN 0018
C***                                                                    FUN 0019
C     NDSET=0
C     DD=0.0D0
      IF(NPASSO.NE.0) GO TO 10                                          FUN 0021
      NCCS=KKINDS(12,1)                                                 FUN 0022
      NLIMV=KKINDS(14,1)                                                FUN 0023
      NTOT=NOPT+NCCS+NLIMV                                              FUN 0024
      NPARTS=0                                                          FUN 0025
   10 IF(NOPT.EQ.0) GO TO 60                                            FUN 0026
      DO 20 I=1,NOPT                                                    FUN 0027
      JCX=KKINDS(13,I+1)                                                FUN 0028
      NJCXI=JFIG (1,JCX)                                                FUN 0029
      NIND=DATINP(4,JCX)                                                FUN 0030
      IF(NPASSO.NE.0) GO TO 20                                          FUN 0031
C*** NOW DIMENSIONALIZE OPT VARIABLES  TO 1.0                           FUN 0032
      X(I)=1.0D0                                                         FUN 00
      XINIT(I)=DATINP(NIND,NJCXI)                                       FUN 0034
   20 DATINP(NIND,NJCXI)=X(I)*XINIT(I)                                  FUN 0035
      IF(NDSET.EQ.0) GO TO 60                                           FUN 0036
      DO 50 I=1,NCCS                                                    FUN 0037
      JCX=KKINDS(12,I+1)                                                FUN 0038
      IF(DATINP(1,JCX).LE.0.0D0) GO TO 50                                FUN 0
      NJCXI=JFIG (4,JCX)                                                FUN 0040
      NIND=DATINP(4,JCX)                                                FUN 0041
      KL=33*(I-1)+1                                                     FUN 0042
      XSET=SPLNO1(KL,SDATA,DD)                                          FUN 0043
C*** CHECK NEW CONVERGENCE VARIABLES                                    FUN 0044
C*** DO NOT PERMIT SPLINE UPDATE OUTSIDE OF XMIN OR XMAX  IF ACTIVE     FUN 0045
      XMIN=DATINP(2,JCX)                                                FUN 0046
      IF(XMIN.EQ.0.0D0) GO TO 30                                         FUN 0
      IF(XSET.LT.XMIN) XSET=XMIN                                        FUN 0048
      GO TO 40                                                          FUN 0049
   30 XMAX=DATINP(3,JCX)                                                FUN 0050
      IF(XMAX.EQ.0.0D0) GO TO 40                                         FUN 0
      IF(XSET.GT.XMAX) XSET=XMAX                                        FUN 0052
   40 DATOUT(1,JCX)=XSET                                                FUN 0053
   50 CONTINUE                                                          FUN 0054
   60 SELAST=0.0D0                                                       FUN 0
      IF(NPARTS.EQ.1) SELAST=1.0D20                                      FUN 005
      CALL GONEP                                                        FUN 0057
      NVAPT=IABS(NVOPT)                                                 FUN 0058
      DEP=PERPF(NVAPT)                                                  FUN 0059
      IF(NJOPT.NE.0) DEP=DATOUT(NVAPT,NJOPT)                            FUN 0060
      IF(NVOPT.LT.0.) DEP=-DEP                                          FUN 0061
      DEPP=DEP                                                          FUN 0062
      PENAL=0.0D0                                                        FUN 0
C*** IF NO CONVERGENCE SET FLAG TO NOT STORE VARIABLE VALUE             FUN 0064
      IF(NIT.LE.50) GO TO 70                                            FUN 0065
      NDSET=-1                                                          FUN 0066
C*** PENALIZE DEP IF  NO CONVERGENCE                                    FUN 0067
      DEP=DEP+1.0D0                                                      FUN 0
   70 DO 170 I=1,NTOT                                                   FUN 0069
      JCX=KKINDS(12,I+1)                                                FUN 0070
      IF(I.LE.NCCS) GO TO 90                                            FUN 0071
      IF(I.GT.(NCCS+NOPT)) GO TO 80                                     FUN 0072
      L=I-NCCS+1                                                        FUN 0073
      JCX=KKINDS(13,L)                                                  FUN 0074
      GO TO 90                                                          FUN 0075
   80 L=I-NCCS-NOPT+1                                                   FUN 0076
      JCX=KKINDS(14,L)                                                  FUN 0077
C*** CHECK FOR ACTIVE CONTROL                                           FUN 0078
   90 IF(DATINP(1,JCX).LE.0.0D0)  GO TO 170                               FUN 0
      XMIN=DATINP(2,JCX)                                                FUN 0080
      XMAX=DATINP(3,JCX)                                                FUN 0081
```

2 OF 2

N 79 20159 UNCLAS



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963-A

```
      NJCXI=JFIG (4,JCX)
      IF(I.GT.(NCCS+NOPT)) GO TO 100                                    FUN 0082
      NIND=DATINP(4,JCX)                                                FUN 0083
      VAR=DATINP(NIND,NJCXI)                                            FUN 0085
      GO TO 130                                                         FUN 0086
  100 JCV=DATINP(4,JCX)
      JFIX=JCV/10
      NIND=JCV-10*JFIX
      K=JFIX-1
      IF(K) 109,110,120
  109 VAR=SIAPAY(NJCXI,NIND)
      GO TO 130                                                         FUN 0091
  110 VAR=DAIDJF(NIND,NJCXI)
      GO TO 130                                                         FUN 0096
  120 VAR=PERPE(NIND)
  130 IF(XMAX.EQ.0.0D0) GO TO 140                                          FUN 0
      DIFF= VAR-XMAX                                                    FUN 0100
      IF(DIFF.LE.0.0D0)GO TO 140                                           FUN 0
      IF(VAR.NE.0.0D0)  DIFF=DIFF/DABS(VAR)
      PENAL=PENAL+(DIFF*DIFF)**.25D0                                        FUN 01
      GO TO 150                                                         FUN 0104
  140 IF(XMIN.EQ.0.0D0) GO TO 150                                          FUN 0
      DIFF=XMIN-VAR                                                     FUN 0106
      IF(DIFF.LE.0.0D0) GO TO 150                                          FUN 0
      IF(VAR.NE.0.0D0) DIFF=DIFF/DABS(VAR)
      PENAL=PENAL+(DIFF*DIFF)**.25D0                                        FUN 01
  150 IF(I.GT.NCCS.OR.NOSET.LT.0) GO TO 170                             FUN 0110
      KL=33*(I-1)+1                                                     FUN 0111
      IF(NOSET.GT.0) GO TO 160                                          FUN 0112
      SDATA(KL)=0.0D0                                                      FUN 0
      IF(DD.EQ.0.0D0) GO TO 160                                            FUN 0
      CALL SPSET(KL,SDATA,0.0D0,XOPTL(I))                                  FUN 0
  160 XOPTL(I)=VAR                                                      FUN 0116
C*** LIMIT SPLINE STORAGE TO 10 POINTS                                  FUN 0117
      IF(SDATA(KL).EQ.10.0D0)  SDATA(KL)=0.0D0                              FU
C*** UPDATE DATA FOR SPLINE FIT FOR NEXT PASS                           FUN 0119
      CALL SPSET(KL,SDATA,DD,VAR)                                       FUN 0120
  170 CONTINUE                                                          FUN 0121
      IF(NPASSO.EQ.0) DEPS=DABS(DEP)
      DEP=DEP/DEPS+PENAL                                                FUN 0123
C*** DIAGN PRINT                                                        FUN 0124
      PRINT 180,DEP,PENAL,DEPP,(X(IP),IP=1,NOPT)                        FUN 0125
  180 FORMAT(1A,10D13.5)                                                FUN 0126
      NPASSO=NPASSO+1                                                   FUN 0127
      NOSET=1                                                           FUN 0128
      RETURN                                                            FUN 0129
      END                                                               FUN 0130
CHEATXC
      SUBROUTINE HEATXC(I)                                              HTXC0001
      IMPLICIT REAL*8(A-H,O-Z)
      COMMON WFE(30),TOPRES(30),TOTEMP(30),FAH(30),CORFLO(30),VMACH(30) EP  0005
      COMMON STATP(30),ERROR(30),DATINP(15,40),DATOUT(9,40)
      COMMON DEPV(15),DTOL(15),PERPE(12),TOL,TOLT,TOLTT
      COMMON JM1,JM2,JP1,JP2,JCX,LOCTBL(9,40)
      COMMON JFIG(5,40),JFLOW(50),IDEDAP(14),JCOMP(50),NIT,IWAY
      COMMON KNKDS(15,25),NCOMP,NOSTAT,NITER,NFINIS,NPASS,JCC,NCIS
      COMMON JCIND(15),JCDEP(15),JCVIND(15),JCVDEP(15),KDTYP(15)
      COMMON RCM
      J1=JM1                                                            HTXC0006
      J2=JP1                                                            HTXC0007
      K=1                                                               HTXC0008
      JCXL=JFLOW(I-1)                                                   HTXC0009
C ** CHECK FOR ENTERING CONDITION 1)HEATED FLOW 2)HEATER FLOW           HTXC0010
      IF(JFIG(4,JCXL).EQ.JM1.OR.JFIG(5,JCXL).EQ.JM1) GO TO 10           HTXC0011
      K=2                                                               HTXC0012
      J1=JM2                                                            HTXC0013
```

```
      JO=JP2                                                            HTXC0014
   10 DELP=DATINP(K,JCX)                                                HTXC0015
      NDP=LOCTBL(K,JCX)                                                 HTXC0016
      IF(NDP.EQ.0) GO TO 20                                             HTXC0017
      G=CORFLO(JI)                                                      HTXC0018
      CALL TABLU(NDP,G,0.0D0,0.0D0,DELP)                                    HT
   20 TOPRES(JO)=TOPRES(JI)*(1.0D0-DELP)                                  HTXC0
      DATOUT(K,JCX)=DELP                                                HTXC0021
      IF(JI.NE.JM1) GO TO 30                                            HTXC0022
      TOTEMP(JO)=TOTEMP(JI)+DATINP(3,JCX)                               HTXC0023
C *** END OF HEATED FLOW PASS                                           HTXC0024
      GO TO 40                                                          HTXC0025
C *** HEATER FLOW PASS BEGIN                                            HTXC0026
   30 EFF=DATINP(4,JCX)                                                 HTXC0027
      NEF=LOCTBL(4,JCX)                                                 HTXC0028
      WR=WTF(JM2)/WTF(JM1)                                              HTXC0029
      IF(NEF.NE.0) CALL TABLU(NEF,WTF(JM1),WR,0.0D0,EFF)                   HTXC0
      EFF=EFF*DATINP(5,JCX)                                             HTXC0031
      FAR1=FAR(JM1)                                                     HTXC0032
      FAR2=FAR(JM2)                                                     HTXC0033
      TJM2=TOTEMP(JM2)                                                  HTXC0034
      PJ2=TOPRES(JM2)
      PJ1=TOPRES(JM1)
      TJM1=TOTEMP(JM1)                                                  HTXC0035
      CALL THERMO (TJM1,PJ1,HJ,SJ,5,RCH,FAR1,ZERO,ZERO,ZERO,0,GA,RA)
      CALL THERMO (TJM2,PJ2,HJ,SJ,5,RCH,FAR2,ZERO,ZERO,ZERO,0,GG,RG)
      RA=RA*GA
      RG=RG*GG
      WCPA=WTF(JM1)*RA/(GA-1.0D0)                                          HTXC0
      WCPG=WTF(JM2)*RG/(GG-1.0D0)                                          HTXC0
      WCPR=1.0D0                                                           HTXC0
      IF(WCPG.LT.WCPA) WCPR=WCPG/WCPA                                   HTXC0043
      DELT=EFF*WCPR*(TJM2-TJM1)                                         HTXC0044
      TOTEMP(JP2)=TJM2-WCPA*DELT/WCPG
      DATOUT(4,JCX)=EFF                                                 HTXC0052
      DATOUT(5,JCX)=DATINP(5,JCX)                                       HTXC0053
      DATOUT(6,JCX)=DELT                                                HTXC0054
      DATOUT(7,JCX)=DELT/(TJM2-TJM1)                                    HTXC0055
      DATOUT(8,JCX)= DATINP(3,JCX)/DELT-1.0D0                              HTXC0
   40 FAR(JO)=FAR(JI)                                                   HTXC0057
      WTF(JO)=WTF(JI)                                                   HTXC0058
      CORFLO(JO)=WTF(JO)*DSQRT(TOTEMP(JO))/TOPRES(JO)
      RETURN                                                            HTXC0060
      END                                                               HTXC0061
*CINLET
      SUBROUTINE INLET                                                  INLT0001
      IMPLICIT REAL*8(A-H,O-Z)
      COMMON WTF(30),TOPRES(30),TOTEMP(30),FAR(30),CORFLO(30),VMACH(30) EP  0005
      COMMON STATP(30),ERROR(30),DATINP(15,40),DATOUT(9,40)
      COMMON DEPV(15),DTOL(15),PERPF(12),TOL,TOLT,TOLTT
      COMMON JM1,JM2,JP1,JP2,JCX,LOCTBL(9,40)
      COMMON JFIG(5,40),JFLOW(50),IDEDAP(14),JCOMP(50),NIT,IWAY
      COMMON KKINDS(15,25),NCOMP,NOSTAT,NITER,NFINIS,NPASS,JCC,NCTS
      COMMON JCIND(15),JCDEP(15),JCVIND(15),JCVDEP(15),KDTYP(15)
      COMMON RCH
      DIMENSION HB(10),TMB(10),DELTAB(10),ALM(10)                       INLT0005
      DATA HB/-5.0D0,0.0D0,11.0D0,20.0D0,32.0D0,47.0D0,52.0D0,61.0D0,79.
     10D0,88.743D0/
      DATA TMB/320.65D0,288.15D0,216.65D0,216.65D0,226.65D0,270.65D0,270
     1.65D0,252.65D0,180.65D0,180.65D0/
      DATA DELTAB/1.7536D0,1.0D0,2.2336D-1,5.4032D-02,8.5666D-03,1.9
     19455D-03,5.8228D-04,1.7971D-04,1.0241D-05,1.6223D-06/
      DATA ALM/-6.5D0,-6.5D0,0.0D0,1.0D0,2.8D0,0.0D0,-2.0D0,-4.0D0,0.0D0
     1,0.0D0/
      DATA  REF159/2.0855531D07/, GZ    /9.8066500/,
     2      AMZ   /28.9644D0      /, RSTAR /8.31432D0/.                 INLT0013
```

B.20.

```
     3      FTTOKM/3.048D-04     /, CAZ    /1116.45D0/                    INLT0014
      T1=TOTEMP(JM1)                                                       INLT0015
      TP1=TOPRES(JM1)                                                      INLT0016
      HFT=DATINP(9,JCX)                                                    INLT0017
      IF(HFT) 10,30,20                                                     INLT0018
   10 T1=DATINP(2,JCX)                                                     INLT0019
      TP1=DATINP(3,JCX)                                                    INLT0020
      DELTA=TP1/14.696D0                                                     INLT00
      DATOUT(9,JCX)=-1.0D-20
      GO TO 90                                                             INLT0022
   20 IF(HFT.EQ.DATOUT(9,JCX)) GO TO 90                                    INLT0023
   30 DATOUT(9,JCX)=HFT                                                    INLT0024
      DATOUT(7,JCX)=1.0D0                                                    INLT0
C***  CONVERT  ALTITUDE FROM GEOMETERIC(INPUT) TO GEOPOTENTIAL             INLT0026
      IF(DATINP(11,JCX).EQ.0.0D0) HFT=(REFT59/(REFT59+HFT))*HFT              INLT0
      H = FTTOKM*HFT                                                       INLT0028
      TMZ=TMB(2)                                                           INLT0029
      DO 40 M=1,10                                                         INLT0030
      IF (H-HB(M)) 50,60,40                                                INLT0031
   40 CONTINUE                                                             INLT0032
   50 M = M-1                                                              INLT0033
   60 DELH = H-HB(M)                                                       INLT0034
      IF (ALM(M).EQ.0.0D0)  GO TO 70                                         INLT00
      TMK = TMB(M)+ALM(M)*DELH                                             INLT0036
      DELTA = DELTAB(M)*((TMB(M)/TMK)**(GZ*AMZ/(RSTAR*ALM(M))))            INLT0037
      GO TO 80                                                             INLT0038
   70 TMK = TMB(M)                                                         INLT0039
      DELTA = DELTAB(M)*DEXP(-GZ*AMZ*DELH/(RSTAR*TMB(M)))
   80 THETA = TMK/TMZ                                                      INLT0041
      T1=1.8D0*TMK
      TP1=14.696D0*DELTA                                                     INLT00
   90 DATINP(3,JCX)=TP1                                                    INLT0044
      THETA=T1*1.928008174D-3                                              INLT0045
      XM=DATINP(5,JCX)
      CA = CAZ*DSQRT(THETA)
      TOTEMP(JM1)=T1                                                       INLT0047
      TOPRES(JM1)=TP1                                                      INLT0048
C*** CALCULATION OF FOREBODY EFFECT
      DANG=DATINP(15,JCX)
      IF(DANG.LE.0.0D0) GO TO 98
      IF(XM.LE.1.0D0) GO TO 98
      G=1.4D0
      G1=G+1.0D0
      G2=G1/2.0D0
      G3=G1/4.0D0
      G4=G1/16.0D0
      G5=(G-1.0D0)/2.0D0
      RAD=57.2957795D0
      SM=XM**2
C*** CHECK FOR DETACHED SHOCK WAVE
      EX=DARSIN(DSQRT((G3*SM-1.0D0+DSQRT(G1*(1.0D0+G2*SM+G4*SM**2D0)))
     1/(G*SM)))
      DX=DATAN((SM*DSIN(EX)**2.0D0-1.0D0)/((G2*SM-SM*DSIN(EX)**2D0+1.D0)
     1*DTAN(EX)))*RAD
      IF(DANG.GT.DX-.3D0) GO TO 95
C*** OBTAIN FIRST ESTIMATE FOR SHOCK WAVE ANGLE
      SLOPE=.77D0
      IF(XM.LT.1.5D0) SLOPE=1.50D0
      EE=DARSIN(1.0D0/XM)+(DANG*SLOPE)/RAD
C*** CALCULATE SHOCK WAVE ANGLE USING NEWTON RAPHSON ITERATION
   92 TND=DTAN(DANG/RAD)
      A=SM*DSIN(EE)**2.0D0-1.0D0
      B=G2*SM-A
      C=2.0D0*SM*DSIN(EE)*DCOS(EE)
      H=1.0D0/((TND*H)**2.0D0+A**2.0D0)
      FE=EE-DATAN(A/(B*TND))
```

```
      FEP=1.0D0-C*H*TND*(A+B)
      DE=-FE/FEP
      EE=EE+DE
      IF(DABS(DE).GT.0.00001) GO TO 92
      SHANG=EE*RAD
C*** FIND CONDITIONS DOWNSTREAM OF SHOCK
      U1N=AM*DSIN(SHANG/RAD)
      U1NS=U1N*U1N
      U2NS=(U1NS+1.0D0/G5)/(G/G5*U1NS-1.0D0)
      U2N=U2NS**.5D0
      T1=T1*(1.0D0+G5*U1NS)/(1.0D0+G5*U2NS)
      TP1=TP1*(1.0D0+G*U1NS)/(1.0D0+G*U2NS)
      IF (DATINP(14,JCX).GT.0.5D0) GO TO 94
      DATINP(3,JCX)=TP1
   94 CONTINUE
      AM=U2N/DSIN((SHANG-DANG)/RAD)
      THETA=T1*1.92800817D-3
      CA=CAZ*DSQRT(THETA)
      VEL=AM*CA
      DELTA=TP1/14.696D0
      GO TO 98
   95 PRINT 96
   96 FORMAT('   DETACHED SHOCK,DEFLECTION = 0 IS ASSUMED')
   98 MIF(JM1)=DATINP(1,JCX)
      CORFLO(JM1)=MIF(JM1)*DSQRT(T1)/TP1
      MIF(JP1)=MIF(JM1)
      FAR1=DATINP(10,JCX)
      FAR(JM1)=FAR1
      VEL=CA*AM
      RAMP=1.0D0
      T2=T1
      IF(VEL.LE.0.0D0) GO TO 100
      CALL THERMO (T1,TP1,H1,SS,5,RCH,FAR1,ZERO,ZERO,ZERO,0,GAM,ZERO)
      H2=H1+VEL*VEL*1.99708012D-5
      CALL THERMO (T1,TP1,H1,SS,4,RCH,FAR1,T2,H2,TP2,1,GAM,ZERO)
      RAMP=TP2/TP1
  100 H=DATINP(6,JCX)
C*** IF RECOVERY =0 USE AIAA RECOVERY
      IF(H.NE.0.0D0) GO TO 130
  110 IF(AM.GT.1.0D0) GO TO 120
      H=1.0D0
      GO TO 170
  120 IF(AM.GT.5.0D0)GO TO 125
      H=1.0D0-.075D0*((XM-1.0D0)**1.35D0)
      GO TO 130
  125 H=600.D0/(XM**4.0D0+935.0D0)
  130 N1=LOCIBL(6,JCX)
C*** LOOP ON RECOVERY AS A FUNCTION OF EXIT REFERRED FLOW AND MACH
      IF(N1.EQ.0) GO TO 170
      H=DATOUT(7,JCX)
      IF(H.LE.0.0D0) H=1.0D0
      RFMAX=DATINP(7,JCX)
      IF(RFMAX.EQ.0.0D0)RFMAX=1.0D+10
      RFSCAL =DATINP(8,JCX)
      IF(RFSCAL .EQ.0.0D0) RFSCAL =1.0D0
      CONST=RFSCAL *MIF(JP1)*DSQRT(T2)/(TP1*RAMP*1.54969567600)
      NN=0
  140 RB=H
      CF=CONST/H
C*** CHECK ON MAX REFERRED FLOW INPUT
      IF(CF.GT.RFMAX)CF=RFMAX
      CALL TABLU(N1,CF,XM,0.0D0,R)
      IF(H.LE.0.0D0) H=.01D0
      NN=NN+1
      IF(NN.GT.20) GO TO 160
      PRINT 150,AM,CF,R
```

INLT0049
INLT0051
INLT0052
INLT0053
INLT0055
INLT0
INLT0057
INLT0
INLT0065
INLT0066
INLT0
INLT0
INLT0
INLT0070
INLT0072
INLT0073
INLT0074
INLT0076
INLT
INLT0078
IN
INLT0081
INLT0082
INLT0083
INLT0084
INLT0085
INLT0
INL
INLT0088
INLT0089
INLT0090

```
  150 FORMAT(' WARNING RECOVERY HAS FAILED TO CONVERGE  XM= ',D12.5,     INLT0091
     1' CF= ',D12.5,'  R= ',D12.5)
      GO TO 170                                                          INLT0093
  160 IF(DABS(R-RL).GT..0005D0)  GO TO 140
  170 VMACH(JM1)=XM                                                      INLT0095
      TOTEMP(JP1)=T2                                                     INLT0096
      TOPRES(JP1)=RAMP*TP1*R                                             INLT0097
      FAR(JP1)=FAR1                                                      INLT0098
      CORFLO(JP1)=WTF(JP1)*DSQRT(T2)/TOPRES(JP1)
      DRAG=WTF(JP1)*VEL*3.108097707D-2                                   INLT0100
      N2=LOCTBL(4,JCX)                                                   INLT0101
      DRAG2=0.0D0                                                          INLT0
      Q=0.0D0
      IF(XM.EQ.0.0D0) GO TO 180
      Q=1481.354D0*DELTA*XM*XM
      QSF=Q*DATINP(13,JCX)
      DRAG2=QSF*DATINP(4,JCX)
      IF(N2.EQ.0) GO TO 180
      ACAP=DATINP(12,JCX)
      IF(ACAP)175,176,177
  175 CALL THERMO (T1,TP1,H1,SS,S,RCH,FAR1,ZERO,ZERO,ZERO,0,GAM,RINF)
      ACAP=-ACAP
      REF2= WTF(JM1)*RINF*T1*778.161D0/(TP1*VEL*ACAP)
      GO TO 178
  176 ACAP=1.0D0
  177 REF2=CORFLO(JP1)*.6452879849D0/ACAP
  178 CALL TABLU(N2,REF2,XM,0.0D0,DRAG2)
      IF (XM.LT.0.79D0) DRAG2=0.D0
      DRAG2=DRAG2*QSF*ACAP/144.D0
  180 DATOUT(1,JCX)=DRAG+DRAG2
      DATOUT(2,JCX)=VEL                                                  INLT0105
      DATOUT(3,JCX)=Q
      DATOUT(4,JCX)=T2/T1                                                INLT0107
      DATOUT(5,JCX)=RAMP                                                 INLT0108
      DATOUT(6,JCX)=XM                                                   INLT0109
      DATOUT(7,JCX)=R                                                    INLT0110
      DATOUT(8,JCX)=TOTEMP(JP1)* 1.928008174D-3                          INLT0111
      RETURN                                                             INLT0112
      END                                                                INLT0113
CINPRT
      SUBROUTINE INPRT                                                   INPR0001
      IMPLICIT REAL*8(A-H,O-Z)
      COMMON WTF(30),TOPRES(30),TOTEMP(30),FAR(30),CORFLO(30),VMACH(30) INPR0003
      COMMON STATP(30),ERROR(30),DATINP(15,40),DATOUT(9,40)
      COMMON DEPV(15),DTOL(15),PERPF(12),TOL,TOLT,TOLTT
      COMMON JM1,JM2,JP1,JP2,JCX,LOCTBL(9,40)
      COMMON JFIG(5,40),JFLOW(50),IDEDAP(14),JCOMP(50),NIT,IWAY
      COMMON KKINDS(15,25),NCOMP,NOSTAT,NITER,NCINIS,NPASS,JCC,NCTS
      COMMON JCIND(15),JCDEP(15),JCVIND(15),JCVDEP(15),KDTYP(15)
      DIMENSION JCID(2,15)
      REAL*8 IDP(2,9)
      DATA  JCID/4H  IN,4HLET ,4H DUC,4HT B ,4H  VA,4HLVE ,4HCOMP,4HRESHINPR0010
     1,4H TUR,4HBINE,4HHEAT,4H EXC,4HSPLI,4HITER,4H  MI,4HXER ,4H NOZ,4HINPR0011
     2ZLE ,4H  LO,4HAD  ,4H  SH,4HAFT ,4H CON,4HTHOL,4HOPT ,4HVAR ,
     3 4HLIMI,4HTER ,4H    ,4H    /
      DATA IDP/                                                          INPR0013
     1BHNET THRU,BHST (LBS),BHNET BRAK,BHE SHP      ,
     2BHAIRFLOW ,BH(LB/SEC)     ,BHTSFC LB/,BHHR/LB)     ,
     3BHBSFC (LB,BH/HR/HP)      ,BHFUEL FLO,BHW(LB/HR)   ,
     4BHNI THRUS,BHT/AIRFLW  ,BHNET BSHP,BH/AIRFLOW    ,
     5BHINLET DR,BHAG (LBS)    /
      PRINT 130,IDEDAP                                                   INPR0019
      PRINT 10, NOSTAT,NCOMP                                             INPR0020
   10 FORMAT (10X,20HCONFIGURATION DATA  ,I3,11H STATIONS  ,I3,1X,11HCOMINPR0021
     1PONENTS ,//,3X,9HCOMPONENT,2X,5HNKIND,1X,9HCOMPONENT,5X,8HUPSTREAMINPR0022
     2,7X,10HDOWNSTREAM,/,5X,6HNUMBER,11X,4HTYPE,8X,8HSTATIONS,8X,6HSTATINPR0023
```

```
     3IONS,/)
      DO 30 I=1,NCOMP
      JT=JFIG(1,I)
      PRINT 20, I,JT,(JCID(K,JT),K=1,2),(JFIG(L,I),L=2,5)
   20 FORMAT (6X,I2,7X,I2,3X,2A4,5X,4(I2,6X))
   30 CONTINUE
      IF (NCTS.EQ.0) RETURN
   40 PRINT 50
   50 FORMAT (///,10X,19HCONTROL INFORMATION,/)
      DO 120 I=1,NCTS
      K=KKINDS(I2,I+1)
      INDEP=DATINP(4,K)
      IJC=JFIG(4,K)
      DVAL=DATINP(5,K)
      JCV=DATINP(6,K)
      JFIX=JCV/10
      IDEP=JCV-10*JFIX
      IF(JFIX.GT.60,80,100
   60 PRINT 70, K,INDEP,IJC,IDEP,JFIG(2,K),DVAL
   70 FORMAT (1X,I2,7X,12HVARY CDAT    ,I2,1X,13HOF COMPONENT ,I2,1X,
     114HSO THAT STATP ,I2,1X,16HOF FLOW STATION ,I2,1X,7HEQUALS ,D12.5)
      GO TO 120
   80 PRINT 90, K,INDEP,IJC,IDEP,JFIG(2,K),DVAL
   90 FORMAT (1X,I2,7X,12HVARY CDAT    ,I2,1X,13HOF COMPONENT ,I2,1X,
     114HSO THAT DATOUT,I2,1X,16HOF COMPONENT     ,I2,1X,7HEQUALS ,D12.5)
      GO TO 120
  100 PRINT 110, K,INDEP,IJC,(IDP(J,IDEP),J=1,2),DVAL
  110 FORMAT (1X,I2,7X,12HVARY CDAT    ,I2,1X,13HOF COMPONENT ,I2,1X,
     1 8HSO THAT ,9X,2A8,9X,7HEQUALS ,D12.5)
  120 CONTINUE
      RETURN
      ENTRY FINPRT
      PRINT 130, IDEDAP
  130 FORMAT (1H1,20A4,//)
      IF(IWAY.EQ.0) GO TO 170
      PRINT 140
  140 FORMAT(T57,'DESIGN POINT MODE'///)
      DO 160 I=1,NCOMP
      IF(JFIG(1,I).GT.12) GO TO 160
      PRINT 150,I,( DATINP(J,I),J=1,8),I,( DATINP(J,I),J=9,15)
  150 FORMAT(' CDAT(',I2,',1-8 )',3X,9D13.5,/' CDAT(',I2,',9-15)',3X,
     1 7D13.5)
  160 CONTINUE
      PRINT 130,IDEDAP
  170 PRINT 180
  180 FORMAT (50X,28HSTATION PROPERTY OUTPUT DATA,//,5X,4HFLOW,7X,6HWEIG
     1HT,8X,5HTOTAL,8X,5HTOTAL,6X,5HFUEL/AIR,5X,9HREFERRED ,6X,4HMACH,8X
     2 ,6HSTATIC,2X,19HINTERFACE RELATIVE ,/,4X,7HSTATION,6X
     3 ,4HFLOW,7X,8HPRESSURE,4X,11HTEMPERATURE,5X
     4 ,5HRATIO,8X,4HFLOW,8X,6HNUMBER,6X,8HPRESSURE
     5 ,5X,10HFLOW ERROR)
      PRINT 190, ((J),J=1,8)
  190 FORMAT (13X,8(3X,5HSTATP,I1,4X))
      DO 210 I=1,NOSTAT
      REFF=CORFLO(I)*.6452879849D0
      PRINT 200, I,WTF(I),TOPRES(I),TOTEMP(I),FAR(I),REFF      ,VMACH(I),
     1STATP(I),ERROR(I)
  200 FORMAT (6X,I2,5X,9(D12.5,1X))
  210 CONTINUE
      PRINT 220, ((J),J=1,9)
  220 FORMAT (//,52X,21HCOMPONENT OUTPUT DATA,/,2X,9HCOMPONENT,/,2X,3HNO
     1.,2X,4HTYPE,2X,9(3X,6HDATOUT,I1,3X))
      DO 240 I=1,NCOMP
      JT=JFIG(1,I)
      IF(JT.EQ.12) GO TO 240
      PRINT 230, I,(JCID(L,JT),L=1,2),(DATOUT(K,I),K=1,9)
```

```
  230 FORMAT (1X,I2,1X,2A4,1X,9(D12.5,1X))                          INPR0090
  240 CONTINUE                                                      INPR0091
      PRINT 250,((J,(IDP(K,J),K=1,2),PERPF(J)),J=1,9)               INPR0092
  250 FORMAT(//,T54,'PERFORMANCE OUTPUTS',/                         INPR0093
     1 /,  3X,'(',I1,') ',2A8,F15.2,    3X,'(',I1,') ',2A8,F15.2,
     2     3X,'(',I1,') ',2A8,F15.2,/, 3X,'( ,I1,') ',2A8,F15.4,
     3     3X,'(',I1,') ',2A8,F15.4,   3X,'(',I1,') ',2A8,F15.2,
     4 /,  3X,'(',I1,') ',2A8,F15.2,   3X,'(',I1,') ',2A8,F15.2,
     5     3X,'(',I1,') ',2A8,F15.2)
      PRINT 260, NIT,NPASS                                          INPR0099
  260 FORMAT (//,40X,I3,12H ITERATIONS ,2X,I3,7H PASSES)            INPR0100
      IF (ERRIS.NE.0) PRINT 270                                     INPR0101
  270 FORMAT(//,10X,30HERROR PRINT *** NO CONVERGENCE)              INPR0102
      RETURN                                                        INPR0103
      END                                                           INPR0104
CMINV
      SUBROUTINE MINV(A,N,DM,L,M)                                   MINV0001
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION A(225),L(15),M(15)
      NK=-N                                                         MINV0003
      DM=1.000                                                        MINV00
      DO 140 K=1,N                                                  MINV0005
      NK=NK+N                                                       MINV0006
      LB=K                                                          MINV0007
      MB=K                                                          MINV0008
      KK=NK+K                                                       MINV0009
      BIGA=A(KK)                                                    MINV0010
      DO 30 J=K,N                                                   MINV0011
      IZ=N*(J-1)                                                    MINV0012
      DO 30 I=K,N                                                   MINV0013
      IJ=IZ+I                                                       MINV0014
   10 IF(DABS(BIGA)-DABS(A(IJ))) 20,30,30                           MINV0015
   20 BIGA=A(IJ)                                                    MINV0016
      LB=I                                                          MINV0017
      MB=J                                                          MINV0018
   30 CONTINUE                                                      MINV0019
      L(K)=LB                                                       MINV0020
      M(K)=MB                                                       MINV0021
      J=LB                                                          MINV0022
      IF(J-K) 60,60,40                                              MINV0023
   40 KI=K-N                                                        MINV0024
      JI=J-N                                                        MINV0025
      DO 50 I=1,N                                                   MINV0026
      KI=KI+N                                                       MINV0027
      HOLD=-A(KI)                                                   MINV0028
      JI=JI+N                                                       MINV0029
      A(KI)=A(JI)                                                   MINV0030
   50 A(JI) =HOLD                                                   MINV0031
   60 I=MB                                                          MINV0032
      IF(I-K) 90,90,70                                              MINV0033
   70 JI=N*(I-1)                                                    MINV0034
      JK=NK                                                         MINV0035
      DO 80 J=1,N                                                   MINV0036
      JK=JK+1                                                       MINV0037
      JI=JI+1                                                       MINV0038
      HOLD=-A(JK)                                                   MINV0039
      A(JK)=A(JI)                                                   MINV0040
   80 A(JI) =HOLD                                                   MINV0041
   90 IF(BIGA) 110,100,110                                          MINV0042
  100 DM=0.000                                                        MIN 00
      RETURN                                                        MINV0044
  110 BIGAR=1.000/BIGA                                                MINV0
      DO 130 I=1,N                                                  MINV0046
      IF(I-K) 120,130,120                                           MINV0047
  120 IK=NK+I                                                       MINV0048
      A(IK)=-A(IK)*BIGAR                                            MINV0049
```

B.25.

```
  130 CONTINUE                                                          MINV0050
      IK=NK                                                             MINV0051
      DO 160 I=1,N                                                      MINV0052
      IK=IK+1                                                           MINV0053
      HOLD=A(IK)                                                        MINV0054
      IJ=I-N                                                            MINV0055
      KM1=K-1                                                           MINV0056
      DO 160 J=1,N                                                      MINV0057
      IJ=IJ+N                                                           MINV0058
      IF(I-K) 140,160,140                                               MINV0059
  140 IF(J-K) 150,160,150                                               MINV0060
  150 KJ=IJ+KM1                                                         MINV0061
      A(IJ)=HOLD*A(KJ)+A(IJ)                                            MINV0062
  160 CONTINUE                                                          MINV0063
      KJ=K-N                                                            MINV0064
      DO 180 J=1,N                                                      MINV0065
      KJ=KJ+N                                                           MINV0066
      IF(J-K) 170,180,170                                               MINV0067
  170 A(KJ)=A(KJ)*BIGAR                                                 MINV0068
  180 CONTINUE                                                          MINV0069
      DM=DM*BIGA                                                        MINV0070
      A(KK)=BIGAR                                                       MINV0071
  190 CONTINUE                                                          MINV0072
      K=N                                                               MINV0073
  200 K=(K-1)                                                           MINV0074
      IF(K) 270,270,210                                                 MINV0075
  210 I=L(K)                                                            MINV0076
      IF(I-K) 240,240,220                                               MINV0077
  220 JK=N*(K-1)                                                        MINV0078
      JI=N*(I-1)                                                        MINV0079
      DO 230 J=1,N                                                      MINV0080
      JK=JK+1                                                           MINV0081
      HOLD=A(JK)                                                        MINV0082
      JI=JI+1                                                           MINV0083
      A(JK)=-A(JI)                                                      MINV0084
  230 A(JI) =HOLD                                                       MINV0085
  240 J=M(K)                                                            MINV0086
      IF(J-K) 200,200,250                                               MINV0087
  250 KI=K-N                                                            MINV0088
      DO 260 I=1,N                                                      MINV0089
      KI=KI+N                                                           MINV0090
      HOLD=A(KI)                                                        MINV0091
      JI=KI-K+J                                                         MINV0092
      A(KI)=-A(JI)                                                      MINV0093
  260 A(JI) =HOLD                                                       MINV0094
      GO TO 200                                                         MINV0095
  270 RETURN                                                            MINV0096
      END                                                               MINV0097
CMIN4PT
      SUBROUTINE MIN4PT (N,X,Y,DELX,FMAX,AC1)
      IMPLICIT REAL*8(A-H,O-Z)
C***  4 PT LEAST SQUARES SEARCH                                         MM4P0002
      DIMENSION YY(4)                                                   MM4P0003
      DATA NALL/30/
      DELS=DELX                                                         MM4P0004
      IF(N)100,50,10                                                    MM4P0005
   10 IF(Y.LE.YLAST) GO TO 60                                           MM4P0006
      IF(J-2) 20,70,30
   20 DELS=-DELX                                                        MM4P0008
      DELX=DELS+DELS                                                    MM4P0009
      X(1)=X                                                            MM4P0010
      Y=YLAST                                                           MM4P0011
      GO TO 70                                                          MM4P0012
   30 SC=0.000                                                          MM4P0
      IAVG=0.000
      SN=0.000                                                          MM4P0
```

B.26.

```
      YY(K)=Y                                                           MM4P0015
      Z=-3.0D0                                                             MM4P0
      FMAX=-1.D20
      DO 40 J=1,4                                                       MM4P0017
      K=K-(K/4)*4+1                                                     MM4P0018
      YYY=YY(K)
      IF(YYY.GT.FMAX)FMAX=YYY
      SN=SN+Z*YYY                                                       MM4P0019
      SD=SD+YYY  *(5.0D0-Z*Z)                                              MM4P0
      YAVG=YAVG+YYY
   40 Z=Z+2.0D0                                                            MM4P0
      YAVG=DABS((YAVG-YIN)/3.0D0)
      NOISE=0
      DO 41 I=1,4
      IF(YY(I).EQ.YIN) GO TO 41
      IF((DABS(YY(I))-YAVG).GT.AC1) GO TO 42
   41 CONTINUE
      NOISE=1
   42 IF(SD.EQ.0.0D0) GO TO 80                                             MM4P0
      DM=.8D0*SN/SD
      IF(DABS(DM).GT.1.5D0)  GO TO 101
      X=  X+DELX*(DM-1.5D0)
      N=-1                                                              MM4P0024
      RETURN                                                            MM4P0025
   50 NMM=10
      YIN=Y
      XIN=X
      NORAND=9
   51 K=1
      J=0
   60 YLAST=Y                                                           MM4P0027
      XLAST=X
   70 X=X+DELX                                                          MM4P0028
      YY(K)=Y                                                           MM4P0029
      K=K-(K/4)*4+1                                                     MM4P0030
      N=N+1                                                             MM4P0031
      J=J+1
      DELX=DELS                                                         MM4P0032
      IF(N.LT.NMM) RETURN
      NMM=NMM+10
      DELX=DELX+DELX
      IF(N.LT.NALL)   GO TO 51
   80 PRINT 90                                                          MM4P0034
   90 FORMAT(1X,27HMIN4PT,ERROR NO CONVERGENCE )                        MM4P0035
  100 IF(Y.GT.(YIN+AC1))GO TO 110
      AC=DABS(Y-YIN)
      IF(NOISE.EQ.0) GO TO 102
      AC1=AC
      PRINT 103,AC1
  103 FORMAT(
     1' NOISE IN OBJECTIVE FUNCTION HAS EXCEEDED CONVERGENCE TOLERENCE'/
     1,' TOLERANCE HAS BEEN RESET TO ',F15.8)
  102 DELX=-DELX*.1D0
      DELS=DELX
      X=XIN
      Y=YIN
      N=0
      PRINT 1001,X,Y,DELX,YAVG,NOISE
 1001 FORMAT(' X=',D12.5,' Y=',D12.5,' DELX=',D12.5,
     1 'YAVG=',D12.5,' N=',I5)
      NORAND=NORAND-1
      IF(NORAND.EQ.0) STOP
      IF(NOISE.EQ.0) GO TO 51
      N=0
      RETURN
  101 N=-2
```

```
      X=XLAST
      RETURN
  110 IF(N.EQ.-2) GO TO 111
      PRINT 1002,X,Y,YLAST,YIN
 1002 FORMAT(' X=',D12.5,'Y=',D12.5,'YLAST=',D12.5,' YIN=',D12.5)
      IF(Y.GT.(YLAST+AC1)) GO TO 101
  111 N=0
      RETURN
      END                                                               NM4P0037
CMIXER
      SUBROUTINE MIXER                                                  MIXR0001
      IMPLICIT REAL*8(A-H,O-Z)
      COMMON MIR(30),TOPRES(30),TOTEMP(30),FAR(30),CORFLO(30),VMACH(30) EP  0005
      COMMON STATP(30),ERROR(30),DATINP(15,40),DATOUT(9,40)
      COMMON DEPV(15),DTOL(15),PERPF(12),TOL,TOLT,TOLTT
      COMMON J41,J42,JP1,JP2,JCX,LOCTBL(9,40)
      COMMON JFIG(5,40),JFLOW(50),IDEDAP(14),JCOMP(50),NIT,IWAY
      COMMON KRINOS(15,25),NCOMP,NOSTAT,NITER,NFINIS,NPASS,JCC,NCTS
      COMMON JCIND(15),JCDEP(15),JCVIND(15),JCVDEP(15),KDTYP(15)
      COMMON RCH
   10 K=1                                                               MIXR0005
      J=JM1                                                             MIXR0006
   20 AREA=DATINP(K,JCX)                                                MIXR0007
      TP1=TOPRES(J)                                                     MIXR0008
      FAR1=FAR(J)                                                       MIXR0009
      T1=TOTEMP(J)                                                      MIXR0010
      CALL THERMO (T1,TP1,H1,S1,5,RCH,FAR1,ZERO,ZERO,ZERO,0,GAM3,R1)
      MIR=MIR(J)                                                        MIXR0014
      IF(IMAY.EQ.0) GO TO 50                                            MIXR0015
      IF(P.EQ.2) GO TO 40                                               MIXR0016
      PP=DATINP(3,JCX)                                                  MIXR0017
      VMIS=PP*PP                                                        MIXR0018
      IF(VMIS.GT.1.0D0) GO TO 40                                        MIXR0
      TS=T1/(1.0D0+.2D0*VMIS)                                           MIX
   30 CALL THERMO (T1,TP1,ZERO,S1,3,RCH,FAR1,TS,H2,PS,3,GAM,R1)
      VMSC=2.0D0*(H1-H2)/(GAM*R1*TS)                                    MIXR0
      DM=VMIS-VMSC                                                      MIXR0024
      TS=TS*(1.0D0-.5D0*(GAM-1.0D0)*DM/(1.0D0+.5D0*(GAM-1.0D0)*VMIS))
      IF(DABS(DM/VMIS).GT..00001D0) GO TO 30
      GO TO 60                                                          MIXR0028
   40 PS=TP1/PP
      CALL THERMO (T1,TP1,ZERO,S1,1,RCH,FAR1,TS,H2,PS,1,GAM,R1)
      IF(TS-T1)61,62,62
   62 TS=.9999D0*T1
      GO TO 60                                                          MIXR0032
   50 CONST=AREA*TP1/(R1*TP1*778.161D0)                                 MIXR00
      TS=TN=0.0D0                                                       MIXR0
      VMIS=0.0D0                                                        MIXR0
      PS=TP1
      NN=0                                                              MIXR0037
      FLOWG=MIR*DSQRT(R1*778.161D0*T1)/(AREA*TP1)
      IF(FLOWG.LT.1.0D-6) GO TO 150                                     MIXP003
      GAM=GAM1
      FOURAC=4.0D0*FLOWG/32.174D0*FLOWG/GAM                             MIX
      ROOT=0.0D0                                                        MIXR0
      IF(FOURAC.LT.1.0D0) ROOT=DSQRT(1.0D0-FOURAC)
      TDEL=(1.0D0-ROOT)*.25D0*(GAM-1.0D0)
      TS =T1*(1.0D0-TDEL)                                               MIXR0
      CA=0.0D0                                                          MIXR0
   60 CALL THERMO (T1,TP1,ZERO,S1,3,RCH,FAR1,TS,H2,PS,3,GAM,R1)
   61 V1=223.770200*DSQRT(H1-H2)
      VMIS=2.0D0*(H1-H2)/(GAM*R1*TS)                                    MIXR0
      IF(IMAX.EQ.0) GO TO 70                                            MIXR0051
      AREA=MIR/PS*TS/V1*R1*778.161D0                                    MIXR00
      IF(AREA.LE.0.0D0) AREA=1.0D20                                     MIXR
      DATINP(K,JCX)=AREA                                                MIXR0054
```

```
      GO TO 150                                                         MIXR0055
C***                                                                    MIXR0056
C*** COMPUTE  FLOW FOR CHECK WITH INCOMING FLOW                         MIXR0057
C***                                                                    MIXR0058
   70 WTIG=PS*CONST*V1/TS                                               MIXR0060
      IF(VM1S.LE.1.0D0) GO TO 90                                          MIXR0
C***                                                                    MIXR0062
C***  ITERATION HAS GONE SONIC -FIND STATIC TEMP FOR MACH=1.            MIXR0063
C***                                                                    MIXR0064
      TSMIN=.833300*T1                                                    MIXR00
   80 TS=TSMIN                                                          MIXR0066
      CALL THERMO (T1,TP1,ZERO,S1,3,RCH,FAR1,TS,HCRIT,ZERO,3,GAM,H1)
      VM3S=2.0D0*(H1-HCRIT)/(GAM*R1*TS)                                   MIXR0
      Z=.5D0*(GAM-1.0D0)*VM3S                                               MIX
      DM=1.0D0-VM3S                                                       MIXR0
      TSNEW=TSMIN*(1.0D0-Z/(1.0D0+Z)*DM/VM3S)                               MI
      IF(DABS(DM).GT..0000100 ) GO TO 80
      TS=TSMIN+.00500                                                     MIXR00
      CX=1.0D0                                                              MIXR0
      GO TO 60                                                          MIXR0076
   90 WTERR=(WTIR-WTIG)/WTIR                                            MIXR0077
      KM=KM+1                                                           MIXR0078
      IF(KM.GT.25) GO TO 110                                            MIXR0079
      IF(DABS(WTERR).LT..0001D0) GO TO 150
C***                                                                    MIXR0081
C*** UPDATE STATIC TEMP USING INFLUENCE COEFFICIENT                     MIXR0082
C***                                                                    MIXR0083
      FAC=-WTERR*  (GAM-1.0D0)*VM1S/(1.0D0-VM1S)                            MI
      IF(CX*WTERR.GT.0.0D0) GO TO 130                                     MIXR0
      CX=0.0D0                                                            MIX 0
      AFAC=DABS(FAC)
      IF(AFAC.GT..01D0) FAC=.01D0*FAC/AFAC                                 MIXR
      TOLD=TS                                                           MIXR0089
      TS=TS*(1.0D0+FAC)                                                   MIXR0
      IF(TS .GT.TSMIN) GO TO 100                                        MIXR0091
      TS =.5D0*(TSMIN+TOLD)                                               MIXR00
      GO TO 60                                                          MIXR0093
  100 IF(TS .GT.T1) TS =.99D0*T1+.01D0*TOLD                                MIXR
      GO TO 60                                                          MIXR0095
  110 PRINT 120,JCX                                                     MIXR0096
  120 FORMAT(' MACH NUMBER ITERATION HAS FAILED  '' COMPONENT ',I2)     MIXR0097
      GO TO 150                                                         MIXR0098
  130 PRINT 140,J                                                       MIXR0099
  140 FORMAT(10X,41HWARNING '*** VELOCITY IS SONIC AT STATION ,I2)      MIXR0100
  150 PR=TP1/PS                                                         MIXR0101
      SPMIX=TP1/PR                                                      MIXR0102
      VMACH(J)=DSQRT(VM1S)
      STATP(J)=SPMIX                                                    MIXR0104
      DATOUT(K,JCX)=AREA                                                MIXR0105
      DATOUT(K+2,JCX)=PR                                                MIXR0106
      DATOUT(K+4,JCX)=V1                                                MIXR0107
      S2=S1
      IF(K.EQ.2) GO TO 160                                              MIXR0109
      K=2                                                               MIXR0110
      SP1=SPMIX                                                         MIXR0111
      J=J+2                                                             MIXR0112
      PR=TOPRES(J)/SPMIX                                                MIXR0113
      W12=WTIR                                                          MIXR0114
      V10=WTIR*V1                                                       MIXR0115
      M12=M1*WTIR                                                       MIXR0116
      AIR12=WTIR/(1.0D0+FAR1)                                             MIXR0
      FAR12=FAR1*AIR12                                                  MIXR0118
      MS=M1                                                             MIXR0119
      SIN=S2*WTIR                                                       MIXR0120
      GO TO 20                                                          MIXR0121
  160 SPAVG=.5D0*(SPMIX+SP1)                                              MIXR01
```

```
      DATOUT(8,JCX)=(SPMIX-SP1)/SPAVG                                   MIXR0123
      SPMIX=SPAVG                                                       MIXR0124
      W12=W12+WT1R                                                      MIXR0125
      IF(W12.GT.0.0D0) GO TO 170                                          MIXR0
      H12=.5D0*(H1+HS)                                                   MIXR01
      GO TO 180                                                         MIXR0128
  170 AIR2=AIR1R/(1.0D0+FAR1)                                             MIXR0
      AIR12=AIR12+AIR2                                                  MIXR0130
      FAR12=(FAR12+FAR1*AIR2)/AIR12                                     MIXR0131
      W12R=1.0D0/W12                                                      MIXR0
      SIN=(SIN+S2*WT1R)*W12R                                            MIXR0133
      H12=(H12+H1*WT1R)*W12R                                            MIXR0134
      VID=(VID+V1*WT1R)*W12R                                            MIXR0135
      H31=H12-VID*VID*1.99708D-5
  180 CALL THERMO (T1,TP1,ZERO,SIN,4,RCH,FAR12,T12,H12,P12,1,GAM,R12)
      V12=VID*DATINP(4,JCX)                                             MIXR0138
      H32=H12-V12*V12*1.99708D-5                                        MIXR0139
      CALL THERMO (T12,P12,ZERO,SIN,4,RCH,FAR12,T32,H31,P32,1,GAM,R12)
      CALL THERMO (T32,SPMIX,H32,SOUT,6,RCH,FAR12,ZERO,ZERO,ZERO,0,GAM,
     1R12)
      PMIX=SPMIX*P12/P32                                                MIXER02
      IF(SOUT.LT.SIN) PMIX=P12
      DATOUT(9,JCX)=PMIX/SPMIX                                          MIXR0146
      DATOUT(7,JCX)=V12                                                 MIXR0147
      TOTEMP(JP1)=T12                                                   MIXR0148
      TOPRES(JP1)=PMIX                                                  MIXR0149
      CORFLO(JP1)=W12*DSQPT(T12)/PMIX
      FAR(JP1)=FAR12                                                    MIXR0151
      WTF(JP1)=W12                                                      MIXR0152
      RETURN                                                            MIXR0153
      END                                                               MIXR0154
CNEPSUB
      SUBROUTINE NEPSUB                                                 NEP20001
      IMPLICIT REAL*8(A-H,O-Z)
      INTEGER CWD,DWD
      COMMON/NEPOPT/SELAST,DD,NDSET,NPARTS,IOPTP,NPASSO,NVOPT,NJOPT,    NEP20002
     1TOLOPT,NOPT                                                       NEP20003
      COMMON WTF(30),TOPRES(30),TOTEMP(30),FAR(30),CORFLO(30),VMACH(30) NEP20005
      COMMON STATP(30),ERROR(30),DATINP(15,40),DATOUT(9,40)
      COMMON DEPF(15),DTOL(15),PERPF(12),TOL,TOLT,TOLTT
      COMMON JM1,JM2,JP1,JP2,JCX,LOCTBL(9,40)
      COMMON JFIG(5,40),JFLOW(50),JDEDAP(14),JCOMP(50),NIT,IWAY
      COMMON KKINDS(15,25),NCOMP,NOSTAT,NITER,NFINIS,NPASS,JCC,NCTS     NEP20008
      COMMON JCIND(15),JCDEP(15),JCVIND(15),JCVDEP(15),KDTYP(15)
      COMMON/TABLE/TTAB(50),NTBL                                        NEP20011
      DIMENSION F1(15),F2(15),CR2(15),CR3(15),T(225),V(15),XSA(15)      NEP20012
      DIMENSION IDCK(8),IDCE(8),IDCC(32),LMINV(15),MMINV(15),ICARD(15)  NEP20013
      DIMENSION JCACT(15)
      DIMENSION CDAT(15,40)                                             NEP20015
      DIMENSION ISET(74),IBUG(14)
      EQUIVALENCE(DATINP(1,1),CDAT(1,1))
C*** SPECIAL COMMON FOR INSTALLATION                                     NEP2001
      COMMON/QIN/IDEL,XMA,ALT,WMAX,PUNCHO,TIT,JCB,JN1,JN2,IDESN,IPRINT,
     2 JCAB2,JCAB1,NP,NM
      DIMENSION XMA(16),IDEL(7)                                         NEP20022
      NAMELIST/D/NCOMP,NOSTAT,IDESN,IPRINT,TITLE,TABLES,FIGSET,ENDRUN,  NEP20023
     1 JFIG,CDAT,NP,IDEL,XMA,NM,ALT,JCB,JN1,JN2,JCAB1,JCAB2,WMAX,TIT,   NEP20024
     2 IOPTP,NVOPT,NJOPT,TOLOPT,PUNCHO                                  NEP20025
      DATA IDCK /1,4,5,6,8,9,11,12/                                     NEP20028
      DATA IDCE / 1,11,21,24,27,29,30,32/                               NEP20029
      DATA IDCC /1,3,4,5,6,7,8,9,12,13,14,1,3,4,5,6,7,8,11,12,13,       NEP20030
     1  3,4,5,1,2,4,1,5,1,4,6/                                          NEP20031
      DATA CWD,DWD /'D E',' S'/
C     TITLE=0.0D0
C     TABLES=0.0D0
C     FIGSET=1.0D0
```

ORIGINAL PAGE IS
OF POOR QUALITY

```
C     ENDSET=0.0D0
C     NVOPT=0
C     IDESN=0
C     NJOPT=0
C     IOPIP=0
C     IPRINT=0
C     IOLOPT=.0002D0
C     ENDRUN=0.0D0
C1    READ (5,100,ERR=5,END=5)(ICARD(K),K=1,15)
C     WRITE(6,100)(ICARD(K),K=1,15)
C     GO TO 1
C5    REWIND 5
C***  CLEAR INPUT,OUTPUT WITH NEW CONFIGURATION READ IN                    NEP 0039
      PRINT 10                                                             NEP 0040
   10 FORMAT(1H1,//////////////,50X,'NAVAL AIR DEVELOPMENT CENTER',//)     NEP 0041
      PRINT 40                                                             NEP 0065
   40 FORMAT(//,41X,'NEPII   NAVY ENGINE PERFORMANCE COMPUTER CODE',
     1/52X,'VERSION II FOR IBM 360  ')
      PRINT 42
   42 FORMAT(/57X,' MODIFIED AT')
      PRINT 43
   43 FORMAT(/42X,' THE UNIVERSITY OF TENNESSEE SPACE INSTITUTE')
      PRINT 44
   44 FORMAT(/57X,' FEBRUARY 1979')
      DO 15 I=1,15
      DO 15 J=1,40
      CDAT(I,J)=0.0D0
   15 DATINP(I,J)=0.0D0
      DO 20 I=1,9
      DO 20 J=1,40
      DATOUT(I,J)=0.0D0
   20 DOCTBL(I,J)=0
      DO 25 I=1,5
      DO 25 J=1,40
   25 JFIG(I,J)=0
      DO 30 I=1,15
      DO 30 J=1,25
   30 KKINDS(I,J)=0
      DO 45 I=1,50
      JCOMP(I)=0
   45 JFLOW(I)=0
      DO 50 I=1,30
      WIP(I)=0.0D0
      IOPRES(I)=0.0D0
      IOTEMP(I)=0.0D0
      FAR(I)=0.0D0
      CORELO(I)=0.0D0
      VMACH(I)=0.0D0
      STATP(I)=0.0D0
   50 ERROR(I)=0.0D0
      DO 60 K=1,12                                                         NEP20090
   60 PERPF(K)=0.0D0
      IWAY=0
      TOL=0.0D0
      TOLI=0.0D0
      TOLII=0.0D0
      XSCM=.1D0D0                                                           NEP200
      TOL=.0005D0                                                           NEP200
      TOLII=.001D0                                                          NEP200
      NTBL=0                                                               NEP20095
      ENTRY  NPREAD                                                        NEP20096
      SELAST=0.0D0
   70 IR=0                                                                 NEP20097
      PRINT 80                                                             NEP20098
   80 FORMAT(/,      ' NAMELIST INPUT CARDS FOR NEXT SOLUTION')            NEP20099
C100  FORMAT(A2,A3,A3,12A6)
```

ORIGINAL PAGE IS
OF POOR QUALITY

```
  140 READ (5,0)                                                        NEP20114
      PRINT 160                                                         NEP20115
  160 FORMAT(1X)                                                        NEP20116
      IF(ENDRUN.EQ.1.0D0) STOP                                            NEP2
      IF(TITLE.EQ.1.0D0) READ (5,170)IDEDAP                                 NE
  170 FORMAT(20A4)                                                      NEP20
      TITLE=0.0D0                                                         NEP20
      ITPRT=TABLES-1.0D0                                                  NEP20
      IF(TABLES.NE.0.0D0) CALL TABRD(ITPRT,XD,YD,ZD,FXYZ)                 NEP20
      IF(FIGSET.EQ.0.0D0) GO TO 230                                       NEP20
      TABLES=0.0D0                                                        NEP20
      CALL CONFIG                                                       NEP20125
      FIGSET=0.0D0                                                        NEP20
C****    QUICK CHECK OF CDAT INPUTS                                     NEP20127
      IS=1                                                              NEP20128
      DO 210 I=1,8                                                      NEP20129
      JT=IDCP(I)                                                        NEP20130
      NT=KKINDS(JT,1)                                                   NEP20131
      IE=IDCE(I)                                                        NEP20132
      IF(NT.EQ.0) GO TO 210                                             NEP20133
      DO 200 J=1,NT                                                     NEP20134
      JCX=KKINDS(JT,J+1)                                                NEP20135
      CK=1.0D0                                                            NEP20
      DO 180 K=IS,IE                                                    NEP20137
      IDCCK=IDCC(K)
  180 CK=CK*DATINP(IDCCK,JCX)                                           NEP20138
      IF(CK.EQ.0.0D0) PRINT 190,JCX                                       NEP20
  190 FORMAT(' WARNING ONE OR MORE NORMALLY NON ZERO CDAT INPUTS TO COMPNEP20140
     1ONENT ',I2,' IS ZERO')                                            NEP20141
  200 CONTINUE                                                          NEP20142
  210 IS=IE+1                                                           NEP20143
      DO 215 I=1,9
      DO 215 J=1,40
      DATOUT(I,J)=0.0D0
  215 LOCTBL(I,J)=0
      DO 220 I=1,30
      WTF(I)=0.0D0
      TOPRES(I)=0.0D0
      TOTEMP(I)=0.0D0
      FAR(I)=0.0D0
      CORFLO(I)=0.0D0
  220 VMACH(I)=0.0D0
  230 RETURN                                                            NEP20146
      ENTRY GOVEP                                                       NEP20147
      IF(NTBL.EQ.0) GO TO 260                                           NEP20148
      DO 250 J=1,NCOMP                                                  NEP20149
      DO 250 I=1,9                                                      NEP20150
      LOCTBL(I,J)=0                                                     NEP20151
      DATIN=CDAT(I,J)                                                   NEP20152
      DO 240 N=1,NTBL                                                   NEP20153
      TABL=ITAB(N)                                                      NEP20154
      IF(TABL.EQ.DATIN) LOCTBL(I,J)=N                                   NEP20155
  240 CONTINUE                                                          NEP20156
  250 CONTINUE                                                          NEP20157
  260 IWAY=IDESN                                                        NEP20158
      IF(IWAY.NE.0.) IWAY=-1                                            NEP20159
      NCTS=KKINDS(12,1)                                                 NEP20160
      N=0                                                               NEP20161
      IF(NCTS.LE.0) GO TO 290                                           NEP20162
      DO 280 I=1,NCTS                                                   NEP20163
      JCX=KKINDS(12,I+1)                                                NEP20164
      ETOL=CDAT(1,JCX)                                                  NEP20165
      IF(ETOL.LE.0.0D0) GO TO 270                                         NEP20
      N=N+1                                                             NEP20167
      JCINC(N)=JFIG(4,JCX)                                              NEP20168
      JCDEP(N)=JFIG(2,JCX)                                              NEP20169
```

ORIGINAL PAGE IS
OF POOR QUALITY

```
      JCVIND(N)=DATINP(4,JCX)                                           NEP20170
      DEPV(N)=DATINP(5,JCX)                                             NEP20171
      IF(ETOL.EQ.1.0D0) ETOL=TOL                                          NEP20
      DTOL(N)=ETOL                                                      NEP20173
      JCV=CCAT(6,JCX)                                                   NEP20174
      JFIX=JCV/10                                                       NEP20175
      MDTYP(N)=JFIX-1                                                   NEP20176
      JCVDEP(N)=JCV-10*JFIX                                             NEP20177
      JCACT(N)=JCX                                                      NEP20178
      NI=JCVIND(N)                                                      NEP20179
      NJ=JCIND(N)                                                       NEP20180
      IF(DATOUT(1,JCX).NE.0.0D0) DATINP(NI,NJ)=DATOUT(1,JCX)              NEP20
      GO TO 280                                                         NEP20182
  270 DATOUT(1,JCX)=0.0D0                                                 NEP20
  280 CONTINUE                                                          NEP20184
  290 NCTS=N                                                            NEP20185
      NPASS=0                                                           NEP20186
      NIT=0                                                             NEP20187
      SE=0.0D0                                                            NEP20
C*** MOD                                                                NEP20189
      SE=SELAST                                                         NEP20190
      GO TO 520                                                         NEP20191
  300 IF(SELAST) 430,430,310                                            NEP20192
  310 SRATIO=SE/SELAST                                                  NEP20193
      IF(SRATIO.GT..6D0)GO TO 330                                        NEP201
  320 NSET=0                                                            NEP20195
      GO TO 470                                                         NEP20196
  330 IF(NIT)340,470,340
  340 IF(SRATIO.GT.1.0D0)GO TO 350                                        NEP20
      GO TO 370
  350 IF(NSET.EQ.1)GO TO 360                                            NEP20199
      GO TO 370
  360 NSET=0                                                            NEP20200
      GO TO 430                                                         NEP20201
  370 CT=0.0D0                                                            NEP02
      NSET=1                                                            NEP20203
      IF(IPRINT .GT.1) PRINT 380                                        NEP20204
  380 FORMAT(32H BROYDEN'S METHOD NOW BEING USED)                       NEP20205
      DO 390 I=1,NCTS                                                   NEP20206
      NI=JCVIND(I)                                                      NEP20207
      NJ=JCIND(I)                                                       NEP20208
  390 V(I)=(DATINP(NI,NJ)-XSA(I))/SCM                                   NEP20209
      DO 410 I=1,NCTS                                                   NEP20210
      C1=0.0D0                                                            NEP20
      C2=0.0D0                                                            NEP20
      K=1-NCTS                                                          NEP20213
      L=NCTS*(I-1)                                                      NEP20214
      DO 400 J=1,NCTS                                                   NEP20215
      K=K+NCTS                                                          NEP20216
      L=L+1                                                             NEP20217
      C1=C1+T(K)  *(F1(J)-F2(J))                                        NEP20218
  400 C2=C2+V(J)*T(L)                                                   NEP20219
      CR2(I)=C2                                                         NEP20220
      CR3(I)=V(I)*SCM-C1                                                NEP20221
  410 CT=CT+C2*(F1(I)-F2(I))                                            NEP20222
      DO 420 I=1,NCTS                                                   NEP20223
      CONST=CR3(I)/CT                                                   NEP20224
      K=1-NCTS                                                          NEP20225
      DO 420 J=1,NCTS                                                   NEP20226
      K=K+NCTS                                                          NEP20227
  420 T(K)  =CONST*CR2(J)+T(K)                                          NEP20228
      GO TO 470                                                         NEP20229
  430 JP=0                                                              NEP20230
      DO 450 I=1,NCTS                                                   NEP20231
      NJCAT=JCIND(I)                                                    NEP20232
      NIND=JCVIND(I)                                                    NEP20233
```

ORIGINAL PAGE IS
OF POOR QUALITY

B.33.

```
      X1=DATINP(NIND,NJCXI)                                             NEP20234
      DEL=TOLTI*X1                                                      NEP20235
      IF(DEL.EQ.0.0D0) DEL=TOLTT                                          NEP20
      X2=X1+DEL                                                         NEP20237
      DATINP(NIND,NJCXI)=X2                                             NEP20238
      CALL FLOCAL(NJCXI,SS,F2)                                          NEP20239
      IF(IPRINT.GT.2) CALL FINPRT                                       NEP20240
      DATINP(NIND,NJCXI)=X1                                             NEP20241
      DO 440 II=1,NCTS                                                  NEP20242
      JP=JP+1                                                           NEP20243
  440 T(JP)  =(F2(II)-F1(II))/DEL                                       NEP20244
C*****SPECIAL PRINTOUT OF PARTIAL MATRIX
C*****
C 443 PRINT 441,II,F2(II),F1(II),T(JP)
  441 FORMAT(I3,3(2X,E20.14))
  450 CONTINUE
      CALL MINV(T,NCTS,DET,LMINV,MMINV)                                 NEP20246
C***  ADD TO  NEP                                                       NEP20247
      NPARIS=1                                                          NEP20248
      IF(DET.EQ.0.0D0) PRINT 460                                          NEP20
  460 FORMAT(' MATRIX NO GO')                                           NEP20250
  470 DO 490 I=1,NCTS                                                   NEP20251
      DXX=0.0D0                                                           NEP20
      K=I-NCTS                                                          NEP20253
      DO 480 J=1,NCTS                                                   NEP20254
      K=K+NCTS                                                          NEP20255
  480 DXX=DXX-T(K)  *F1(J)                                              NEP20256
      F2(I)=F1(I)                                                       NEP20257
  490 V(I)=DXX                                                          NEP20258
      XMAX=0.0D0                                                          NEP20
      DO 500 J=1,NCTS                                                   NEP20260
      NIND=JCVIND(J)                                                    NEP20261
      NJCXI=JCIND(J)                                                    NEP20262
      XBAR=DATINP(NIND,NJCXI)                                           NEP20263
      IF(DABS(XBAR).LT.XSCM) XBAR=XSCM
      XMAX1=DABS(V(J)/XBAR)
      IF (XMAX1.GT.XMAX) XMAX=XMAX1                                     NEP20266
  500 CONTINUE                                                          NEP20267
      SCM=1.0D0                                                           NEP20
      IF (XMAX.GT.XSCM) SCM=XSCM/XMAX                                   NEP20269
      DO 510 K=1,NCTS                                                   NEP20270
      NIND=JCVIND(K)                                                    NEP20271
      NJCXI=JCIND(K)                                                    NEP20272
      XSA(K)=DATINP(NIND,NJCXI)                                         NEP20273
  510 DATINP(NIND,NJCXI)=DATINP(NIND,NJCXI)+V(K)*SCM                    NEP20274
      NII=NII+1                                                         NEP20275
  520 SELAST=SE                                                         NEP20276
      ITL=0
      CALL FLOCAL(ITL,SE,F1)
      IF(IPRINT.GT.1) PRINT 530,SE                                      NEP20278
  530 FORMAT(20H SUM OF (ERRORS**2)=,D12.5)
      IF(IPRINT.NE.3) GO TO 550                                         NEP20280
      PRINT 540,SELAST,SE,SCM, SRATIO,XMAX                              NEP20281
  540 FORMAT(1X,5D12.5)                                                 NEP20282
      CALL FINPRT                                                       NEP20283
  550 IF(NFINIS.EQ.0) GO TO 560                                         NEP20284
      IF(NII.LT.50) GO TO 300                                           NEP20285
  560 IF(IPRINT.GT.1) CALL FINPRT                                       NEP20286
      IF(NFINIS.NE.0) RETURN                                            NEP20287
      IF(NCTS.EQ.0) RETURN                                              NEP20288
      DO 570 I=1,NCTS                                                   NEP20289
      JCX=JCACT(I)                                                      NEP20290
      NI=JCVIND(I)                                                      NEP20291
      NJ=JCIND(I)                                                       NEP20292
  570 DATSUI(I,JCX)=DATINP(NI,NJ)                                       NEP20293
      RETURN                                                            NEP20294
```

B.34.

```
      END                                                               NEP20295
CNOZZLE
      SUBROUTINE NOZZLE                                                 NOZL0001
      IMPLICIT REAL*8(A-H,O-Z)
      COMMON WTF(30),TOPRES(30),TOTEMP(30),FAR(30),CORFLO(30),VMACH(30) EP  0005
      COMMON STATP(30),ERROR(30),DATINP(15,40),DATOUT(9,40)
      COMMON DEPV(15),DTOL(15),PERPF(12),TOL,TOLT,TOLTT
      COMMON JM1,JM2,JP1,JP2,JCX,LOCTBL(9,40)
      COMMON JFIG(5,40),JFLOW(50),IDEDAP(14),JCOMP(50),NIT,IWAY
      COMMON KKINDS(15,25),NCOMP,NOSTAT,NITER,NFINIS,NPASS,JCC,NCTS
      COMMON JCIND(15),JCDEP(15),JCVIND(15),JCVDEP(15),KDTYP(15)
      COMMON RCH
      TP1=TOPRES(JM1)                                                   NOZL0005
      SPE=DATINP(4,JCX)                                                 NOZL0006
      JINL=DATINP(9,JCX)                                                NOZL0008
      IF(JINL.LE.0) JINL=1
      IF(SPE.GT.0.0D0)GO TO 10
      SPE=DATINP(3,JINL)
C** DEFAULT PO IS AT FIRST COMPONENT     MUST BE INLET                   NOZL0011
   10 T1=TOTEMP(JM1)                                                    NOZL0012
      FAR1=FAR(JM1)                                                     NOZL0013
      PTOPA=TP1/SPE                                                     NOZL0014
      TPOPA=PTOPA
      CD=DATINP(2,JCX)                                                  NOZL0015
      IF(CD.LE.0.0D0) CD=1.0D0                                               NO
      AREA=DATINP(1,JCX)                                                NOZL0017
      TS1=.833300*T1                                                      NOZL00
      IP=0                                                              NOZL0019
   20 IP=IP+1                                                           NOZL0020
      IF(IP.GT.10) GO TO 30                                             NOZL0021
      TS=TS1                                                            NOZL0022
      CALL THERMO (T1,TP1,H1,S1,3,RCH,FAR1,TS,ZERO,ZERO,0,GAM,R1)
      TS1=T1/(1.0D0+(GAM-1.0D0)*.5D0)
      IF (DABS(TS-TS1).GT..01D0) GO TO 20
   30 PCRIT=(2.0D0/(GAM+1.0D0))**(GAM/(1.0D0-GAM))
      CALL THERMO (T1,TP1,H1,S1,5,RCH,FAR1,ZERO,ZERO,ZERO,0,GAM,R1)
      SPI=SPE                                                           NOZL0029
      NCD=LOCTBL(2,JCX)                                                 NOZL0030
      IF(NCD.GT.0) CALL TABLU(NCD,PTOPA,0.0D0,0.0D0,CD)
      PR=PTOPA
      DRAGN=0.0D0
      SIGN=1.0D0
      IF(PR.GT.1.0D0) GO TO 40                                             NOZL0
      SPI=TP1*PR
      PR=1.0D0/PR
      SIGN=-1.0D0
      PTOPA=PR
   40 IF (PR.LE.PCRIT)  GO TO 50                                        NOZL0043
      PR=PCRIT                                                          NOZL0044
      VM1=1.0D0                                                            NOZL0
      SPI=TP1/PR                                                        NOZL0046
   50 TP2=TP1/PR
      CALL THERMO (T1,TP1,H1,S1,1,RCH,FAR1,T2,H2,TP2,1,GAMS,R1)
      V1=223.770200*DSQRT(H1-H2)*SIGN
      SPVOL=778.161D0*R1*T2/SPT                                            NOZL00
      IF(IWAY+DATINP(7,JCX).LE.0.0D0) GO TO 60                             NOZL0
      WTIR=WTF(JM1)                                                     NOZL0054
      AREA=WTIR*SPVOL/(V1*CD)                                           NOZL0055
      IF(IWAY.NE.0) DATINP(1,JCX)=AREA                                  NOZL0056
      GO TO 70                                                          NOZL0057
   60 WTIR=AREA*V1*CD/SPVOL                                             NOZL0058
   70 CORFR=WTIR*DSQRT(T1)/TP1
      IF(PR.EQ.PCRIT)GO TO 80                                           NOZL0060
      VM1=DSQRT((T1/T2-1.0D0)*2.0D0/(GAMS-1.0D0))
   80 VS=V1/VM1                                                         NOZL0063
      STATP(JM1)=SPI                                                    NOZL0064
```

ORIGINAL PAGE IS OF POOR QUALITY

```
      IF(DATINP(6,JCX).NE.0.0D0)GO TO 90                                NOZL0
      VIDEAL=V1
      VE=VS
      PROUT=PR                                                          NOZL0067
      GO TO 100                                                         NOZL0068
C     CO NOZZLE *** FULL EXPANSION                                      NOZL0069
   90 PROUT=PTOPA
      TP4=TP1/PROUT
      CALL THERMO (T1,TP1,H1,S1,1,RCH,FAR1,T4,H4,TP4,1,GAM4,R1)
      VIDEAL=223.770200*DSQRT(H1-H4)*SIGN
      VE=VS*DSQRT(GAM4*T4/(GAM5*T2))
      SPT=SPE                                                           NOZL0076
  100 CV=DATINP(5,JCX)                                                  NOZL0077
      NCV=DOCIOD(5,JCX)                                                 NOZL0078
      NCA=DOCIOD(8,JCX)                                                 NOZL0079
      AREAIN=DATINP(6,JCX)                                              NOZL0080
      AKAT=AREA/DATINP(1,JCX)                                           NOZL0081
      IF(NCA.GT.0) CALL TABLU(NCA,AKAT,0.0D0,0.0D0,ALATM)
      IF(NCV.GT.0) CALL TABLU(NCV,PROUT,ALATM,0.0D0,CV)
      VACT=CV*VIDEAL                                                    NOZL0084
      FG=(WTIN*VACT*3.108099707D-2)*SIGN+AREA*(SPT-SPE)                 N
      D=DATOUT(3,JINL)
      IF(D.EQ.0.0D0) GO TO 110
      DRAGN=DATINP(3,JCX)
      NRD=DOCIOD(3,JCX)
      IF(NRD.GT.0) CALL TABLU(NRD ,TOPA,DATOUT(6,JINL),0.0D0,DRAGN)
      DRAGN=DRAGN*D*DATINP(10,JCX)*DATINP(11,JCX)*AREA/144.D0
  110 VMACH(JM1)=V1/VS                                                  NOZL0086
      WTR(JM1)=WTIN                                                     NOZL0087
      CONFLO(JM1)=CONFR                                                 NOZL0088
      TOTMP(JM1)=T1                                                     NOZL0089
      TOPRES(JM1)=TP1                                                   NOZL0090
      WTR(JM1)=WTIR                                                     NOZL0091
      CONFLO(JM1)=CONFR                                                 NOZL0092
      FAR(JM1)=FAR1                                                     NOZL0093
      VMACH(JM1)=VACT/VE
      STATP(JM1)=SPE                                                    NOZL0095
      DATOUT(1,JCX)=FG                                                  NOZL0096
      DATOUT(2,JCX)=VACT                                                NOZL0097
      DATOUT(3,JCX)=PROUT                                               NOZL0098
      DATOUT(4,JCX)=VIDEAL                                              NOZL0099
      DATOUT(5,JCX)=AREA                                                NOZL0100
      DATOUT(6,JCX)=CD                                                  NOZL0101
      DATOUT(7,JCX)=CV                                                  NOZL0102
      DATOUT(8,JCX)=DRAGN
      DATOUT(9,JCX)=TPOPA
      RETURN                                                            NOZL0105
      END                                                               NOZL0106
CSNEST0
      SUBROUTINE SNEST(N,DY,X,DELX,TOL,ABDS,DYL,ABDYL,XCHECK,XLOC)      SNES
      IMPLICIT REAL*8(A-H,O-Z)
C** NEW FORM OF SOLVER                                                  0001
C*** MAY BE USED WITH NESTED ITERATIONS                                 0002
      ABDY=DABS(DY)
      IF(ABDY-TOL)140,140,10                                            0004
   10 IF(N)30,20,30                                                     0005
   20 ABDS=DABS(DELX)*2.0D0
      GO TO 100                                                         0007
   30 IF(X-XCHECK)40,50,40                                              0008
   40 DELX=-.5D0*(DELX+X-XCHECK)                                        00
      GO TO 100                                                         0010
   50 IF(ABDYL-ABDY)70,100,60                                           0011
   60 ABDS=ABDS*.5D0                                                    00
   70 DF=DYL-DY                                                         0013
      IF(DF)=0,100,80
   80 DELX=DY*DELX/DF                                                   0015
```

B.36.

```
      ABD=DABS(DELX)                                                    016
      IF(ABD-ABDS)100,100,90                                            0017
   90 DELX=ABDS*DELX/ABD                                                0018
  100 DYL=DY                                                            0019
      N=N+1                                                             0020
      X=X+DELX                                                          0021
      ACHECK=X                                                          0022
      ABDYL=ABDY                                                        0023
      IF(N-30)110,120,120                                               0024
  110 RETURN                                                            0025
  120 WRITE (    6   ,130) N,XLOC
  130 FORMAT(1X,25HNO CONVERGENCE IN SOLVER ,I3,19H TRYS**CALLED FROM ,  0027
     1A6)                                                               028
  140 N=0                                                               0029
      RETURN                                                            0030
      END                                                               0031
CSPLITR
      SUBROUTINE SPLITR
      IMPLICIT REAL*8(A-H,O-Z)
      COMMON WTF(30),TOPRES(30),TOTEMP(30),FAR(30),CORFLO(30),VMACH(30) EP  0005
      COMMON STATP(30),ERROR(30),DATINP(15,40),DATOUT(9,40)
      COMMON DEPV(15),DTOL(15) PERSF(12),TOL,TOLT,TOLTI
      COMMON JM1,JM2,JP1,JP2, CX,LOCTBL(9,40)
      COMMON JFIG(5,40),JFLOW(50),IDEDAP(14),JCOMP(50),NIT,IWAY
      COMMON KKINDS(15,25),NCOMP,NDSTAT,NITER,NFINIS,NPASS,JCC,NCTS
      COMMON JCIND(15),JCDEP(15),JCVIND(15),JCVDEP(15),KDTYP(15)
      T1=TOTEMP(JM1)
      TP=TOPRES(JM1)                                                    SPLT0010
      TOTEMP(JP1)=T1                                                     SPLT000
      TOTEMP(JP2)=T1                                                     SPLT000
      CF1=CORFLO(JM1)
      DMAIN=DATINP(2,JCX)
      DBYPS=DATINP(3,JCX)
      N2=LOCTBL(2,JCX)
      N3=LOCTBL(3,JCX)
      IF(N2.NE.0) CALL TABLU(N2,CF1,0.0D0,0.0D0,DMAIN)
      TPM=TP*(1.0D0-DMAIN)
      IF(N3.NE.0) CALL TABLU(N3,CF1,0.0D0,0.0D0,DBYPS)
      TPB=TP*(1.0D0-DBYPS)
      FAR(JP1)=FAR(JM1)
      FAR(JP2)=FAR(JM1)
      TROUT=DSQRT(T1)
      B=DATINP(1,JCX)                                                   SPLT0012
      IF(B.LT.0.0D0) B=0.0D0                                                SP
      WTF(JP1)=WTF(JM1)/(B+1.0D0)                                        SPLT0
      WTF(JP2)=WTF(JM1)-WTF(JP1)                                        SPLT0015
      TOPRES(JP1)=TPM                                                    SPLT00
      TOPRES(JP2)=TPB                                                    SPLT00
      CORFLO(JP1)=WTF(JP1)*TROUT/TPM                                       SPLT
      CORFLO(JP2)=WTF(JP2)*TROUT/TPB                                       SPLT
      DATOUT(1,JCX)=B                                                   SPLT0018
      RETURN                                                            SPLT0019
      END                                                               SPLT0020
CSPLNQ
      FUNCTION  SPLNQ1    (NLOC,X,XINDEP)                               SPLN0001
      IMPLICIT REAL*8(A-H,O-Z)
C*** LOCAL CUBIC FIT   8/9/77  M.J. CADDY                               SPLN0002
      DIMENSION X(1100),QM(3)
      EQUIVALENCE (QM(1),T3),(QM(2),Q2),(QM(3),Q3)                      SPLN0004
      XIN=XINDEP                                                        SPLN0005
      NS=NLOC                                                           SPLN0006
      NSPTS=X(NS)                                                       SPLN0007
      ID=NS+NSPTS                                                       SPLN0008
      NSP1=NS+1                                                         SPLN0009
      NSP2=NS+2                                                         SPLN0010
      IF(NSPTS.LE.1) GO TO 130                                          SPLN0011
```

```
      IF(NOPTS.GT.2) GO TO 10                                           SPLN0012
      N=ID+NOPTS                                                        SPLN0013
      Y3=(X(N)-X(N-1))/(X(ID)-X(ID-1))                                  SPLN0014
      M=ID                                                              SPLN0015
      NTRAP=1                                                           SPLN0016
      GO TO 280                                                         SPLN0017
   10 NS2=NOPTS*2+NSP1                                                  SPLN0018
      L=X(NS2)                                                          SPLN0019
      LSC=NS2+1                                                         SPLN0020
      IDMODE=X(LSC)                                                     SPLN0021
      K=L+NS                                                            SPLN0022
      NL=NSP1                                                           SPLN0023
      NH=ID                                                             SPLN0024
      NTRAP=-1                                                          SPLN0025
C*** BINARY SEARCH FOR INTERVAL                                         SPLN0026
      IF(XIN-X(ID))30,140,20                                            SPLN0027
   20 NTRAP=0                                                           SPLN0028
      GO TO 150                                                         SPLN0029
   30 IF(XIN-X(NSP1))40,40,60                                           SPLN0030
   40 NTRAP=1                                                           SPLN0031
   50 K=NSP2                                                            SPLN0032
      GO TO 160                                                         SPLN0033
   60 IF(L)120,120,70                                                   SPLN0034
   70 IF(XIN-X(K))80,100,100                                            SPLN0035
   80 NH=K                                                              SPLN0036
      K=K-1                                                             SPLN0037
   90 IF(XIN-X(K))110,100,100                                           SPLN0038
  100 NL=K                                                              SPLN0039
      GO TO 120                                                         SPLN0040
  110 NH=K                                                              SPLN0041
  120 K=(NH-NL)/2+NL                                                    SPLN0042
      IF(K-NL)90,140,90                                                 SPLN0043
  130 YOUT=X(NSP2)                                                      SPLN0044
      GO TO 320                                                         SPLN0045
  140 LFAST=L-NH+NS                                                     SPLN0046
      X(NS2)=NH-NS                                                      SPLN0047
  150 K=NH                                                              SPLN0048
  160 M=K                                                               SPLN0049
      N=M+NOPTS                                                         SPLN0050
      Y3=X(N-1)                                                         SPLN0051
      X3=X(M-1)                                                         SPLN0052
C*** CHECK FOR FAST MODE AND  EXTRAPOLATION                             SPLN0053
      IF(NTRAP.GE.0) GO TO 180                                          SPLN0054
      IF(IDMODE*L.EQ.0.OR.LFAST.NE.0) GO TO 180                         SPLN0055
      DO 170 I=1,3                                                      SPLN0056
  170 QM(I)=X(LSC+I)                                                    SPLN0057
      GO TO 310                                                         SPLN0058
  180 Y4=X(N)                                                           SPLN0059
      X4=X(M)                                                           SPLN0060
      A3=X4-X3                                                          SPLN0061
      S3=(Y4-Y3)/A3                                                     SPLN0062
      IF(M.EQ.NSP2) GO TO 190                                           SPLN0063
      X2=X(M-2)                                                         SPLN0064
      Y2=X(N-2)                                                         SPLN0065
      S2=(Y3-Y2)/(X3-X2)                                                SPLN0066
      IF(M.EQ.ID) GO TO 200                                             SPLN0067
  190 X5=X(M+1)                                                         SPLN0068
      Y5=X(N+1)                                                         SPLN0069
      S4=(Y5-Y4)/(X5-X4)                                                SPLN0070
      IF(M.EQ.NSP2)   S2=S3+S3-S4                                       SPLN0071
      GO TO 210                                                         SPLN0072
  200 S4=S3+S3-S2                                                       SPLN0073
  210 IF(M.GE.(NSP2+1))    GO TO 220                                    SPLN0074
      S1=(Y2-X(N-3))/(X2-X(M-3))                                        SPLN0075
      GO TO 230                                                         SPLN0076
  220 S1=S2+S2-S3                                                       SPLN0077
```

```
  230 IF(M.GE.(ID-1))     GO TO 240
      S5=(X(N+2)-Y5)/(X(N+2)-X5)
      GO TO 250
  240 S5=S4+S4-S3
  250 W2=DABS(S4-S3)
      W3=DABS(S2-S1)
      SW=W2+W3
      IF(SW.NE.0.0D0)      GO TO 260
      W2=0.5D0
      W3=0.5D0
      SW=1.0D0
  260 T3=(W2*S2+W3*S3)/SW
      W3=DABS(S5-S4)
      W4=DABS(S3-S2)
      SW=W3+W4
      IF(SW.NE.0.0D0)     GO TO 270
      W3=0.5D0
      W4=0.5D0
      SW=1.0D0
  270 T4=(W3*S3+W4*S4)/SW
      IF(NIMAP.GT.0) GO TO 290
      IF(NIMAP.EQ.0) T3=T4
  280 IA=4-NIMAP
C*** FAST EXIT FOR 2 POINTS AND LINEAR EXTRAPOLATION
      YOUT=X(IA+NOPTS)+(XIN-X(IX))*T3
      GO TO 320
  290 Q2=(2.0D0*(S3-T3)+S3-T4)/A3
      Q3=(-S3-S3+T3+T4)/(A3*A3)
      IF(LPODE*LFAST.EQ.0) GO TO 310
      DO 300 I=1,3
  300 X(LSC+I)=Q*(I)
  310 DX=XIN-X3
      YOUT=T3+DX*(T3+DX*(Q2+DX*Q3))
  320 SPLNQ1=YOUT
      RETURN
      END
CSPSET
      SUBROUTINE SPSET(L,X,XIN,YIN)
      IMPLICIT REAL*8(A-H,O-Z)
C***   SETS UP ARRAY FOR SPLNQ1 TO USE
      DIMENSION X(1100)
      NP=X(L)
      J=L+1
      IF(NP.LE.0) GO TO 20
      DO 10 I=1,NP
      J=I+L
      IF(XIN-X(J)) 20,60,10
   10 CONTINUE
      J=J+1
   20 NX=J
      N1=NX+NP+1
      N2=NP*2+2+L
      X(N2+1)=0.0D0
      X(N2+2)=1.0D0
      X(L)=NP+1
      K=2
   30 N1=N2-K
      X(N2)=X(N1)
      IF(N2.EQ.NX) GO TO 50
      IF(N2.NE.N1) GO TO 40
      K=1
      X(N2)=YIN
   40 N2=N2-1
      GO TO 30
   50 X(NX)=XIN
   60 RETURN
```

```
SPLN0078
SPLN0079
SPLN0080
SPLN0081

SPLN0084
  SPLN00
  SPLN00
  SPLN00
  SPLN00
SPLN0089

SPLN0092
  SPLN00
  SPLN00
  SPLN00
  SPLN00
SPLN0097
SPLN0098
SPLN0099
SPLN0100
SPLN0101
SPLN0102
SPLN0103
  SPLN01
SPLN0105
SPLN0106
SPLN0107
SPLN0108
SPLN0109
SPLN0110
SPLN0111
SPLN0112
SPLN0113

SPSE0001

SPSE0002

SPSE0004
SPSE0005
SPSE0006
SPSE0007
SPSE0008
SPSE0009
SPSE0010
SPSE0011
SPSE0012
SPSE0013
SPSE0014
  SPSE0
  SPSE0
SPSE0017
SPSE0018
SPSE0019
SPSE0020
SPSE0021
SPSE0022
SPSE0023
SPSE0024
SPSE0025
SPSE0026
SPSE0027
SPSE0028
```

ORIGINAL PAGE IS
OF POOR QUALITY

```
      END                                                               SPSE0029
CTABRD
      SUBROUTINE TABRD (II,X,Y,Z,FXYZ)                                  TABR0001
      IMPLICIT REAL*8(A-H,O-Z)
C  REVISED  9/76  MJC,DBK                                               TABR0002
      INTEGER E*D,F*D
      COMMON /INIZE/IDATA(3000),NMAX                                    TABR0003
      COMMON/TABLE/ITAB(50),NTBL                                        TABR0004
      DIMENSION A(100),IREP (30),IDD(4),LOCTB(30)                       TABR0005
      DATA E*D /'    '/
      DATA F*D /'EOT '/
C     NTABL=0
C     NMAX=3000
      MR=0                                                              TABR0007
      IF(NTBL.NE.0) GO TO 20                                            TABR0008
      LOC=1                                                             TABR0009
      DO 10 M=1,NMAX                                                    TABR0010
   10 IDATA(M)=0.0D0                                                      TABR0
   20 READ (5,30) IP,ITABNO                                               TABR0
   30 FORMAT (I1,I4,70H                                                 TABR0013
     1                    )                                            TABR0014
      IF(ITABNO.EQ.0) GO TO 100                                         TABR0015
      NTBL=NTBL+1                                                       TABR0016
      ITAB(NTBL)=ITABNO                                                 TABR0017
      LOCTB(NTBL)= LOC                                                  TABR0018
      IF(NTBL.LE.1) GO TO 150                                           TABR0019
      DO 40 I=2,NTBL                                                    TABR0020
      IF(ITABNO.EQ.ITAB(I-1))  GO TO 50                                 TABR0021
   40 CONTINUE                                                          TABR0022
      GO TO 150                                                         TABR0023
   50 MLOC=LOCTB(I-1)
      ILOC=MLOC                                                         TABR0024
      LOCTB(I-1)=LOC
      NTBL=NTBL-1                                                       TABR0045
      MR=MR+1                                                           TABR0025
      IREP(MR)=ITABNO                                                   TABR0026
      LIBLOC=100000                                                     TABR0027
      DO 60 IRK=1,NTBL                                                  TABR0029
      LIBRA=LOCTB(IRK)                                                  TABR0030
      IF((LIBRA.GE.MLOC).AND.(LIBRA.LT.LIBLOC)) LIBLOC=LIBRA
   60 CONTINUE                                                          TABR0032
      LEO=LIBLOC-MLOC                                                   TABR0033
      IF(LEO.EQ.0)  GO TO 89
      IZAR=LOC-1                                                        TABR0028
      DO 70 I=LIBLOC,IZAR                                               TABR0034
      IDATA(MLOC)=IDATA(I)                                              TABR0035
   70 MLOC=MLOC+1                                                       TABR0036
      DO 80 I=1,NTBL                                                    TABR0037
      LLOC=LOCTB(I)                                                     TABR0038
      IF(LLOC.GT.ILOC) LOCTB(I)   =LLOC-LEO                             TABR0039
   80 CONTINUE                                                          TABR0040
   89 DO 90 I=MLOC,LOC                                                  TABR0042
   90 IDATA(I)=0.0D0                                                      TABR0
      LOC=MLOC                                                          TABR0044
      GO TO 150                                                         TABR0046
  100 NREM=NMAX-LOC                                                     TABR0047
      IF(II.LE.0) GO TO 135                                             TABR0048
      PRINT 110,NTBL                                                    TABR0049
  110 FORMAT (1H1,35X,24HTABLE DATA INPUT SUMMARY,1XI2,1X,6HTABLES,//,28TABR0050
     1X,40HTABLE NUMBER  REFERENCE NUMBER   ARRAY LOCATION )            TABR0051
      PRINT 120, ((N,ITAB(N),LOCTB(N)),N=1,NTBL)                        TABR0052
  120 FORMAT (32X,I2,12X,I5,15X,I5)                                     TABR0053
      PRINT 130, NMAX,NREM                                              TABR0054
  130 FORMAT (//,35X,24HDATA STORAGE ALLOCATION ,I5,/35X,24HDATA STORAGETABR0055
     1 NOT USED   ,I5,/)                                                TABR0056
  135 IF(MR.GT.0) PRINT 140,(IREP(IQ),IQ=1,MR)                          TABR0057
```

```
140 FORMAT(10X,'THE FOLLOWING TABLES HAVE BEEN REPLACED',10(I5,','))  TABR0058
    RETURN                                                            TABR0060
150 IF(II.LE.0) GO TO 170                                             TABR0061
    IP=1                                                              TABR0062
    PRINT 30, IP,ITABNO                                               TABR0063
    PRINT 160                                                         TABR0064
160 FORMAT(///////)                                                   TABR0065
170 ICC=0                                                             TABR0066
    LZ=LOC                                                            TABR0067
    DO 180 ICL=1,4
180 IDD(ICL)=EMD
    ID=0
190 IDL=ID                                                            TABR0070
    READ (5,200)ID,N,(A(I),I=1,N)                                     TABR0
200 FORMAT(A4,I3,3X,(T11,7F10.0))                                     TABR0072
    IF(ID.EQ.EMD )GO TO 20
    ICC=ICC+1                                                         TABR0074
    IF(ICC.LE.4) IDD(ICC)=ID                                          TABR0075
    IF(ID.EQ.IDL) GO TO 280                                           TABR0076
    IF(ID.EQ.IDD(4)) GO TO 210                                        TABR0077
    IF(IDL.EQ.IDD(2)) GO TO 280                                       TABR0078
    LOC=LE                                                            TABR0079
    L=LX                                                              TABR0080
    GO TO 220                                                         TABR0081
210 TDATA(LOC)=N                                                      TABR0082
    L=LOC                                                             TABR0083
    IF(ID.EQ.IDD(3)) LX=L                                             TABR0084
    IF(ID.NE.IDD(2)) GO TO 260                                        TABR0085
    LE=L                                                              TABR0086
    LZ=LZ+1                                                           TABR0087
    GO TO 260                                                         TABR0088
220 IF(IP.EQ.0) GO TO 260                                             TABR0089
    LE=LE+1                                                           TABR0090
    PRINT 230,IDD(1),TDATA(LZ),IDD(2),TDATA(LE)                       TABR0091
230 FORMAT(1X,A4,1H=,D13.5,1X,A4,1H=,D13.5)
    JF=0                                                              TABR0093
    M=N                                                               TABR0094
    LF=LX                                                             TABR0095
240 NP=M                                                              TABR0096
    IF(M.GT.8)NP=8                                                    TABR0097
    M=M-NP                                                            TABR0098
    LE=LF+NP                                                          TABR0099
    LF=LF+1                                                           TABR0100
    PRINT 250,IDD(3),(TDATA(I),I=LF,LE)                               TABR0101
250 FORMAT(20X,A4,1X,8D13.5)                                          TABR0102
    LF=LE                                                             TABR0103
    JE=JF+NP                                                          TABR0104
    JF=JF+1                                                           TABR0105
    PRINT 250,IDD(4),(A(I),I=JF,JE)                                   TABR0106
    JF=JE                                                             TABR0107
    IF(M.GT.0) GO TO 240                                              TABR0108
260 DO 270 I=1,N                                                      TABR0109
    LOC=LOC+1                                                         TABR0110
270 TDATA(LOC)=A(I)                                                   TABR0111
    LE=LOC                                                            TABR0112
    IF(ID.EQ.IDD(4)) TDATA(LOC+2)=1.0D0                               TABR0
    LOC=L+3*N+3                                                       TABR0114
    IF(LOC.GT.NMAX) GO TO 300                                         TABR0115
    GO TO 190                                                         TABR0116
280 TDATA(LOC)=TDATA(LX)                                              TABR0117
    L=LOC                                                             TABR0118
    DO 290 I=1,N                                                      TABR0119
    LOC=LOC+1                                                         TABR0120
290 TDATA(LOC)=TDATA(LX+I)                                            TABR0121
    GO TO 220                                                         TABR0122
300 PRINT 310, ITABNO                                                 TABR0123
```

ORIGINAL PAGE IS
OF POOR QUALITY

```
  310 FORMAT (1X,32H*********TABLE OVER FLOW ,TABLE ,I5,11H NOT LOADED) TABR0124
      GO TO 100                                                         TABR0125
      ENTRY TABLU(II,X,Y,Z,FXYZ)
      IF(II.LE.0) RETURN                                                TABR0127
      IZ=LOCTB(II)                                                      TABR0128
      INZ=IDATA(IZ)                                                     TABR0129
      IY=3*INZ+IZ+3                                                     TABR0130
      IX=IY                                                             TABR0131
      IZ1=IZ+INZ+1                                                      TABR0132
      IZ2=IZ+2*INZ                                                      TABR0133
      DO 330 IZS=IZ1,IZ2                                                TABR0134
      INY=IDATA(IY)                                                     TABR0135
      IX=3*INY+IX+3                                                     TABR0136
      IY1=IY+INY+1                                                      TABR0137
      IY2=IY+2*INY                                                      TABR0138
      DO 320 IYS=IY1,IY2                                                TABR0139
      IDATA(IYS)=SPLNQ1(IX ,TDATA,X)                                    TABR0140
  320 IX=IX+3*IDATA(IX)+3                                               TABR0141
      IDATA(IZS)=SPLNQ1(IY,TDATA,Y)                                     TABR0142
  330 IY=IX                                                             TABR0143
      FXYZ=SPLNQ1(IZ,TDATA,Z)                                           TABR0144
  340 RETURN                                                            TABR0145
      END                                                               TABR0146
CTURB
      SUBROUTINE TURBIN                                                 TURB0001
      IMPLICIT REAL*8(A-H,O-Z)
      COMMON WIF(30),TOPRES(30),TOTEMP(30),FAR(30),CORFLO(30),VMACH(30) EP  0005
      COMMON STATP(30),ERROP(30),DATINP(15,40),DATOUT(9,40)
      COMMON DEPV(15),DTOL(15),PERPF(12),TOL,TOLT,TOLTT
      COMMON JM1,JM2,JP1,JP2,JCX,LOCTBL(9,40)
      COMMON DFIG(5,40),JFLOW(50),IDELAP(14),JCOMP(50),NIT,IWAY
      COMMON KKINDS(15,25),NCOMP,NOSTAT,NITER,NFINIS,NPASS,JCC,NCTS
      COMMON JCIND(15),JCDEP(15),JCVIND(15),JCVDEP(15),KDIYP(15)
      COMMON RCH
C***  REVISED 3/75 M CADDY                                              TURB0005
      FAR1=FAR(JM1)                                                     TURB0006
      T1=TOTEMP(JM1)                                                    TURB0007
      TP1=TOPRES(JM1)                                                   TURB0009
      CALL THERMO (T1,TP1,H1,S1,5,RCH,FAR1,ZERO,ZERO,ZERO,0 GAM,R1)
      NCOR=LOCTBL(4,JCX)                                                TURB0010
      NEFF=LOCTBL(6,JCX)                                                TURB0011
      SQT1=1.0D0/DSQRT(T1)
      CRPM=DATOUT(2,JCX)*22.77432765D0*SQT1                              TURB00
      VGP=DATINP(10,JCX)                                                TURB0014
      PRT=DATINP(1,JCX)                                                 TURB0015
      IF(IWAY.EQ.0) GO TO 10                                            TURB0016
      CRPMT=DATINP(12,JCX)                                              TURB0017
      DATINP(3,JCX)=CRPM/CRPMT                                          TURB0018
      DHACTL=0.0D0                                                        TURB0
      HPT=0.0D0                                                           TURB0
      CORFF=CORFLO(JM1)                                                 TURB0021
      PR=2.0D0                                                            TURB0
      GO TO 20                                                          TURB0023
   10 CRPMT=CRPM/DATINP(3,JCX)                                          TURB0024
   20 CORFT=DATINP(4,JCX)                                               TURB0025
      IF(NCOR.GT.0) CALL TABLU(NCOR,PRT,CRPMT,VGP,CORFT)                TURB0026
      CORFT=CORFT*1.549695676D0                                           TURB00
      EFFT=DATINP(6,JCX)                                                TURB0028
      IF(NEFF.GT.0) CALL TABLU(NEFF,PRT,CRPMT,VGP,EFFT)                 TURB0029
      IF(IWAY.NE.0) GO TO 30                                            TURB0030
      CORFF=CORFT*DATINP(5,JCX)                                         TURB0031
      EFF=EFFT*DATINP(7,JCX)                                            TURB0032
   30 WT1=CORFF*TP1*SQT1                                                TURB0033
      AIR1=WT1/(1.0D0+FAR1)                                               TURB0
      FUEL1=FAR1*AIR1                                                   TURB0035
      WTFOUT=WT1                                                        TURB0036
```

B.42

```
      WTIN=WT1                                                          TURB0037
      WB=WTF(JM2)*DATINP(2,JCX)                                         TURB0038
      IF(WB.GT.0.0D0) GO TO 40                                            TURB0
      AF2=FAR1                                                          TURB0040
      TB2=T1                                                            TURB0041
      H2=H1                                                             TURB0042
      WB2=0.0D0                                                           TURB0
      S2=0.D0
      GO TO 50                                                          TURB0044
   40 T2=TOTEMP(JM2)                                                    TURB0045
      FAR2=FAR(JM2)                                                     TURB0046
      TP2=TOPRES(JM2)
      CALL THERMO (T2,TP2,HB,S2,5,RCH,FAR2,ZERO,ZERO,ZERO,0,GAM,R1)
      WB1=WB*DATINP(9,JCX)                                              TURB0048
      WTIN=WTIN+WB1                                                     TURB0049
      C=1.0D0/(1.0D0+FAR2)                                                 TU
      AB1=WB1*C                                                         TURB0051
      WB2=WB-WB1                                                        TURB0052
      AB2=WB2*C                                                         TURB0053
      FUEL1=FUEL1+FAR2*AB1                                              TURB0054
      AIR1=AIR1+AB1                                                     TURB0055
      AF2=FUEL1/AIR1                                                    TURB0056
      FUEL1=FUEL1+FAR2*AB2                                              TURB0057
      AIR1=AIR1+AB2                                                     TURB0058
      WTFOUT=WTFOUT+WB                                                  TURB0059
C***  FLOW WEIGHT ENTHALPY TO GET MIXED INLET TEMP   ( WHEN WB1 GT 0)   TURB0060
      HB=(WT1*H1+WB1*HB)/WTIN                                           TURB0061
   50 S3=(S1*WT1+S2*WB1)/WTIN
      CALL THERMO (T1,TP1,HZ,S3,4,RCH,AF2,TB2,H2,P3,4,GAM,R1)
      IF(IWAT)80,60,70                                                  TURB0064
   60 PR=DATINP(8,JCX)*(PRT-1.0D0)+1.0D0                                   TU
      TP3=P3/PR
      CALL THERMO (TB2,P3,H2,S3,1,RCH,AF2,T3,H3,TP3,4,GAM,R1)
      DHACTL=EFF*(H2-H3)                                                TURB0069
      HPT=1.415D0*WTIN*DHACTL                                             TURB00
      GO TO 80                                                          TURB0071
   70 DATINP(5,JCX)=COREF/CORFT                                         TURB0072
      EFF=DATINP(11,JCX)                                                TURB0073
      DATINP(7,JCX)=EFF/EFFT                                            TURB0074
      HPT=DATOUT(1,JCX)                                                 TURB0075
      H3I=H2-HPT/(1.415D0*WTIN*EFF)                                       TURB00
      CALL THERMO (TB2,P3,H2,S3,4,RCH,AF2,T3I,H3I,P3I,4,GAM,R1)
      PR=P3/P3I
      DATINP(8,JCX)=(PR-1.0D0)/(PRT-1.0D0)                                 TU
      DHACTL=EFF*(H2-H3I)                                               TURB0081
   80 HOUT=H2-DHACTL                                                    TURB0082
C*** FLOW WEIGHT ENTALPY TO GET EXIT TEMP   (WHEN WB2 GT 0)             TURB0083
      IF(WB2.GT.0.0D0)HOUT=(HOUT*WTIN+HB*WB2)/WTFOUT                      TURB0
      FAR(JP1)=FUEL1/AIR1                                               TURB0085
      FAR2=FAR(JP1)
      P2=TP1/PR
      CALL THERMO (TOUT,P2,HOUT,S1,6,RCH,FAR2,ZERO,ZERO,ZERO,0,GAM,R1)
      TOTEMP(JP1)=TOUT                                                  TURB0087
      TOPRES(JP1)=TP1/PR                                                TURB0088
      WTF(JP1)=WTFOUT                                                   TURB0089
      CORFLO(JP1)=WTFOUT*DSQRT(TOUT)/TOPRES(JP1)
      WTF(JM1)=WT1                                                      TURB0091
      CORFLO(JM1)=COREF                                                 TURB0092
      DATOUT(1,JCX)=HPT                                                 TURB0093
      DATOUT(3,JCX)=VGP                                                 TURB0094
      DATOUT(4,JCX)=PRT                                                 TURB0095
      DATOUT(5,JCX)=DATINP(3,JCX)                                       TURB0096
      DATOUT(6,JCX)=CRPMT                                               TURB0097
      DATOUT(7,JCX)=DATINP(5,JCX)                                       TURB0098
      DATOUT(8,JCX)=EFF                                                 TURB0099
      DATOUT(9,JCX)=PR                                                  TURB0100
```

```
      RETURN                                                            TURB0101
      END                                                               TURB0102
      BLOCK DATA
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION TDEL(7),XMA(16)
      COMMON/SIN/ TDEL,XMA,ALT,WMAX,PUNCHO,TIT,JCB,JN1,JN2,IDESN,IPRINT,
     1  JCARD,JCARD1,NP,NM
      COMMON/NOPUT/ SELAST,DD,NDSET,NPARTS,IOPTP,NPASSO,NVOPT,NJOPT,
     1  NJOPT1,NOPT
      COMMON/ISIZE/ IDATA(3000),NMAX
      COMMON/IARGE/ IIAB(59),NIBL
      DATA TDEL,TIT,PUNCHO / 990.D0/
      DATA NJOPT,NVOPT,IDESN,NOOPT,IOPTP,IPRINT,NIBL / 7*0/
      DATA DD,IDOPT1,WMAX / 0.0D0,.000200,3000/
      END
      SUBROUTINE THERMOD(TEMP,P,R,J1,IDD,RCM,REQ,T2,H1,P2,MUF,GAM,PP)
C       THERMODYNAMIC PROPERTIES OF HYDROCARBON-AIR COMBUSTION PRODUCTS
C  X(1)   X(2) X(3) X(4) X(5) X(6) X(7) X(8) X(9) X(10) X(11) X(12)
C  H2O    CO2    O2    H2   N2   AR    O     H    CO    OH    NO     N
      IMPLICIT REAL *4(A-H,O-Z)
      DIMENSION TT(16),HT(12),X(12),Y(99),F(99),CP1(16,2),CP2(16,10),
     1Z(99),T(99),IS(311),HT1(16,5),HT2(16,7),ST1(16,5),ST2(16,7)
      REAL H,H1,F1,F2,F3,F4,F5,F6,F7,F8,F9,F10
C  **** THERMODYNAMIC PROPERTIES OF PURE CONSTITUENTS ******
      DATA H1 /18.01600,44.0100,32.0000,2.01600,28.01600,
     139.94800,16.00000,1.00800,28.0100,17.00800,30.00800,14.00800/
      DATA TT /0.D0,200.D0,400.D0,600.D0,800.D0,1000.D0,1300.D0,
     1100.D0,2000.D0,2500.D0,3000.D0,3500.D0,4000.D0,5000.D0,6000.D0,
     27000.D0/
      DATA HT1 /31.D0,655.D0,1594.D0,2400.D0,3222.D0,4069.D0,5195.D0
     1,6745.D0,8762.D0,11449.D0,14295.D0,17234.D0,20388.D0,26854.D0,
     233507.D0,40480.D0,53.D0,1170.D0,1448.D0,2316.D0,3300.D0,4372.D0
     3,5112.D0,7971.D0,10594.D0,14000.D0,17527.D0,21132.D0,24791.D0,
     432227.D0,40 .D0,48170.D0,0.D0,696.D0,1396.D0,2104
     6.D0,2826.D0 3578.D0,4744.D0,5983.D0,7639.D0,9794.D0,11998.D0,142
     741.D0,16521.D0,21203.D0,26821.D0,30953.D0,0.D0,751.D0,1358.D0,20
     872.D0,2755.D0,3454.D0,4515.D0,5588.D0,7042.D0,8918.D0,10847.D0,
     912555.D0,14784.D0,13212.D0,23744.D0,28355.D0,0.D0,699.D0,1398.D0
     1,2094.D0,2801.D0,3513.D0,4608.D0,5743.D0,7316.D0,9356.D0,11456.D0
     2,13597.D0,15764.D0,20171.D0,24629.D0,29124.D0/
      DATA HT2 / 0.D0,500.D0,1000.D0,1500.D0,2000.D0,2500.D0,
     13250.D0,4000.D0,5000.D0,6250.D0,7500.D0,8750.D0,10000.D0,12500.D0
     2,15000.D0,17500.D0,53425.D0,54000. 0,54436.D0,54900.D0,55145.D0
     3,55465.D0,56801.D0,57800.D0 58594.D0,59855.D0,61110.D0,62356.D0
     4,63612.D0,66120.D0,68640.D0,71183.D0,16757.D0,47300.D0,47712.D0
     5,48360.D0,48674.D0,49336.D0,49977.D0,50703.D0,51752.D0,53098.D0
     6,53401.D0,55503.D0,56756.D0,59255.D0,61758.D0,64257.D0
     7,15.D0,654.D0,1344.D0,1576.D0,2804.D0,3521.D0,4635.D0,5765.D0,
     87379.D0,9447.D0,11569.D0,13728.D0,15915.D0,20345.D0,24854.D0,
     929154.D0,3.D0,677.D0,1324.D0,2034.D0,2401.D0,3576.D0,4622.D0,
     457.D0,7184.D0,9099.D0,11087.D0,13137.D0,15243.D0,19575.D0,
     524237.D0,24693.D0,6.D0,558.D0,1119.D0,1674.D0,2772.D0,3843.D0
     6,4909.D0,5997.D0,7543.D0,9737.D0,11893.D0,14082.D0,16295.D0,
     722772.D0,25243.D0,29854.D0,
     5101422.D0,102200.D0,102060.D0,102156.D0,103312.D0,104590.D0,
     6105154.D0,105433.D0,106754.D0,108173.D0,109422.D0,110663.D0,
     7111415.D0,114425.D0,115954.D0,114518.D0/
      DATA CP1 /3.D0,14.5665,21.5500,23.16700,
     124.33800,25.27300,26.43400,27.40000,28.50500,29.69100,30.72500,
     231.645400,32.474500,33.916300,35.140000,36.200300,0.D0,21.7300,
     324.55300,26.201500,27.416777D0,28.810600D0,30.322900D0,31.513600
     4,33.2455D0,34.594000D0,35.879410D0,36.989500D0,37.971360D0,3
     5100,41.000,42.140D0,0.D0,21.153400D0,23.663300D0,25.072100D0,26.
     6,26.322200D0,27.454310D0,28.740000D0,29.730500D0,30.691500D0,31.494
     732.165D0,32.7500D0,33.839600D0,34.717860D0,35.477810D0,0.D0,12.
     8,14.717200D0,16.104200D0,17.107300D0,17.882300D0,18.814000D0,19.55
```

```
920.3638D0,21.2011D0,21.9103D0,22.5326D0,23.0680D0,24.0484D0,
124.8623D0,25.5747D0,
10.0D0,19.5245D0,22.0313D0,23.430
18D0,24.4362D0,25.2221D0,26.1808D0,26.9656D0,27.8431D0,28.7524D0
2,29.5175D0,30.1789D0,30.758D0,31.74D0,32.55D0,33.25D0/
 DATA SI2 / 0.0D0,
316.11D0,17.96D0,19.90D0,19.61D0,20.16D0,20.82D0,21.341D0,21.899
4D0,22.457D0,22.912D0,23.298D0,23.632D0,24.19D0,24.646D0,25.031
4D0,0.0D0,16.59D0,18.61D0,19.662D0,20.401D0,20.965D0,21.632D0,
522.156D0,22.717D0,23.297D0,23.737D0,24.120D0,24.455D0,
625.015D0,25.474D0,25.866D0,0.0D0,11.280D0,13.08D0,14.0D0,14.787
7D0,15.339D0,15.996D0,16.514D0,17.072D0,17.630D0,18.087D0,
815.471D0,18.81D0,19.363D0,19.619D0,20.204D0,0.0D0,20.39D0,
922.80D0,24.19D0,25.21D0,26.007D0,26.98D0,27.773D0,28.66D0,
229.59D0,30.36D0,31.03D0,31.61D0,32.60D0,33.45D0,34.15D0,
1 0.0D0,19.643D0,21.232D0,
122.455D0,23.515D0,24.400D0,25.234D0,25.981D0,26.805D0,
227.658D0,28.383D0,29.015D0,29.577D0,30.54D0,31.36D0,
332.06D0,0.0D0,21.62D0,21.31D0,25.75D0,26.71D0,27.52D0,
428.540D0,29.397D0,30.269D0,31.250D0,32.036D0,32.712D0,
533.302D0,34.300D0,35.124D0,35.828D0,0.0D0,15.92D0,
617.71D0,18.71D0,19.43D0,19.979D0,20.638D0,21.155D0,
821.713D0,22.272D0,22.727D0,23.112D0,23.446D0,24.005D0,
924.465D0,24.851D0/
 DATA CP1/0.0D0,4.008D0,4.014D0,4.059D0,4.166D0,4.306D0,4.5377D
10,4.786D0,5.124D0,5.513D0,5.834D0,6.100D0,6.307D0,6.605D0
2,6.804D0,6.946D0,0.0D0,3.555D0,4.004D0,4.651D0,5.158D0,
35.554D0,6.015D0,6.354D0,6.677D0,6.943D0,7.117D0,7.239D0,
47.326D0,7.447D0,7.530D0,7.596D0/
 DATA CP2 / 0.0D0,
13.500D0,3.507D0,3.558D0,3.669D0,3.807D0,3.988D0,
24.124D0,4.251D0,4.361D0,4.447D0,4.528D0,4.604D0,4.752D0,
34.879D0,4.905D0,0.0D0,2.795D0,3.351D0,3.499D0,3.517D0,
43.522D0,3.544D0,3.588D0,3.683D0,3.826D0,3.970D0,4.100D0,
5 2122D0,4.395D0,4.544D0,4.676D0,0.000D0,3.500D0,3.501D0,
63.506D0,3.532D0,3.591D0,3.716D0,3.851D0,4.004D0,4.146D0,
84.245D0,4.315D0,4.366D0,4.435D0,4.479D0,4.511D0,0.000D0,
915*2.499D0,0.0D0,2.837D0,2.710D0,2.612D0,2.569D0,2.547D0,
12.528D0,2.519D0,2.512D0,2.508D0,2.505D0,2.504D0,2.505D0,
22.512D0,2.529D0,2.556D0,0.0D0,15*2.499D0,0.0D0,3.500D0,
33.501D0,3.510D0,3.549D0,3.625D0,3.768D0,3.909D0,4.061D0,
44.195D0,4.286D0,4.349D0,4.395D0,4.458D0,4.499D0,4.530D0,
50.000D0,3.704D0,3.605D0,3.582D0,3.552D0,3.546D0,3.571D0,
63.634D0,3.750D0,3.904D0,4.042D0,4.159D0,4.254D0,4.403D0,
74.517D0,4.615D0,0.000D0,3.850D0,3.634D0,3.586D0,3.625D0,
83.717D0,3.872D0,4.012D0,4.152D0,4.270D0,4.350D0,4.402D0,
94.442D0,4.499D0,4.541D0,4.575D0,0.0D0,10*2.499D0,2.500D0,
12.501D0,2.511D0,2.543D0,2.606D0/
 ISAI=1
 S=SI
 IOI1=IEMP
 H1=H
 IP1=P
  P=P/14.696D0
 ICH=0.0D0
 IF(IDD.GE.3) P2=0.D0
 P2=P2/14.696D0
  IZ=1
 IDD1=1
 ID=1
 FST=.028931D0*(1.008D0+12.01D0*RCH)/(1.D0+4.D0*RCH)
 REQ1=REQ
 REQ=REQ/FST
 IF(IDD.GT.6) GO TO 374
 IEMP=H/.24D0
 HZ=H
```

ORIGINAL PAGE IS
OF POOR QUALITY

```
  374  IF(MUF.GT.0)GO TO 487
  500 DO 12 J=1,12
   12  X(J)=0.0D0
C       ************  GAS MODEL CONSTANTS  ********************
       D=4.77[illegible]84D0
       D1=.0061622700
       D2=3.72744500
       D3=(2.0D0*REQ*RCH)/(1.0D0+4.0D0*RCH)
       D4=(2.0D0*REQ)/(1.0D0+4.0D0*RCH)
       IF(TEMP.GT.(100.0D0*DLOG10(P)+2800.0D0))GO  TO  1
     7 IF(REQ.EQ.1.0D0)GO TO 2
       IF(REQ.GT.1.0D0)GO TO 3
C              ************** NON-DISSOCIATING GAS MODEL , REQ. LT 1 *******
       X(1)=(2.0D0*D4)/(D4+2.0D0*D)
       X(2)=(4.0D0*D3)/(D4+2.0D0*D)
       X(3)=(2.0D0-4.0D0*D3-D4)/(D4+2.0D0*D)
       X(5)=(2.0D0*D2)/(D4+2.0D0*D)
       X(6)=(4.0D0*D2*D1)/(D4+2.0D0*D)
       GO  TO   50
C              ************** NON-DISSOCIATING GAS MODEL ,REQ. EQ. 1 *******
     2 X(1)=(2.0D0*(1.0D0-2.0D0*D3))/(D+(1.0D0-2.0D0*D3))
       X(2)=(2.0D0*D3)/(D+(1.0D0-2.0D0*D3))
       X(5)=D2/(D+(1.0D0-2.0D0*D3))
       X(6)=(2.0D0*D2*D1)/(D+(1.0D0-2.0D0*D3))
       GO TO 50
     3 IF(RCH.EQ.0.0D0) GO TO 14
       IF(REQ.GE.((1.0D0+4.0D0*RCH)/(2.0D0*RCH))) GO TO 15
C              ************** NON-DISSOCIATING GAS MODEL ,REQ. GT. 1 *******
       K8=10.0D0**(1.747D0-(3415.0D0/TEMP))
       K9=10.0D0**(9.272D0-(16210.D0/TEMP))
       AA=(1.0D0-K8)*(D+D4+2.0D0*D3-1.0D0)**2
       BB=(D-1.0D0*D4+2.0D0*D3)*(2.0D0*(1.0D0-2.0D0*D3)+K8*(D4+6.0D0*D3
      1-2.0D0))
       CC=K8*(2.0D0-D4-4.0D0*D3)*2.0D0*D3
       X(9)=(DSQRT(BB**2.0D0-4.0D0*AA*(CC)-BB)/(2.0D0*AA)
       X(2)=(2.0D0*D3)/(D+D4+2.0D0*D3-1.0D0))-X(9)
       X(1)=((1.0D0-2.0D0*D3)*X(2)+(1.0D0-D3)*X(9))/D3
       X(4)=X(1)*X(9)/(K8*X(2))
       X(5)=D2*(2.0D0*X(2)+X(9)+X(1))/2.0D0
       X(6)=2.0D0*D1*X(5)
       PLIM=K9*X(2)/(X(9)**2)
  200  FORMAT(20X,'******** PLIM =  ',D16.8,'   *******')
       IF(P.LT.PLIM) GO TO 50
   15  WRITE(6,600)
  600  FORMAT(10X,'*****  SOLID CARBON HAS FORMED *****')
       GO TO 50
C              ************** NON-DISSOCIATING GAS MODEL ,REQ. GT. 1,RCH.EQ. 0 *
   14  X(1)=(2.0D0*(1.0D0-2.0D0*D3))/(D+D4+2.0D0*D3-1.0D0)
       X(2)=(2.0D0*D3)/(D+D4+2.0D0*D3-1.0D0)
       X(4)=(D4-2.0D0*4.0D0*D3)/(D+D4+2.0D0*D3-1.0D0)
       X(5)=D2/(D+D4+2.0D0*D3-1.0D0)
       X(6)=(2.0D0*D2*D1)/(D+D4+2.0D0*D3-1.0D0)
       K10=10.0D0**((10114.0D0/TEMP)-12.069D0)
       PLIM=0.01D0/(DSQRT(K10*X(5)*(X(4)**3)))
       IF(P.LT.PLIM) GO TO 50
       WRITE(6,601)
  601  FORMAT(10X,'****** AMMONIA HAS FORMED *****')
       GO TO 50
C        **************   DISSOCIATING COMBUSTION GAS MODEL  *************
     1 K1=10.0D0**((89877.D0/TEMP)-12.7295D0)
       K2=10.0D0**((42367.0D0/TEMP)-6.2325D0)
       K3=10.0D0**((47850.D0/TEMP)-6.9570D0)
       K5=10.0D0**((41512.0D0/TEMP)-5.872D0)
       K6=10.0D0**((95047.0D0/TEMP)-6.9505D0)
       K7=10.0D0**((60437.0D0/TEMP)-6.2915D0)
       IF(REQ.EQ.0.D0) GO TO 4
```

ORIGINAL PAGE IS
OF POOR QUALITY

```
      IF(XCM.NE.0.D0) GO TO 5
      K4=0.0D0
      GO TO 6
    5 K4=10.0D0**((50173.D0/TEMP)-7.8785D0)
    6 A22=P**3*K1*K4*(1.0D0-2.0D0*D3+D)
      A21=P**2*(K1*(1.0D0+D)+2.0D0*K2*K4*(1.0D0-2.0D0*D3))
      A20=2.0D0*P*K2*(1.0D0-D3)
      A12=P**2*K4*K5*(1.0D0-2.0D0*D3+D)
      A11=P*(K5*(1.0D0+D)+2.0D0*K4*(1.0D0-2.0D0*D3))
      A10=2.0D0*(1.0D0-D3)
      A03=2.0D0*P**2*D3*K4
      A02=P*(K4*(1.0D0-2.0D0*D3+D)+2.0D0*K3*(D3+D))
      A01=1.0D0+D-2.0D0*P*K4*(1.0D0-2.0D0*D3)
      A00=2.0D0*(D3-1.0D0)
      B22=P**3*K1*K4*(2.0D0-4.0D0*D3-D4)
      B21=P**2*(K1*(2.0D0-2.0D0*D3-D4)+2.0D0*K2*K4*(1.0D0-2.0D0*D3))
      B20=2.0D0*P*K2*(1.0D0-D3)
      B12=P**2*K4*K5*(1.0D0-2.0D0*D3-D4)
      B11=P*(K5*(1.0D0-D3-D4)+K4*(1.0D0-2.0D0*D3))
      B10=1.0D0-D3
      B03=2.0D0*D4*P**2*K3*K4
      B02=D4*P*(2.0D0*K3+K4)
      B01=D4
C          ****************** ITERATION FOR CHEMICAL COMPOSITION ************
   21 F(1)=(1.0D0*DSQRT((1.D0+D)**2+16.D0*D*P*K3)-(1.D0+D))/(4.D0*D
     1*P*K3)
      L=1
      IF(REQ.GT.1.D0) GO TO 25
   16 B=(Y(L)*(Y(L)*B12+B11)+B10)**2+4.D0*(Y(L)*(Y(L)*B22+B21)+B20)
     1*(Y(L)*(Y(L)*(Y(L)*B03+B02)+B01))
      IF(B.LT.0.)GO TO 20
      Z(L)=(DSQRT(B)-1.0D0*(Y(L)*(Y(L)*B12+B11)+B10))/((Y(L)*(Y(L)*B22
     1+B21)+B20)*2.D0)
      IF((Y(L).GT.-.00001D0).AND.(REQ.LE.1.D0)) GO TO 7
      F(L)=Z(L)*(Z(L)*(Y(L)*(Y(L)*A22+A21)+A20)+(Y(L)*(Y(L)*A12+A11)+
     1A10))+(Y(L)*(Y(L)*(Y(L)*A03+A02)+A01)+A00)
      IF((F(L).GT.-.00001D0).AND.(F(L).LT..00001D0)) GO TO 6
      DELF=(Z(L)**2)*(2.0D0*A22*Y(L)+A21)+Z(L)*(2.0D0*A12*Y(L)+A11)+3
     1.0D0*A03*Y(L)**2+2.0D0*A02*Y(L)+A01-(2.0D0*(Y(L)*(Y(L)*A22+A21)
     2+A20)*Z(L)+(Y(L)*(Y(L)*A12+A11)+A10))*((Z(L)**2)*(2.0D0*B22*Y(L
     3)+B21)+Z(L)*(2.0D0*B12*Y(L)+B11)-(3.0D0*B03*Y(L)**2+2.0D0*B02*Y
     4(L)+B01))/(2.0D0*(Y(L)*(Y(L)*B22+B21)+B20)*Z(L)+(Y(L)*(Y(L)*B12
     +B11)+B10))
      F(L+1)=F(L)-F(L)/DABS(DELF)
      L=L+1
      GO TO 16
   20 Y(L)=.1D0*Y(L)
      IF((Y(L).LT..00001D0).AND.(REQ.LE.1.D0)) GO TO 7
      GO TO 16
   25 Z(1)=(1.0D0*DSQRT((2.0D0*D4*(1.0D0-D3)+1.0D0+D)**2+16.0D0*P*K2
     1*D4*(1.0D0-D3)*(D4*(1.0D0-D3)+1.0D0+D))-(2.0D0*D4*(1.0D0-D3)+1
     2.D0+D))/(4.0D0*P*K2*(D4*(1.0D0-D3)+1.0D0+D))
   28 B=(B22*Z(L)**2+B11*Z(L)-B01)**2-4.0D0*(B20*Z(L)**2+B10*Z(L))*(
     1B22*Z(L)**2+B12*Z(L)-B02)
      KZ=1
      II(KZ)=(-1.0D0*DSQRT(B)-(B21*Z(L)**2+B11*Z(L)-B01))/(2.0D0*(B22
     1*Z(L)**2+B12*Z(L)-B02))
   27 DEL=(B22*II(KZ)**2+B21*II(KZ)+B20)*Z(L)**2+(B12*II(KZ)**2+B11*
     1II(KZ)+B10)*Z(L)-(B03*II(KZ)**3+B02*II(KZ)**2+B01*II(KZ))
      IF((DEL.LT..00001D0).AND.(DEL.GT.-.00001D0)) GO TO 26
      II(KZ+1)=II(KZ)-DEL/(-3.0D0*B03*II(KZ)**2+2.0D0*(B22*Z(L)**2+B12
     1*Z(L)-B02)*II(KZ)+(B21*Z(L)**2+B11*Z(L)-B01))
      KZ=KZ+1
      GO TO 27
   26 Z(L)=II(KZ)
      F(L)=Z(L)*(Z(L)*(Y(L)*(Y(L)*A22+A21)+A20)+(Y(L)*(Y(L)*A12+A11)+
```

```
     1A10))+(Y(L)*(Y(L)*(Y(L)*A03+A02)+A01)+A00)
      IF((F(L).GT.-.0001D0).AND.(F(L).GT.-.0001D0)) GO TO 8
      IF(Z(L).GT.-.00001D0) GO TO 7
      IF(L.EQ.1) GO TO 29
      Z(L+1)=Z(L)-F(L)*(Z(L-1)-Z(L))/(F(L-1)-F(L))
      L=L+1
      GO TO 28
   29 Z(2)=.5D0*Z(1)
      L=2
      GO TO 28
    8 X(7)=Y(L)
      IF(X(7).EQ.0.D0) GO TO 22
      X(8)=Z(L)
      X(1)=P**2*K1*X(7)*X(8)**2
      X(3)=P*K3*X(7)**2
      X(10)=P*K5*X(7)*X(8)
      X(9)=(D3*(X(1)+2.0D0*X(3)+X(7)+X(10)))/((1.0D0-2.0D0*D3)*P*K4*
     1X(7)+1.0D0-D3)
      X(2)=P*K4*X(7)*X(9)
      X(4)=P*K2*X(7)**2
      X(5)=(D2/2.0D0)*(2.0D0*X(2)+X(1)+2.0D0*X(3)+X(7)+X(9)+X(10))
      X(6)=2.0D0*D1*X(5)
      GO TO 50
C            ****************** DISSOCITING AIR  ******************
    4 A22=0.D0
      A21=0.D0
      A20=P*K6*(1.0D0+2.0D0*D1)
      A12=0.D0
      A11=P*K7*(1.0D0+D1)
      A10=1.0D0+D1
      A03=0.D0
      A02=P*K3
      A01=1.0D0
      A00=-1.0D0
      B22=0.D0
      B21=0.D0
      B12=0.D0
      B20=2.0D0*P*K6
      B11=P*K7*(1.0D0-D2)
      B10=1.0D0
      B03=0.D0
      B02=2.0D0*P*K3*D2
      B01=D2
      GO TO 21
   22 X(12)=Z(L)
      X(11)=P**7*X(7)*X(12)
      X(3)=P*K3*X(7)**2
      X(5)=(D2*(2.0D0*X(3)+X(7)+X(11))-X(11)-X(12))/2.0D0
      X(6)=D1*(2.0D0*X(5)+X(11)+X(12))
C   ******** CALCULATION OF GAS MIXTURE THERMODYNAMIC PROPERTIES  *********
   50 DO 9 I=1,16
      IF(TEMP-TT(I)) 10,10,9
    9 CONTINUE
   10 DELH=(TEMP-TT(I-1))/(TT(I)-TT(I-1))
      DELS=(DLOG(TEMP/TT(I-1)))/(DLOG(TT(I)/TT(I-1)))
      M=0.D0
      H=0.D0
      S=0.D0
      GAM=0.D0
      DO 11 IJ=1,12
      J=IJ
      IF(X(J).EQ.0.D0) GO TO 11
      M=M+X(J)*MT(J)
      IF(J.GT.5) GO TO 889
      H=H+X(J)*(HT1(I-1,J)+(HT1(I,J)-HT1(I-1,J))*DELH)
      S=S+X(J)*(ST1(I-1,J)+(ST1(I,J)-ST1(I-1,J))*DELS-DLOG(P*X(J)))
```

```
      IF(J.GT.2) GO TO 848
      CPP=CP1(I-1,J)+(CP1(I,J)-CP1(I-1,J))*DELH
       GOTO 883
  848 J=IJ-2
      CPP=CP2(I-1,J)+(CP2(I,J)-CP2(I-1,J))*DELH
      GO TO 883
  889 J=IJ-2
      CPP=CP2(I-1,J)+(CP2(I,J)-CP2(I-1,J))*DELH
      J=IJ-5
      H=H+X(IJ)*(HT2(I-1,J)+(HT2(I,J)-HT2(I-1,J))*DELH)
      S=S+X(IJ)*(ST2(I-1,J)+(ST2(I,J)-ST2(I-1,J))*DELS-DLOG(P*X(IJ)))
  883 GAM=GAM+X(IJ)*CPP/(CPP-1.D0)
   11 CONTINUE
      H=H*1.98588D0/M
      S=S*1.98588D0/M
      RR=1.98588D0/M
      CPP=GAM*RR/(GAM-1.D0)
      ZXC=GAM/(GAM-1.0D0)
C                    ******************  OUT PUT ********************
       GOTO(801,800,900),IS=I
C 801 WRITE(6,700)(X(J),J=1,12)
  801 IF(IDD-5)487,894,897
  894  S1=S
       P=IP1
       GOTO 984
  897 IF(DABS(HZ-H)-.00001D0*HZ)634,634,635
  634 P=P*14.696D0
      S1=S
      H=HZ
      GO TO 984
  635 TEMP=TEMP+(HZ-H)/CPP
      ICH=ICH+1
      IF(ICH.LE.30)GO TO 500
      WRITE(6,205)
      STOP
  487 S1=S
      T1=TEMP
      P1=P
      H1=H
  700 FORMAT(6X,4HXH2O,12X,4HXCO2,12X,3HXO2,13X,3HXH2,/,4D16.8,/,
     16X,3HXN2,13X,3HXAR,14X,2HXO,14X,2HXH,/,4D16.8,/,6X,3HXCO,13X
     2,3HXOH,13X,3HXNO,13X,2HXN,/,4D16.8)
C     WRITE(6,400)M,H,S,CPP
  400 FORMAT(/,2X,2HM=,D15.8,2X,2HH=,D15.8,7HBTU/LBM,2X,2HS=,D15.8
     1,9HBTU/LBM-R,2X,3HCP=,D15.8,9HBTU/LBM-R,//)
  800 GOTO(319,325,335,432),IDD
  432 GOTO(301,300,900),IS=I
  301 TEMP=HI/CPP
      P=P1
      ICI=0
      IS=I=2
      GO TO 500
  300 IF(DABS(H-HI).LE.,00001D0*HI)GO TO 820
      TEMP=TEMP+(HI-H)/CPP
      ICI=ICI+1
      IF(ICI.LE.30)GO TO 500
      WRITE(6,205)
      STOP
  820 IF(IZ.GE.2)GO TO 117
      P=.800*P1*(TEMP/T1)**ZXC
  117 IS=I=3
      P3=P
      IHC=0
       ICI=1
      GOTO 500
  900 IF(DABS(S-S1)-.0001D0*S1)213,213,201
```

```
201 P=P1*DEXP((S-S1)/RR+DLOG(P/P1))
    IHC=IHC+1
    IF(IHC-30)500,500,203
203 WRITE(6,205)
    STOP
213 IZ=IZ+1
    TG(IZ)=TEMP
    ISWI=2
    IF(IZ.LE.2)GOTO 500
    IF((.ABS(P-P3).LE..01D0*P3).AND.(DABS(TG(IZ)-TG(IZ-1)).LE..0001
   1*TG(IZ))) GOTO 127
    IF(IZ.LE.30)GOTO 500
    WRITE(6,205)
    STOP
127 TZ=TEMP
    HI=H
    PZ=P*14.696D0
    P=P1
    H=H1
    TEMP=TUT1
204 FORMAT(20X,4D16.8)
205 FORMAT(30X,'SSSSSSTTTOOPPP')
    GOTO 964
319 IF(IDD1.GT.1)GOTO 318
    P=PZ
    IDD1=2
    TEMP=T1*(P/P1)**(1.D0/ZXC)
    ISWI=2
    GOTO 500
318 IF(DABS(S-S1)-.0001*S1)320,320,321
321 TEMP=TEMP*(DEXP((S1-S)*(1.D0/CPP)))
    IDD1=2
    GOTO 500
320 PZ=PZ*14.696D0
    TZ=TEMP
    HI=H
    H=H1
    P=P1
    TEMP=TUT1
    GOTO 964
325 IF(IDD1.GT.1)GOTO 327
    TEMP=HI/CPP
    ICI=0
    IDD1=2
    P=PZ
    ISWI=2
    GOTO 500
327 IF(DABS(H-HI).LE..00001*HI)GO TO 328
    TEMP=TEMP+(HI-H)/CPP
    ICI=ICI+1
    IF(ICI.LE.30)GOTO 500
    WRITE(6,205)
    STOP
328 TZ=TEMP
    PZ=PZ*14.696D0
    HI=H
    TEMP=TUT1
    P=P1
    H=H1
    GOTO 964
335 IF(IDD1.GT.1)GO TO 330
    TEMP=TZ
    P=P1*(TEMP/T1)**ZXC
    ISWI=2
    IDD1=2
    ICI=0
```

```
      GO TO 500
  338 IF(DABS(S1-S).LE..0001*S1)GO TO 339
      P=P1*DEXP((S-S1)/RP+DLOG(P/P1))
      ICI=ICI+1
      IF(ICI.LE.30)GO TO 500
      WRITE(6,205)
      STOP
  339 I2=TEMP
      H1=H
      P2=P*14.696D0
      P=IP1
      TEMP=IOT1
      H=H1
  984  REQ=REQ1
       RETURN
       END
//GO.SYSIN    DD  *
```

ORIGINAL PAGE IS
OF POOR QUALITY

APPENDIX C

SAMPLE INPUT AND OUTPUT

C1. UNAUGMENTED AFT FAN TURBOFAN

C2. AUGMENTED AFT FAN ENGINE

C3. RAMJET ENGINE

PRECEDING PAGE BLANK NOT FILMED

PRECEDING PAGE BLANK NOT

ORIGINAL PAGE IS
OF POOR QUALITY

C1. UNAUGMENTED AFT FAN TURBOFAN

SAMPLE INPUT AND OUTPUT

FOR THE

ENGINE PERFORMANCE CALCULATION

WITH INSTALLATION EFFECTS AND H_2 FUEL

(DISSOCIATION ARTIFICIALLY PRECLUDED)

ORIGINAL PAGE IS
OF POOR QUALITY

```
&D
NCOMP=21,NUSTAT=14,IDESM=1,IPRINT=0,TITLE=1,TABLES=1,
JFIG(1,1)=1,1,0,2,0,
JFIG(1,2)=7,2,0,3,10,
JFIG(1,3)=4,3,0,4,13,
JFIG(1,4)=2,4,0,5,0,
JFIG(1,5)=5,5,13,5,0,
JFIG(1,6)=5,6,0,7,0,
JFIG(1,7)=6,7,12,8,0,
JFIG(1,8)=9,14,0,9,0,
JFIG(1,9)=2,10,0,11,0,
JFIG(1,10)=4,11,0,12,0,
JFIG(1,11)=11,3,5,0,0,
JFIG(1,12)=11,6,10,0,0,
JFIG(1,13)=2,8,0,14,0,
JFIG(1,14)=12,14,0,6,0,
JFIG(1,15)=12,11,0,2,0,
JFIG(1,16)=12,6,0,5,0,
JFIG(1,17)=12,5,0,3,0,
JFIG(1,18)=12,3,0,1,0,
JFIG(1,19)=12,11,0,3,0,
JFIG(1,20)=12,12,0,10,0,
JFIG(1,21)=12,7,0,10,0,
CDAT(1,1)=980.,0.,0.,100.,0.,75.,4000.,1.,0.,0.,1.,-8500.,1.,1.,10.,
CDAT(1,2)=1.2,
CDAT(1,3)=1.,.1,1.,300.,445.45,305.,1.,16.,1.,0.,0.,.85,16.,1.,0.,
CDAT(1,4)=.01,.0,.0,3000.,.99,49900.,3*0.,1000.,0.0,
CDAT(1,5)=2.,1.,1.,1.,1.,.65,2*1.,.35,0.,.88,2*1.,2*0.,
CDAT(1,6)=2.,0.,3*1.,.99,3*1.,.5,.95,2*1.,2*0.,
CDAT(1,7)=2*1.,1.,2*1.,1.,
CDAT(1,8)=2*1.,150.,0.,120.,1.,0.,0.,1.,1.,5.,
CDAT(1,9)=.02,
CDAT(1,10)=1.,0.,1.,200.,534.54,205.,1.,3.1,1.,2*0.,.64,3.1,1.,0.,
CDAT(1,11)=5*1.,
CDAT(1,12)=5*1.,
CDAT(1,13)=.02,
CDAT(1,14)=0.,0.,0.,1.,0.,08.,
CDAT(1,15)=0.,0.,0.,1.,0.,08.,
CDAT(1,16)=0.,0.,0.,1.,0.,08.,
CDAT(1,17)=0.,0.,0.,1.,0.,08.,
CDAT(1,18)=0.,0.,0.,1.,0.,08.,
CDAT(1,19)=0.,0.,0.,8.,0.,18.,
CDAT(1,20)=0.,0.,0.,6.,0.,18.,
CDAT(1,21)=0.,0.,0.,1.,0.,18.,
WMAX=980.,JCB=4,
JN1=8,JN2=0,JCAB1=0,JCAB2=0,
FIGSET=1.  &END
 AF1 FAN ENGINE, DESIGN POINT
 50      FLOW SCHEDULE
Z      1   0.
Y      1   0.
THET  21   .5        .6        .67       .675      .68       .685      .69
           .75       .80       .85       .90       .95       .975      1.0
           1.157     1.35      1.54      1.735     1.93      2.12      2.31
WRA   21   1.06      1.06      1.06      1.06      1.06      1.06      1.06
           1.054     1.048     1.041     1.033     1.022     1.014     1.0
           .918      .796      .709      .644      .596      .556      .520
EOT
   75      RAM RECOVERY
Z      1   0.
MACH  17   0.        .25       .5        .75       1.0       1.25      1.5
           1.75      1.95      2.0       2.5       3.0       3.5       4.0
           4.5       5.0       5.2
```

```
WCOR   1   2000.
RR     1   1.0
RR     1   1.0
RR     1   1.0
RR     1   1.0
RR     1   1.0
RR     1   .98
RR     1   .94
RR     1   .88
RR     1   .82
RR     1   .925
RR     1   .87
RR     1   .81
RR     1   .74
RR     1   .67
RR     1   .59
RR     1   .51
RR     1   .48
EOT
  100      SPILLAGE DRAG
Z      1   0.
MACH   9   .8       .9       1.       1.25     2.       3.       4.
           5.       5.2
MFR    8   .35      .4       .5       .6       .7       .8       .9
           1.
CDS    8   .0275    .022     .014     .0095    .006     .0035    .0002
           0.
MFR    7   .4       .5       .6       .7       .8       .9       1.
CDS    7   .045     .0265    .017     .0105    .006     .0002    0.
MFR    7   .4       .5       .6       .7       .8       .9       1.
CDS    7   .0545    .033     .022     .014     .008     .0003    0.
MFR    7   .4       .5       .6       .7       .8       .9       1.
CDS    7   .072     .045     .0265    .018     .0105    .0005    0.
MFR    6   .5       .6       .7       .8       .9       1.
CDS    6   .057     .035     .022     .012     .0005    0.
MFR    4   .7       .8       .9       1.
CDS    4   .028     .013     .0005    0.
MFR    3   .8       .9       1.
CDS    3   .009     .0002    0.
MFR    4   .8       .9       .973     1.
CDS    4   .017     .0003    0.       0.
MFR    1   1.
CDS    1   0.
EOT
  120      NOZZLE THRUST COEFFICIENT
Z      1   0.
Y      1   0.
PR    13   3.       4.       5.       6.       8.       10.      12.
           14.      16.      18.      20.      22.      24.
CV    13   .94      .91      .89      .9       .93      .95      .96
           .97      .979     .983     .985     .985     .985
EOT
  150      AFTERBODY DRAG
Z      1   0.
MACH   3   1.5      1.8      2.0
NPR   11   4.       6.       8.       10.      12.      14.      16.
           18.      20.      22.      24.
CDAB  11   .131     .125     .107     .077     .054     .038     .027
           .02      .015     .011     .009
NPR   10   6.       8.       10.      12.      14.      16.      18.
           20.      22.      24.
CDAB  10   .079     .07      .056     .037     .023     .013     .005
           .0       -.003    -.005
NPR   11   5.       6.       8.       10.      12.      14.      16.
           18.      20.      22.      24.
CDAB  11   .061     .059     .052     .04      .025     .01      -.002
```

```
            -.009      -.013      -.017      -.019
EOT
  200       R VS. CORRECTED FLOW-FAN USED FOR BPR=1-2
Z      1    0.
Y      1    1.
R      3    0.         .5         1.1
WRA    3    0.         .5         1.1
EOT
  205       R VS. EFFICIENCY-FAN USED FOR BPR=1-2
Z      1    0.
Y      1    1.
R     12    .4         .5         .6         .7         .8         .9         .925
            .952       .98        .99        1.         1.1
EFF   12    .831       .842       .851       .856       .858       .858       .858
            .8565      .8548      .853       .85        .884
EOT
  300       R VS. CORRECTED FLOW COMPRESSOR
Z      1    0.
Y      1    1.
R      3    0.         .5         1.011
WRA    3    0.         .5         1.011
EOT
  305       R VS. EFFECIENCY-COMPRESSOR
Z      1    0.
Y      1    1.
R      9    .416       .522       .633       .76        .889       .944       .968
            1.0        1.011
EFF    9    .666       .74        .774       .794       .813       .813       .813
            .81        .804
EOT
            END OF TABLE DATA
 &D ALT=0.,NM=1,NP=1,TDEL=0.,XMA=0.0,
 IPRINT=1,TITLE=1,
 CDAT(1,14)=1.,CDAT(1,15)=1.,CDAT(1,16)=1.,CDAT(1,17)=1.,
 CDAT(1,18)=1.,CDAT(1,19)=1.,CDAT(1,20)=1.,CDAT(1,21)=1. &END
        AFT FAN DESIGN POINT, CONTROLS ON
 &D ALT=0.,NM=6,XMA=0.,.2,.4,.6,.8,.9,NP=5,TDEL=4*100.,TIT=3000.,
 TITLE=1.,IPRINT=0,
 CDAT(1,14)=1.,CDAT(1,15)=1.,CDAT(1,16)=1.,CDAT(1,17)=1.,
 CDAT(1,18)=1.,CDAT(1,19)=1.,CDAT(1,20)=1.,CDAT(1,21)=1. &END
            AFT FAN ENGINE, OFF DESIGN
 &D ALT=10000.,NM=6,XMA=.2,.4,.6,.8,.9,1,NP=5,TDEL=4*100.,TIT=3000. &END
 &D ALT=20000.,NM=6,XMA=.2,.4,.6,.8,.9,1,NP=5,TDEL=4*100.,TIT=3000. &END
 &D ALT=30000.,NM=6,XMA=.2,.4,.6,.8,.9,1,NP=5,TDEL=4*100.,TIT=3000. &END
 &D ALT=36000.,NM=6,XMA=.2,.4,.6,.8,.9,1,NP=5,TDEL=4*100.,TIT=3000. &END
 &D ENDRUN=1 &END
```

ORIGINAL PAGE IS
OF POOR QUALITY

NAVAL AIR DEVELOPMENT CENTER

NEPII NAVY ENGINE PERFORMANCE COMPUTER CODE
VERSION II IBM 360

NAMELIST INPUT CARDS FOR NEXT SOLUTION

ORIGINAL PAGE IS
OF POOR QUALITY

AFT FAN ENGINE, DESIGN POINT
CONFIGURATION DATA 14 STATIONS 21 COMPONENTS

COMPONENT NUMBER	NAIND	COMPONENT TYPE	UPSTREAM STATIONS		DOWNSTREAM STATIONS	
1	1	INLET	1	0	2	0
2	7	SPLITTER	2	0	3	10
3	4	COMPRESR	3	0	4	13
4	2	DUCT B	4	0	5	0
5	5	TURBINE	5	13	6	0
6	5	TURBINE	6	0	7	0
7	6	MIXER	7	12	8	0
8	9	NOZZLE	14	0	9	0
9	2	DUCT B	10	0	11	0
10	4	COMPRESR	11	0	12	0
11	11	SHAFT	3	5	0	0
12	11	SHAFT	6	10	0	0
13	2	DUCT B	8	0	14	0
14	12	CONTROL	14	0	6	0
15	12	CONTROL	11	0	2	0
16	12	CONTROL	6	0	5	0
17	12	CONTROL	5	0	3	0
18	12	CONTROL	3	0	1	0
19	12	CONTROL	11	0	3	0
20	12	CONTROL	12	0	10	0
21	12	CONTROL	7	0	10	0

CONTROL INFORMATION

20	VARY	CDAT	8	OF COMPONENT	10	SO THAT	DATOUT	8	OF COMPONENT	12	EQUALS 0.0
21	VARY	CDAT	1	OF COMPONENT	10	SO THAT	DATOUT	8	OF COMPONENT	7	EQUALS 0.0
14	VARY	CDAT	1	OF COMPONENT	6	SO THAT	STATP	8	OF FLOW STATION	14	EQUALS 0.0
16	VARY	CDAT	1	OF COMPONENT	5	SO THAT	STATP	8	OF FLOW STATION	6	EQUALS 0.0
17	VARY	CDAT	1	OF COMPONENT	3	SO THAT	STATP	8	OF FLOW STATION	5	EQUALS 0.0
19	VARY	CDAT	8	OF COMPONENT	3	SO THAT	DATOUT	8	OF COMPONENT	11	EQUALS 0.0
15	VARY	CDAT	1	OF COMPONENT	2	SO THAT	STATP	8	OF FLOW STATION	11	EQUALS 0.0
18	VARY	CDAT	1	OF COMPONENT	1	SO THAT	STATP	8	OF FLOW STATION	3	EQUALS 0.0

AF! FAN ENGINE, DESIGN POINT

DESIGN POINT MODE

CDAT(1,1-8)	0.98000D 03	0.0	0.14696D 02	0.10000D 03	0.0	0.75000D 02	0.40000D 04	0.10000D 01
CDAT(1,9-15)	0.0	0.0	0.10000D 01	-0.85000D 04	0.10000D 01	0.10000D 01	0.10000D 02	
CDAT(2,1-8)	0.12000D 01	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CDAT(2,9-15)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
CDAT(3,1-8)	0.10000D 01	0.10000D 00	0.10000D 01	0.30000D 03	0.44543D 03	0.30500D 03	0.10494D 01	0.16009D 03
CDAT(3,9-15)	0.10000D 01	0.0	0.0	0.65000D 00	0.16000D 02	0.10000D 01	0.0	
CDAT(4,1-8)	0.0	0.0	0.27713D-05	0.30000D 04	0.99000D 00	0.49900D 05	0.0	0.0
CDAT(4,9-15)	0.0	0.10000D 04	0.0	0.0	0.0	0.0	0.0	
CDAT(5,1-8)	0.20000D 01	0.10000D 01	0.41580D 00	0.10000D 01	0.61563D 02	0.88000D 00	0.10000D 01	0.20788D 01
CDAT(5,9-15)	0.35000D 00	0.0	0.88000D 00	0.10000D 01	0.10000D 01	0.0	0.0	
CDAT(6,1-8)	0.20000D 01	0.0	0.37540D 00	0.12000D 01	0.18399D 03	0.89000D 00	0.10000D 01	0.61894D 00
CDAT(6,9-15)	0.10000D 01	0.0	0.89000D 00	0.10000D 01	0.10000D 01	0.0	0.0	
CDAT(7,1-8)	0.29347D 04	0.50513D 05	0.10200D 01	0.10000D 01	0.0	0.0	0.0	0.0
CDAT(7,9-15)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
CDAT(8,1-8)	0.15991D 04	0.10000D 01	0.15000D 03	0.0	0.12000D 03	0.10000D 01	0.0	0.0
CDAT(8,9-15)	0.10000D 01	0.10000D 01	0.50000D 01	0.0	0.0	0.0	0.0	
CDAT(9,1-8)	0.0	0.0	0.29145D-07	0.0	0.0	0.0	0.0	0.0
CDAT(9,9-15)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
CDAT(10,1-8)	0.10000D 01	0.0	0.10000D 01	0.20000D 03	0.54545D 03	0.20500D 03	0.98824D 00	0.31000D 01
CDAT(10,9-15)	0.10000D 01	0.0	0.0	0.84000D 00	0.31000D 01	0.10000D 01	0.0	
CDAT(11,1-8)	0.10000D 01	0.10000D 01	0.10000D 01	0.10000D 01	0.10000D 01	0.0	0.0	0.0
CDAT(11,9-15)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
CDAT(12,1-8)	0.10000D 01	0.10000D 01	0.10000D 01	0.10000D 01	0.10000D 01	0.0	0.0	0.0
CDAT(12,9-15)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
CDAT(13,1-8)	0.0	0.0	0.30257D-07	0.0	0.0	0.0	0.0	0.0
CDAT(13,9-15)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
CDAT(14,1-8)	0.10000D 01	0.0	0.0	0.10000D 01	0.0	0.80000D 01	0.0	0.0
CDAT(14,9-15)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
CDAT(15,1-8)	0.10000D 01	0.0	0.0	0.10000D 01	0.0	0.80000D 01	0.0	0.0
CDAT(15,9-15)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
CDAT(16,1-8)	0.10000D 01	0.0	0.0	0.10000D 01	0.0	0.80000D 01	0.0	0.0
CDAT(16,9-15)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
CDAT(17,1-8)	0.10000D 01	0.0	0.0	0.10000D 01	0.0	0.80000D 01	0.0	0.0
CDAT(17,9-15)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
CDAT(18,1-8)	0.10000D 01	0.0	0.0	0.10000D 01	0.0	0.80000D 01	0.0	0.0
CDAT(18,9-15)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
CDAT(19,1-8)	0.10000D 01	0.0	0.0	0.80000D 01	0.0	0.18000D 02	0.0	0.0
CDAT(19,9-15)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
CDAT(20,1-8)	0.10000D 01	0.0	0.0	0.60000D 01	0.0	0.18000D 02	0.0	0.0
CDAT(20,9-15)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
CDAT(21,1-8)	0.10000D 01	0.0	0.0	0.10000D 01	0.0	0.18000D 02	0.0	0.0
CDAT(21,9-15)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	

ORIGINAL PAGE IS
OF POOR QUALITY

AFT FAN ENGINE, DESIGN POINT

STATION PROPERTY OUTPUT DATA

FLOW STATION	WEIGHT FLOW STATP1	TOTAL PRESSURE STATP2	TOTAL TEMPERATURE STATP3	FUEL/AIR RATIO STATP4	REFERRED FLOW STATP5	MACH NUMBER STATP6	STATIC PRESSURE STATP7	INTERFACE RELATIVE FLOW ERROR STATP8
1	0.980000 03	0.146960 02	0.518670 03	0.0	0.980000 03	0.0	0.0	0.0
2	0.980000 03	0.146960 02	0.518670 03	0.0	0.980000 03	0.0	0.0	0.0
3	0.445450 03	0.146960 02	0.518670 03	0.0	0.445450 03	0.0	0.0	0.0
4	0.400910 03	0.235140 03	0.124120 04	0.0	0.367620 02	0.0	0.0	0.0
5	0.405470 03	0.232760 03	0.300000 04	0.113870-01	0.615630 02	0.0	0.0	0.0
6	0.450020 03	0.756080 02	0.229500 04	0.102480-01	0.183990 03	0.0	0.0	0.0
7	0.450020 03	0.467020 02	0.207660 04	0.102480-01	0.263350 03	0.176050 00	0.457870 02	0.0
8	0.944570 03	0.455260 02	0.141330 04	0.465830-02	0.524630 03	0.0	0.0	0.0
9	0.944570 03	0.446150 02	0.141330 04	0.465830-02	0.535340 03	0.328730 01	0.146960 02	0.0
10	0.534550 03	0.146960 02	0.518670 03	0.0	0.534550 03	0.0	0.0	0.0
11	0.534550 03	0.144020 02	0.518670 03	0.0	0.534550 03	0.0	0.0	0.0
12	0.534550 03	0.446460 02	0.755940 03	0.0	0.212420 03	0.710610-02	0.446450 02	0.0
13	0.445450 02	0.235140 03	0.124120 04	0.0	0.0	0.0	0.0	0.0
14	0.944570 03	0.446150 02	0.141330 04	0.465830-02	0.535340 03	0.100000 01	0.238290 02	0.0

COMPONENT OUTPUT DATA

COMPONENT NO.	TYPE	DATOUT1	DATOUT2	DATOUT3	DATOUT4	DATOUT5	DATOUT6	DATOUT7	DATOUT8	DATOUT9
1	INLET	0.0	0.0	0.0	0.100000 01	0.100000 01	0.0	0.100000 01	0.100000 01	0.0
2	SPLITTER	0.120000 01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	COMPRESR	-0.112230 06	0.100000 01	0.0	0.100000 01	0.100000 01	0.100000 01	0.445450 03	0.850300 00	0.160000 02
4	DUCT 8	0.0	0.100000-01	0.0	0.113870-01	0.0	0.164350 05	0.0	0.499000 05	0.990000 00
5	BURNER	0.112230 06	0.100000 01	0.0	0.200000 01	0.415600 00	0.100000 01	0.615630 02	0.860000 00	0.307800 01
6	TURBINE	0.442380 05	0.100000 01	0.0	0.200000 01	0.475400 00	0.100000 01	0.183990 03	0.890000 00	0.161890 01
7	MIXER	0.293470 04	0.505130 05	0.102000 01	0.100000 01	0.392440 03	0.955930 01	0.183560 03	-0.252510-01	0.100690 01
8	NOZZLE	0.629620 05	0.205750 04	0.303590 01	0.219170 04	0.159910 04	0.100000 01	0.936750 00	0.0	0.303590 01
9	DUCT 8	0.0	0.200000-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	COMPRESR	-0.432380 05	0.100000 01	0.0	0.100000 01	0.100000 01	0.100000 01	0.545450 03	0.840000 00	0.310000 01
11	SHAFT	0.0	0.100000 01	0.100000 01	0.100000 01	0.0	0.0	0.0	0.0	0.0
12	SHAFT	0.0	0.100000 01	0.100000 01	0.100000 01	0.0	0.0	0.0	0.0	0.0
13	DUCT 8	0.0	0.200000-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0

PERFORMANCE OUTPUTS

(1) NET THRUST (LBS)	62962.27	(2) NET BRAKE SHP	0.0	(3) AIRFLOW (LB/SEC)	980.00
(4) ISFC LB/HR/LB)	0.2610	(5) BSFC (LB/HP/HR)	0.0	(6) FUEL FLOW(LB/HR)	16436.59
(7) NET THRUST/AIRFLW	64.25	(8) NET BSHP/AIRFLOW	0.0	(9) INLET DRAG (LBS)	0.0

0 ITERATIONS 2 PASSES

1PT FAN ENGINE, DESIGN POINT

NAMELIST INPUT CARDS FOR NEXT SOLUTION

ALTITUDE	MACH	FN	BSHP	WF	TSFC	REF FLOW	BPR	BOT	T19	PR19	A19	T9	PR9	A9	RR	MIT

ORIGINAL PAGE IS
OF POOR QUALITY

AFT FAN DESIGN POINT, CONTROLS ON

STATION PROPERTY OUTPUT DATA

FLOW STATION	WEIGHT FLOW STATP1	TOTAL PRESSURE STATP2	TOTAL TEMPERATURE STATP3	FUEL/AIR RATIO STATP4	REFERRED FLOW STATP5	MACH NUMBER STATP6	STATIC PRESSURE STATP7	INTERFACE RELATIVE FLOW ERROR STATP8
1	0.98032D 03	0.14696D 02	0.51867D 03	0.0	0.98032D 03	0.0	0.0	0.0
2	0.98032D 03	0.14696D 02	0.51867D 03	0.0	0.98032D 03	0.0	0.0	0.0
3	0.44443D 03	0.14696D 02	0.51867D 03	0.0	0.44443D 03	0.0	0.0	-0.29168D-05
4	0.39999D 03	0.23437D 03	0.12397D 04	0.0	0.36776D 02	0.0	0.0	0.0
5	0.49453D 03	0.23702D 03	0.29943D 04	0.11352D-01	0.61563D 02	0.0	0.0	-0.12554D-05
6	0.44997D 03	0.75356D 02	0.22904D 04	0.10217D-01	0.18399D 03	0.0	0.0	-0.31152D-06
7	0.44997D 03	0.46064D 02	0.20681D 04	0.10217D-01	0.28602D 03	0.17773D 00	0.45145D 02	0.0
8	0.98486D 03	0.45458D 02	0.14087D 04	0.46320D-02	0.52471D 03	0.0	0.0	0.0
9	0.98485D 03	0.44549D 02	0.14087D 04	0.46320D-02	0.51542D 03	0.12864D 01	0.14696D 02	0.0
10	0.53589D 03	0.14696D 02	0.51867D 03	0.0	0.53589D 03	0.0	0.0	0.0
11	0.53589D 03	0.14401D 02	0.51867D 03	0.0	0.54668D 03	0.0	0.0	0.35908D-05
12	0.53589D 03	0.45146D 02	0.75901D 03	0.0	0.21102D 03	0.70596D-02	0.45144D 02	0.0
13	0.44443D 02	0.23437D 03	0.12397D 04	0.0	0.0	0.0	0.0	0.0
14	0.98185D 03	0.44549D 02	0.14087D 04	0.46320D-02	0.51542D 03	0.10000D 01	0.23791D 02	0.54181D-05

COMPONENT OUTPUT DATA

COMPONENT NO.	TYPE	DATOUT1	DATOUT2	DATOUT3	DATOUT4	DATOUT5	DATOUT6	DATOUT7	DATOUT8	DATOUT9
1	INLET	0.0	0.0	0.0	0.10000D 01	0.10000D 01	0.0	0.10000D 01	0.10000D 01	0.0
2	SPLITTER	0.12058D 01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	COMPRESSR	-0.11173D 06	0.10000D 01	0.0	0.99770D 00	0.10000D 01	0.10000D 01	0.44545D 03	0.85040D 00	0.15948D 02
4	DUCT 8	0.0	0.10007D-01	0.0	0.11352D-01	0.0	0.16347D 05	0.0	0.49900D 03	0.99000D 00
5	TURBINE	0.11174D 06	0.10000D 01	0.0	0.20000D 01	0.41580D 00	0.10010D 01	0.61563D 02	0.80000D 00	0.30789D 01
6	TURBINE	0.43908D 05	0.10000D 01	0.0	0.20474D 01	0.47540D 00	0.10010D 01	0.18399D 03	0.89000D 00	0.16359D 01
7	MIXER	0.29347D 04	0.50513D 05	0.10204D 01	0.10000D 01	0.39538D 03	0.95158D 01	0.18541D 03	-0.17726D-04	0.10069D 01
8	NOZZLE	0.62443D 05	0.20530D 04	0.30313D 01	0.21666D 04	0.15991D 04	0.10000D 01	0.93691D 00	0.0	0.30313D 01
9	DUCT 8	0.0	0.20101D-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	COMPRESSR	-0.43910D 05	0.10000D 01	0.0	0.10026D 01	0.10000D 01	0.10000D 01	0.54545D 03	0.83882D 00	0.31350D 01
11	SHAFT	0.66343D 01	0.10000D 01	0.10000D 01	0.10000D 01	0.0	0.0	0.0	0.77277D-04	0.0
12	SHAFT	-0.15180D 01	0.10000D 01	0.10000D 01	0.10000D 01	0.0	0.0	0.0	-0.34572D-04	0.0
13	DUCT 8	0.0	0.20006D-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0

PERFORMANCE OUTPUTS

(1) NET THRUST (LBS)	62843.40	(2) NET SHAFT SHP	0.0	(3) AIRFLOW (LB/SEC)	980.32
(4) TSFC LB/HR/LB)	0.2601	(5) BSFC (LB/HR/HP)	0.0	(6) FUEL FLOW(LB/HR)	16346.60
(7) NT THRUST/AIRFLW	64.11	(8) NET BSHP/AIRFLOW	0.0	(9) INLET DRAG (LBS)	0.0

3 ITERATIONS 4 PASSES

0.	0.0	62843.	0.	16347.	0.260	980.3	1.206	2994.	0.	0.0	0.	1409.	3.031	1599.	1.000	3	

RAN BLISF INPUT CARDS FOR NEXT SOLUTION

ALTITUDE	MACH	FN	BSHP	WF	TSFC	NET FLOW	HPR	BUT	T19	PR19	A19	T9	PR9	A9	RN	NIT
0.	0.0	62853.	0.	16349.	0.260	980.4	1.206	2994.	0.	0.0	0.	1409.	3.032	1599.	1.000	3
0.	0.0	58166.	0.	14729.	0.253	942.1	1.227	2894.	0.	0.0	0.	1356.	2.855	1599.	1.000	4
0.	0.0	53322.	0.	13147.	0.247	900.8	1.253	2794.	0.	0.0	0.	1308.	2.674	1599.	1.000	2
0.	0.0	48042.	0.	11580.	0.241	852.6	1.280	2694.	0.	0.0	0.	1256.	2.478	1599.	1.000	3
0.	0.0	42225.	0.	9971.	0.236	797.2	1.325	2594.	0.	0.0	0.	1201.	2.263	1599.	1.000	2
0.	0.200	56476.	0.	15659.	0.295	975.9	1.208	3000.	0.	0.0	0.	1412.	3.093	1599.	1.000	1
0.	0.200	51869.	0.	14983.	0.289	936.3	1.230	2900.	0.	0.0	0.	1362.	2.909	1599.	1.000	3
0.	0.200	47286.	0.	13375.	0.283	895.4	1.256	2800.	0.	0.0	0.	1311.	2.725	1599.	1.000	2

ORIGINAL PAGE IS OF POOR QUALITY

0.	0.200	42154.	0.	11751.	0.279	846.0	1.285	2700.	0.	0.0	0.	1259.	2.520	1599.	1.000	3
0.	0.200	36762.	0.	10127.	0.275	792.6	1.333	2600.	0.	0.0	0.	1204.	2.306	1599.	1.000	2
0.	0.400	49923.	0.	17257.	0.346	953.4	1.219	3000.	0.	0.0	0.	1415.	3.241	1599.	1.000	3
0.	0.400	45276.	0.	15460.	0.341	912.0	1.242	2900.	0.	0.0	0.	1364.	3.039	1599.	1.000	2
0.	0.400	40720.	0.	13760.	0.338	870.5	1.270	2800.	0.	0.0	0.	1313.	2.841	1599.	1.000	2
0.	0.400	3[illegible]337.	0.	11959.	0.338	816.7	1.308	2700.	0.	0.0	0.	1259.	2.606	1599.	1.000	2
0.	0.400	33533.	0.	10366.	0.340	769.3	1.354	2600.	0.	0.0	0.	1205.	2.400	1599.	1.000	3
0.	0.600	43173.	0.	18156.	0.421	913.4	1.237	3000.	0.	0.0	0.	1418.	3.477	1599.	1.000	2
0.	0.600	38504.	0.	16238.	0.421	873.3	1.262	2900.	0.	0.0	0.	1367.	3.258	1599.	1.000	2
0.	0.600	33301.	0.	14202.	0.426	823.4	1.300	2800.	0.	0.0	0.	1314.	3.005	1599.	1.000	2
0.	0.600	28300.	0.	12356.	0.436	775.7	1.345	2700.	0.	0.0	0.	1259.	2.768	1599.	1.000	3
0.	0.600	24137.	0.	10797.	0.447	735.6	1.388	2600.	0.	0.0	0.	1207.	2.569	1599.	1.000	3
0.	0.800	33484.	0.	19348.	0.561	860.8	1.266	3000.	0.	0.0	0.	1424.	3.812	1599.	1.000	2
0.	0.800	28316.	0.	16731.	0.568	811.9	1.308	2900.	0.	0.0	0.	1367.	3.517	1599.	1.000	2
0.	0.800	23797.	0.	14850.	0.625	768.5	1.350	2800.	0.	0.0	0.	1315.	3.258	1599.	1.000	3
0.	0.800	19350.	0.	13051.	0.671	731.1	1.391	2700.	0.	0.0	0.	1263.	3.033	1599.	1.000	3
0.	0.800	15341.	0.	11440.	0.741	695.9	1.434	2600.	0.	0.0	0.	1212.	2.829	1599.	1.000	3
0.	0.900	27172.	0.	19802.	0.729	823.8	1.293	3000.	0.	0.0	0.	1423.	3.960	1599.	1.000	2
0.	0.900	21652.	0.	17384.	0.803	779.5	1.336	2900.	0.	0.0	0.	1366.	3.665	1599.	1.000	3
0.	0.900	16922.	0.	15334.	0.906	742.0	1.375	2800.	0.	0.0	0.	1317.	3.436	1599.	1.000	3
0.	0.900	12576.	0.	13496.	1.073	707.4	1.418	2700.	0.	0.0	0.	1265.	3.207	1599.	1.000	3
0.	0.900	8557.	0.	11839.	1.384	674.4	1.462	2600.	0.	0.0	0.	1215.	2.997	1599.	1.000	3

NAMELIST INPUT CARDS FOR NEXT SOLUTION

ALTITUDE	MACH	FN	BSHP	WF	TSFC	NEF	FLOW	BPR	BUT	T19	PR19	A19	T9	WP9	A9	RR	NIT
10000.	0.200	41806.	0.	12261.	0.293	1004.5		1.197	2965.	0.	0.0	0.	1384.	3.265	1599.	1.000	3
10000.	0.200	39858.	0.	11377.	0.285	988.0		1.205	2865.	0.	0.0	0.	1338.	3.152	1599.	1.000	3
10000.	0.200	36917.	0.	10271.	0.278	953.6		1.226	2765.	0.	0.0	0.	1287.	2.960	1599.	1.000	7
10000.	0.200	33420.	0.	9112.	0.273	906.6		1.248	2665.	0.	0.0	0.	1237.	2.775	1599.	1.000	2
10000.	0.200	29325.	0.	8003.	0.267	860.0		1.280	2565.	0.	0.0	0.	1185.	2.570	1599.	1.000	2
10000.	0.400	39697.	0.	13251.	0.343	1000.4		1.196	3000.	0.	0.0	0.	1406.	3.514	1599.	1.000	1
10000.	0.400	36664.	0.	12285.	0.335	982.7		1.206	2900.	0.	0.0	0.	1358.	3.387	1599.	1.000	3
10000.	0.400	33442.	0.	11030.	0.329	944.2		1.231	2800.	0.	0.0	0.	1307.	3.187	1599.	1.000	4
10000.	0.400	30117.	0.	9807.	0.326	899.0		1.252	2700.	0.	0.0	0.	1257.	2.973	1599.	1.000	2
10000.	0.400	26563.	0.	8567.	0.323	849.9		1.286	2600.	0.	0.0	0.	1206.	2.748	1599.	1.000	3
10000.	0.600	35222.	0.	14307.	0.406	981.0		1.206	2993.	0.	0.0	0.	1408.	3.657	1599.	1.000	7
10000.	0.600	31989.	0.	12899.	0.403	943.3		1.226	2893.	0.	0.0	0.	1357.	3.655	1599.	1.000	4
10000.	0.600	28640.	0.	11512.	0.402	901.9		1.252	2793.	0.	0.0	0.	1307.	3.405	1599.	1.000	2
10000.	0.600	25065.	0.	10146.	0.405	854.0		1.279	2693.	0.	0.0	0.	1256.	3.155	1599.	1.000	3
10000.	0.600	21178.	0.	8736.	0.412	796.4		1.325	2593.	0.	0.0	0.	1200.	2.882	1599.	1.000	2
10000.	0.800	29985.	0.	15532.	0.518	934.4		1.227	3000.	0.	0.0	0.	1416.	4.280	1599.	1.000	4
10000.	0.800	26450.	0.	13920.	0.526	894.5		1.251	2900.	0.	0.0	0.	1366.	4.018	1599.	1.000	2
10000.	0.800	22867.	0.	12295.	0.542	849.6		1.284	2800.	0.	0.0	0.	1313.	3.733	1599.	1.000	3
10000.	0.800	18557.	0.	10651.	0.574	796.2		1.327	2700.	0.	0.0	0.	1259.	3.421	1599.	1.000	3
10000.	0.800	15136.	0.	9285.	0.613	753.1		1.370	2600.	0.	0.0	0.	1208.	3.165	1599.	1.000	3
10000.	0.900	25759.	0.	16163.	0.627	904.5		1.243	3000.	0.	0.0	0.	1419.	4.525	1599.	1.000	2
10000.	0.900	21920.	0.	14419.	0.658	863.5		1.270	2900.	0.	0.0	0.	1357.	4.233	1599.	1.000	2
10000.	0.900	17615.	0.	12580.	0.713	812.0		1.312	2800.	0.	0.0	0.	1313.	3.894	1599.	1.000	2
10000.	0.900	13736.	0.	10967.	0.798	766.8		1.353	2700.	0.	0.0	0.	1260.	3.596	1599.	1.000	3
10000.	0.900	10399.	0.	9590.	0.922	727.8		1.396	2600.	0.	0.0	0.	1208.	3.341	1599.	1.000	3
10000.	1.000	22048.	0.	16844.	0.764	871.4		1.260	3000.	0.	0.0	0.	1422.	4.798	1599.	1.000	2
10000.	1.000	17329.	0.	14794.	0.854	823.8		1.299	2900.	0.	0.0	0.	1368.	4.436	1599.	1.000	2
10000.	1.000	13060.	0.	12928.	0.990	777.5		1.342	2800.	0.	0.0	0.	1314.	4.097	1599.	1.000	3
10000.	1.000	9516.	0.	11455.	1.193	739.0		1.383	2700.	0.	0.0	0.	1262.	3.812	1599.	1.000	3
10000.	1.000	6183.	0.	9948.	1.609	702.9		1.426	2600.	0.	0.0	0.	1211.	3.552	1599.	1.000	5

NAMELIST INPUT CARDS FOR NEXT SOLUTION

AFT FAN ENGINE, OFF DESIGN

ALTITUDE	MACH	FN	BSHP	WF	TSFC	REF FLOW	BPR	BOT	T19	PR19	A19	T9	PR9	A9	RR	NIT
20000.	0.200	28907.	0.	8259.	0.286	1017.0	1.193	2851.	0.	0.0	0.	1318.	3.347	1599.	1.000	2
20000.	0.200	27561.	0.	7648.	0.278	1000.9	1.203	2751.	0.	0.0	0.	1271.	3.231	1599.	1.000	2
20000.	0.200	26022.	0.	7016.	0.270	978.4	1.213	2651.	0.	0.0	0.	1224.	3.101	1599.	1.000	5
20000.	0.200	23677.	0.	6226.	0.263	935.2	1.240	2551.	0.	0.0	0.	1172.	2.884	1599.	1.000	4
20000.	0.200	21351.	0.	5479.	0.257	891.1	1.275	2451.	0.	0.0	0.	1120.	2.680	1599.	1.000	2
20000.	0.400	27061.	0.	9029.	0.334	1015.3	1.193	2500.	0.	0.0	0.	1345.	3.620	1599.	1.000	2
20000.	0.400	25707.	0.	8372.	0.326	1000.0	1.203	2600.	0.	0.0	0.	1298.	3.497	1599.	1.000	2
20000.	0.400	24119.	0.	7684.	0.319	977.1	1.213	2700.	0.	0.0	0.	1250.	3.350	1599.	1.000	5
20000.	0.400	21759.	0.	6819.	0.313	932.5	1.240	2800.	0.	0.0	0.	1196.	3.126	1599.	1.000	4
20000.	0.400	19469.	0.	6015.	0.309	887.8	1.268	2500.	0.	0.0	0.	1146.	2.907	1599.	1.000	2
20000.	0.600	25649.	0.	10179.	0.397	1007.8	1.195	2947.	0.	0.0	0.	1372.	4.063	1599.	1.000	2
20000.	0.600	24218.	0.	9445.	0.390	991.6	1.204	2847.	0.	0.0	0.	1320.	3.923	1599.	1.000	2
20000.	0.600	22298.	0.	8576.	0.385	961.3	1.224	2747.	0.	0.0	0.	1277.	3.727	1599.	1.000	7
20000.	0.600	19789.	0.	7598.	0.384	913.2	1.244	2647.	0.	0.0	0.	1220.	3.473	1599.	1.000	3
20000.	0.600	17576.	0.	6685.	0.385	868.0	1.276	2547.	0.	0.0	0.	1174.	3.217	1599.	1.000	2
20000.	0.800	24234.	0.	11856.	0.489	995.3	1.200	3000.	0.	0.0	0.	1406.	4.723	1599.	1.000	2
20000.	0.800	22233.	0.	10912.	0.489	972.6	1.212	2900.	0.	0.0	0.	1359.	4.528	1599.	1.000	6
20000.	0.800	19698.	0.	9759.	0.495	931.2	1.237	2800.	0.	0.0	0.	1308.	4.246	1599.	1.000	3
20000.	0.800	17200.	0.	8675.	0.504	886.6	1.259	2700.	0.	0.0	0.	1259.	3.961	1599.	1.000	2
20000.	0.800	14369.	0.	7542.	0.525	834.4	1.298	2600.	0.	0.0	0.	1204.	3.643	1599.	1.000	3
20000.	0.900	22735.	0.	12628.	0.555	980.7	1.205	3000.	0.	0.0	0.	1412.	5.084	1599.	1.000	4
20000.	0.900	19677.	0.	11375.	0.578	942.3	1.227	2900.	0.	0.0	0.	1361.	4.791	1599.	1.000	4
20000.	0.900	16850.	0.	10155.	0.603	901.0	1.253	2800.	0.	0.0	0.	1311.	4.489	1599.	1.000	2
20000.	0.900	14025.	0.	8949.	0.638	853.0	1.280	2700.	0.	0.0	0.	1259.	4.159	1599.	1.000	3
20000.	0.900	10985.	0.	7707.	0.702	798.6	1.326	2600.	0.	0.0	0.	1203.	3.805	1599.	1.000	2
20000.	1.000	21274.	0.	13255.	0.623	950.2	1.220	3000.	0.	0.0	0.	1415.	5.425	1599.	1.000	4
20000.	1.000	17603.	0.	11876.	0.675	909.1	1.243	2900.	0.	0.0	0.	1364.	5.086	1599.	1.000	2
20000.	1.000	14296.	0.	10567.	0.739	867.4	1.272	2800.	0.	0.0	0.	1313.	4.753	1599.	1.000	2
20000.	1.000	10871.	0.	9161.	0.843	813.2	1.311	2700.	0.	0.0	0.	1259.	4.357	1599.	1.000	2
20000.	1.000	8057.	0.	7956.	0.987	766.6	1.357	2600.	0.	0.0	0.	1205.	4.015	1599.	1.000	3

NAMELIST INPUT CARDS FOR NEXT SOLUTION

ALTITUDE	MACH	FN	BSHP	WF	TSFC	REF FLOW	BPR	BOT	T19	PR19	A19	T9	PR9	A9	RR	NIT
30000.	0.200	19260.	0.	5332.	0.277	1028.1	1.188	2720.	0.	0.0	0.	1244.	3.423	1599.	1.000	2
30000.	0.200	18352.	0.	4925.	0.268	1012.5	1.199	2620.	0.	0.0	0.	1196.	3.301	1599.	1.000	2
30000.	0.200	17427.	0.	4531.	0.260	995.6	1.210	2520.	0.	0.0	0.	1149.	3.174	1599.	1.000	2
30000.	0.200	16208.	0.	4086.	0.252	966.9	1.234	2420.	0.	0.0	0.	1100.	3.001	1599.	1.000	7
30000.	0.200	14582.	0.	3575.	0.245	918.3	1.272	2320.	0.	0.0	0.	1049.	2.772	1599.	1.000	3
30000.	0.400	17974.	0.	5779.	0.322	1024.7	1.190	2756.	0.	0.0	0.	1264.	3.687	1599.	1.000	1
30000.	0.400	17047.	0.	5342.	0.313	1008.3	1.200	2656.	0.	0.0	0.	1217.	3.560	1599.	1.000	2
30000.	0.400	16097.	0.	4919.	0.306	991.3	1.210	2556.	0.	0.0	0.	1170.	3.419	1599.	1.000	3
30000.	0.400	14738.	0.	4401.	0.299	958.1	1.241	2456.	0.	0.0	0.	1116.	3.216	1599.	1.000	8
30000.	0.400	13202.	0.	3877.	0.294	911.2	1.268	2356.	0.	0.0	0.	1070.	2.983	1599.	1.000	2
30000.	0.600	17216.	0.	6580.	0.382	1019.8	1.195	2814.	0.	0.0	0.	1297.	4.160	1599.	1.000	1
30000.	0.600	16243.	0.	6089.	0.375	1003.0	1.202	2714.	0.	0.0	0.	1250.	4.011	1599.	1.000	2
30000.	0.600	15198.	0.	5597.	0.368	983.5	1.212	2614.	0.	0.0	0.	1202.	3.855	1599.	1.000	4
30000.	0.600	13596.	0.	4958.	0.365	939.8	1.241	2514.	0.	0.0	0.	1150	3.593	1599.	1.000	5
30000.	0.600	12037.	0.	4377.	0.364	896.5	1.272	2414.	0.	0.0	0.	1101.	3.336	1599.	1.000	3
30000.	0.800	16842.	0.	7873.	0.467	1013.0	1.194	2900.	0.	0.0	0.	1345.	4.694	1599.	1.000	2
30000.	0.800	15673.	0.	7298.	0.466	997.6	1.204	2800.	0.	0.0	0.	1299.	4.728	1599.	1.000	2
30000.	0.800	14311.	0.	6674.	0.466	972.0	1.216	2700.	0.	0.0	0.	1251.	4.516	1599.	1.000	6
30000.	0.800	12535.	0.	5913.	0.472	926.4	1.241	2600.	0.	0.0	0.	1199.	4.209	1599.	1.000	3
30000.	0.800	10815.	0.	5210.	0.481	881.3	1.272	2500.	0.	0.0	0.	1148.	3.928	1599.	1.000	2
30000.	0.900	16855.	0.	8691.	0.516	1008.3	1.196	2944.	0.	0.0	0.	1370.	5.330	1599.	1.000	2
30000.	0.900	15416.	0.	8064.	0.523	992.1	1.204	2844.	0.	0.0	0.	1320.	5.185	1599.	1.000	2
30000.	0.900	13597.	0.	7328.	0.539	962.4	1.221	2744.	0.	0.0	0.	1275.	4.929	1599.	1.000	7
30000.	0.900	11473.	0.	6492.	0.566	914.5	1.244	2644.	0.	0.0	0.	1223.	4.593	1599.	1.000	3
30000.	0.900	9812.	0.	5712.	0.598	869.2	1.276	2544.	0.	0.0	0.	1173.	4.255	1599.	1.000	2

30000.	1.000	17601.	0.	9600.	0.545	1001.1	1.198	2981.	0.	0.0	0.	1394.	5.914	1599.	1.000	2
30000.	1.000	15859.	0.	8898.	0.561	983.7	1.206	2881.	0.	0.0	0.	1344.	5.704	1599.	1.000	3
30000.	1.000	13312.	0.	7990.	0.600	945.2	1.230	2781.	0.	0.0	0.	1297.	5.368	1599.	1.000	5
30000.	1.000	10410.	0.	7097.	0.657	899.6	1.252	2681.	0.	0.0	0.	1247.	5.004	1599.	1.000	2
30000.	1.000	6471.	0.	6211.	0.733	850.1	1.284	2581.	0.	0.0	0.	1194.	4.621	1599.	1.000	3

NAMELIST INPUT CARDS FOR NEXT SOLUTION

ALTITUDE	MACH	FN	BSHP	WF	TSFC	REF FLOW	BPR	BUT	TIY	PRIY	AIY	TY	PHY	AY	RR	NIT
36000.	0.200	14674.	0.	3940.	0.268	1032.6	1.189	2609.	0.	0.0	0.	1183.	3.441	1599.	1.000	2
36000.	0.200	13954.	0.	3628.	0.260	1016.4	1.200	2509.	0.	0.0	0.	1136.	3.314	1599.	1.000	2
36000.	0.200	13250.	0.	3331.	0.251	1000.0	1.215	2409.	0.	0.0	0.	1089.	3.175	1599.	1.000	2
36000.	0.200	12297.	0.	2995.	0.244	971.6	1.242	2309.	0.	0.0	0.	1041.	3.004	1599.	1.000	7
36000.	0.200	10941.	0.	2609.	0.237	920.1	1.275	2209.	0.	0.0	0.	992.	2.787	1599.	1.000	4
36000.	0.400	13671.	0.	4342.	0.313	1030.6	1.187	2661.	0.	0.0	0.	1212.	3.745	1599.	1.000	2
36000.	0.400	13125.	0.	4000.	0.305	1019.2	1.199	2561.	0.	0.0	0.	1164.	3.600	1599.	1.000	2
36000.	0.400	12401.	0.	3676.	0.296	998.8	1.214	2461.	0.	0.0	0.	1116.	3.458	1599.	1.000	3
36000.	0.400	11440.	0.	3311.	0.289	969.0	1.238	2361.	0.	0.0	0.	1068.	3.269	1599.	1.000	7
36000.	0.400	10157.	0.	2893.	0.285	920.0	1.274	2261.	0.	0.0	0.	1019.	3.018	1599.	1.000	3
36000.	0.600	13303.	0.	4949.	0.372	1024.8	1.190	2720.	0.	0.0	0.	1267.	4.220	1599.	1.000	4
36000.	0.600	12556.	0.	4570.	0.364	1009.0	1.201	2620.	0.	0.0	0.	1217.	4.069	1599.	1.000	2
36000.	0.600	11781.	0.	4203.	0.357	991.8	1.211	2520.	0.	0.0	0.	1150.	3.912	1599.	1.000	2
36000.	0.600	10673.	0.	3760.	0.352	957.4	1.240	2420.	0.	0.0	0.	1100.	3.674	1599.	1.000	8
36000.	0.600	9372.	0.	3292.	0.351	909.5	1.276	2320.	0.	0.0	0.	1050.	3.396	1599.	1.000	2
36000.	0.800	13178.	0.	5948.	0.451	1020.0	1.193	2810.	0.	0.0	0.	1295.	4.982	1599.	1.000	1
36000.	0.800	12215.	0.	5504.	0.451	1003.2	1.201	2710.	0.	0.0	0.	1246.	4.803	1599.	1.000	2
36000.	0.800	11250.	0.	5060.	0.449	983.1	1.212	2610.	0.	0.0	0.	1200.	4.616	1599.	1.000	4
36000.	0.800	9873.	0.	4483.	0.454	940.6	1.241	2510.	0.	0.0	0.	1146.	4.305	1599.	1.000	5
36000.	0.800	8578.	0.	3958.	0.461	897.4	1.272	2410.	0.	0.0	0.	1099.	3.998	1599.	1.000	2
36000.	0.900	13379.	0.	6615.	0.494	1016.3	1.193	2862.	0.	0.0	0.	1324.	5.490	1599.	1.000	1
36000.	0.900	12233.	0.	6127.	0.501	1000.5	1.203	2762.	0.	0.0	0.	1277.	5.291	1599.	1.000	2
36000.	0.900	10988.	0.	5620.	0.511	977.4	1.212	2662.	0.	0.0	0.	1230.	5.079	1599.	1.000	5
36000.	0.900	9267.	0.	4985.	0.537	933.7	1.240	2562.	0.	0.0	0.	1178.	4.726	1599.	1.000	4
36000.	0.900	7790.	0.	4385.	0.563	887.7	1.271	2462.	0.	0.0	0.	1127.	4.390	1599.	1.000	2
36000.	1.000	14275.	0.	7393.	0.513	1011.9	1.195	2914.	0.	0.0	0.	1353.	6.070	1599.	1.000	1
36000.	1.000	12941.	0.	6856.	0.530	996.6	1.205	2814.	0.	0.0	0.	1307.	5.865	1599.	1.000	2
36000.	1.000	11315.	0.	6263.	0.554	970.1	1.217	2714.	0.	0.0	0.	1259.	5.596	1599.	1.000	6
36000.	1.000	9309.	0.	5549.	0.583	923.7	1.243	2614.	0.	0.0	0.	1207.	5.215	1599.	1.000	3
36000.	1.000	7370.	0.	4890.	0.663	878.7	1.272	2514.	0.	0.0	0.	1156.	4.841	1599.	1.000	2

NAMELIST INPUT CARDS FOR NEXT SOLUTION

PRECEDING PAGE BLANK NOT FILMED

C2. AUGMENTED AFT FAN TURBOFAN

SAMPLE INPUT AND OUTPUT

FOR THE

ENGINE PERFORMANCE CALCULATION

WITH INSTALLATION EFFECTS AND H_2 FUEL

(DISSOCIATION ARTIFICIALLY PRECLUDED)

```
&D
NCOMP=21,NOSTAT=14,IDESN=1,IPRINT=0,TITLE=1,TABLES=2,
JFIG(1,1)=1,1,0,2,0,
JFIG(1,2)=7,2,0,3,10,
JFIG(1,3)=4,3,0,4,13,
JFIG(1,4)=2,4,0,5,0,
JFIG(1,5)=5,5,13,6,0,
JFIG(1,6)=5,6,0,7,0,
JFIG(1,7)=8,7,12,8,0,
JFIG(1,8)=9,14,0,9,0,
JFIG(1,9)=2,10,0,11,0,
JFIG(1,10)=4,11,0,12,0,
JFIG(1,11)=11,3,5,0,0,
JFIG(1,12)=11,6,10,0,0,
JFIG(1,13)=2,8,0,14,0,
JFIG(1,14)=12,14,0,6,0,
JFIG(1,15)=12,11,0,2,0,
JFIG(1,16)=12,6,0,5,0,
JFIG(1,17)=12,5,0,3,0,
JFIG(1,18)=12,3,0,1,0,
JFIG(1,19)=12,11,0,3,0,
JFIG(1,20)=12,12,0,10,0,
JFIG(1,21)=12,7,0,10,0,
CDAT(1,1)=980.,0.,0.,100.,0.,75.,4000.,1.,0.,0.,1.,-8500.,1.,1.,10.,
CDAT(1,2)=1.2,
CDAT(1,3)=1.,.1,1.,300.,445.45,305.,1.,16.,1.,0.,0.,.85,16.,1.,0.,
CDAT(1,4)=.01,.0,.0,3000.,.99,49900.,3*0.,1000.,0.0,
CDAT(1,5)=2.,1.,1.,1.,1.,.88,2*1.,.35,0.,.88,2*1.,2*0.,
CDAT(1,6)=2.,0.,3*1.,.89,3*1.,0.,.89,2*1.,2*0.,
CDAT(1,7)=2*1.,1.020,1.,
CDAT(1,8)=2*1.,150.,0.,120.,1.,0.,0.,2*1.,5.,
CDAT(1,9)=.02,
CDAT(1,10)=1.,0.,1.,200.,534.54,205.,1.,3.1,1.,2*0.,.84,3.1,1.,0.,
CDAT(1,11)=5*1.,
CDAT(1,12)=5*1.,
CDAT(1,13)=.02,
CDAT(1,14)=0.,0.,0.,1.,0.,08.,
CDAT(1,15)=0.,0.,0.,1.,0.,08.,
CDAT(1,16)=0.,0.,0.,1.,0.,08.,
CDAT(1,17)=0.,0.,0.,1.,0.,08.,
CDAT(1,18)=0.,0.,0.,1.,0.,08.,
CDAT(1,19)=0.,0.,0.,8.,0.,18.,
CDAT(1,20)=0.,0.,0.,8.,0.,18.,
CDAT(1,21)=0.,0.,0.,1.,0.,18.,
WMAX=980.,JCB=4,
JN1=8,JN2=0,JCAB1=13,JCAB2=0,
FIGSET=1.  &END
 AFT FAN ENGINE, DESIGN POINT
 50      FLOW SCHEDULE
Z      1   0.
Y      1   0.
THET  21   .5       .6       .67      .675     .68      .685     .69
           .75      .80      .85      .90      .95      .975     1.0
           1.157    1.35     1.54     1.735    1.93     2.12     2.31
WRA   21   1.06     1.06     1.06     1.06     1.06     1.06     1.06
           1.054    1.048    1.041    1.033    1.022    1.014    1.0
           .918     .796     .709     .644     .596     .556     .520
EOT
   75      RAM RECOVERY
Z      1   0.
MACH  17   0.       .25      .5       .75      1.0      1.25     1.5
           1.75     1.95     2.0      2.5      3.0      3.5      4.0
           4.5      5.0      5.2
WCOR   1   2000.
```

```
RR     1   1.0
RR     1   1.0
RR     1   1.0
RR     1   1.0
RR     1   1.0
RR     1   .98
RR     1   .94
RR     1   .88
RR     1   .82
RR     1   .925
RR     1   .87
RR     1   .81
RR     1   .74
RR     1   .67
RR     1   .59
RR     1   .51
RR     1   .48
EOT
  100      SPILLAGE DRAG
Z      1   0.
MACH   9   .8       .9       1.       1.25     2.       3.       4.
           5.       5.2
MFR    8   .35      .4       .5       .6       .7       .8       .9
           1.
CDS    8   .0275    .022     .014     .0095    .006     .0035    .0002
           0.
MFR    7   .4       .5       .6       .7       .8       .9       1.
CDS    7   .045     .0265    .017     .0105    .006     .0002    0.
MFR    7   .4       .5       .6       .7       .8       .9       1.
CDS    7   .0545    .033     .022     .014     .008     .0003    0.
MFR    7   .4       .5       .6       .7       .8       .9       1.
CDS    7   .072     .045     .0285    .016     .0105    .0005    0.
MFR    6   .5       .6       .7       .8       .9       1.
CDS    6   .057     .035     .022     .012     .0005    0.
MFR    4   .7       .8       .9       1.
CDS    4   .028     .013     .0005    0.
MFR    3   .8       .9       1.
CDS    3   .009     .0002    0.
MFR    4   .8       .9       .973     1.
CDS    4   .017     .0003    0.       0.
MFR    1   1.
CDS    1   0.
EOT
  120      NOZZLE THRUST COEFFICIENT
Z      1   0.
Y      1   0.
PR    13   3.       4.       5.       6.       8.       10.      12.
           14.      16.      18.      20.      22.      24.
CV    13   .94      .91      .89      .9       .93      .95      .96
           .97      .979     .983     .985     .985     .985
EOT
  150      AFTERBODY DRAG
Z      1   0.
MACH   3   1.5      1.8      2.0
NPR   11   4.       6.       8.       10.      12.      14.      16.
           18.      20.      22.      24.
CDAB  11   .131     .125     .107     .077     .054     .038     .027
           .02      .015     .011     .009
NPR   10   6.       8.       10.      12.      14.      16.      18.
           20.      22.      24.
CDAB  10   .079     .07      .056     .037     .023     .013     .005
           .0       -.003    -.005
NPR   11   5.       6.       8.       10.      12.      14.      16.
           18.      20.      22.      24.
CDAB  11   .061     .059     .052     .04      .025     .01      -.002
           -.009    -.013    -.017    -.019
```

ORIGINAL PAGE IS
OF POOR QUALITY

```
            ....      ....      ...       ....
EOT
  200       R VS. CORRECTED FLOW-FAN USED FOR BPR=1-2
Z      1    0.
Y      1    1.
R      3    0.        .5        1.1
WRA    3    0.        .5        1.1
EOT
  205       R VS. EFFICIENCY-FAN USED FOR BPR=1-2
Z      1    0.
Y      1    1.
R     12    .4        .5        .6        .7        .8        .9        .925
            .952      .98       .99       1.        1.1
EFF   12    .831      .842      .851      .856      .858      .858      .858
            .8565     .8548     .853      .85       .684
EOT
  300       R VS. CORRECTED FLOW COMPRESSOR
Z      1    0.
Y      1    1.
R      3    0.        .5        1.011
WRA    3    0.        .5        1.011
EOT
  305       R VS. EFFECIENCY-COMPRESSOR
Z      1    0.
Y      1    1.
R      9    .416      .522      .633      .76       .889      .944      .968
            1.0       1.011
EFF    9    .666      .74       .774      .794      .813      .813      .813
            .81       .804
EOT
            END OF TABLE DATA
 &D ALT=0.,NM=1,NP=1,TDEL=0.,XMA=0.0
 IPRINT=1,TITLE=1,
 CDAT(1,14)=1.,CDAT(1,15)=1.,CDAT(1,16)=1.,CDAT(1,17)=1.,
 CDAT(1,18)=1.,CDAT(1,19)=1.,CDAT(1,20)=1.,CDAT(1,21)=1. &END
       AFT FAN DESIGN POINT, CONTROLS ON
 &D NP=1,TDEL=0.,TIT=3150.,ALT=0.,CDAT(4,13)=3260.,
 TITLE=1,IPRINT=0,
 CDAT(5,13)=.96,CDAT(6,13)=49900.,CDAT(10,13)=1000.,CDAT(11,13)=0.0,NM=12,
 XMA=0.,.05,.1,.15,.2,.25,.3,.35,.4,.45,.5,.55 &END
      AUGMENTED AFT FAN
 &D ALT=2000.,NM=12,XMA=.2,.3,.4,.5,.6,.7,.8,.9,1.,1.1,1.2,1.3 &END
 &D ALT=4000. &END
 &D ALT=6000. &END
 &D ALT=8000. &END
 &D ALT=10000.,XMA=.4,.5,.6,.7,.8,.9,1.,1.1,1.2,1.3,1.4,1.5 &END
 &D ALT=20000.,XMA=.6,.8,.9,1.,1.1,1.2,1.3,1.4,1.5,1.6,1.7,1.8 &END
 &D ALT=30000.,XMA=.6,.8,.9,1.,1.1,1.2,1.4,1.6,1.7,1.8,2.0,2.2 &END
 &D ALT=40000.,XMA=.8,.9,1.,1.1,1.2,1.4,1.6,2.2,2.4,2.5,2.6,2.8, &END
 &D ALT=50000.,XMA=.8,.9,1.1,1.4,1.6,1.8,2.2,2.4,2.6,2.8,3.,3.2 &END
 &D ALT=60000. &END
 &D ALT=70000.,XMA=.8,1.,1.2,1.6,2.0,2.2,2.4,2.8,3.0,3.2,3.4,3.5
 &END
 &D ALT=85000. &END
 &D ENDRUN=1 &END
```

NAVAL AIR DEVELOPMENT CENTER

NEPII NAVY ENGINE PERFORMANCE COMPUTER CODE
VERSION II IBM 360

NAMELIST INPUT CARDS FOR NEXT SOLUTION

500 FLOW SCHEDULE

Z = 0.0 Y = 0.0

THET	0.50000D 00	0.60000D 00	0.67000D 00	0.67500D 00	0.68000D 00	0.68500D 00	0.69000D 00	0.75000D 00
WRA	0.10600D 01	0.10600D 01	0.10600D 01	0.10600D 01	0.10600D 01	0.10600D 01	0.10600D 01	0.10540D 01
THET	0.80000D 00	0.85000D 00	0.90000D 00	0.95000D 00	0.97500D 00	0.10000D 01	0.11570D 01	0.13500D 01
WRA	0.10480D 01	0.10410D 01	0.10330D 01	0.10220D 01	0.10140D 01	0.10000D 01	0.91800D 00	0.79600D 00
THET	0.15400D 01	0.17350D 01	0.19300D 01	0.21700D 01	0.23100D 01			
WRA	0.70900D 00	0.64400D 00	0.59600D 00	0.55600D 00	0.52000D 00			

Z = 0.0	MACH=	0.0
	WCOR	0.20000D 04
	RR	0.10000D 01
Z = 0.0	MACH=	0.25000D 00
	WCOR	0.20000D 04
	RR	0.10000D 01
Z = 0.0	MACH=	0.50000D 00
	WCOR	0.20000D 04
	RR	0.10000D 01
Z = 0.0	MACH=	0.75000D 00
	WCOR	0.20000D 04
	RR	0.10000D 01
Z = 0.0	MACH=	0.10000D 01
	WCOR	0.20000D 04
	RR	0.10000D 01
Z = 0.0	MACH=	0.12500D 01
	WCOR	0.20000D 04
	RR	0.98000D 00
Z = 0.0	MACH=	0.15000D 01
	WCOR	0.20000D 04
	RR	0.94000D 00
Z = 0.0	MACH=	0.17500D 01
	WCOR	0.20000D 04
	RR	0.86000D 00
Z = 0.0	MACH=	0.19500D 01
	WCOR	0.20000D 04
	RR	0.82000D 00
Z = 0.0	MACH=	0.20000D 01
	WCOR	0.20000D 04
	RR	0.92500D 00
Z = 0.0	MACH=	0.25000D 01
	WCOR	0.20000D 04
	RR	0.87000D 00
Z = 0.0	MACH=	0.30000D 01
	WCOR	0.20000D 04
	RR	0.81000D 00
Z = 0.0	MACH=	0.35000D 01
	WCOR	0.20000D 04
	RR	0.74000D 00
Z = 0.0	MACH=	0.40000D 01
	WCOR	0.20000D 04
	RR	0.67000D 00
Z = 0.0	MACH=	0.45000D 01
	WCOR	0.20000D 04
	RR	0.59000D 00
Z = 0.0	MACH=	0.50000D 01
	WCOR	0.20000D 04
	RR	0.51000D 00
Z = 0.0	MACH=	0.52000D 01
	WCOR	0.20000D 04
	RR	0.46000D 00

ORIGINAL PAGE IS OF POOR QUALITY

```
Z  =  0.0        MACH=  0.800000D 00
                 MFR    0.350000D 00  0.400000D 00  0.500000D 00  0.600000D 00  0.700000D 00  0.800000D 00  0.900000D 00  0.100000D 01
                 CDS    0.275000D-01  0.220000D-01  0.140000D-01  0.950000D-02  0.600000D-02  0.350000D-02  0.200000D-03  0.0
Z  =  0.0        MACH=  0.900000D 00
                 MFR    0.400000D 00  0.500000D 00  0.600000D 00  0.700000D 00  0.800000D 00  0.900000D 00  0.100000D 01
                 CDS    0.450000D-01  0.265000D-01  0.170000D-01  0.105000D-01  0.650000D-02  0.200000D-03  0.0
Z  =  0.0        MACH=  0.100000D 01
                 MFR    0.400000D 00  0.500000D 00  0.600000D 00  0.700000D 00  0.800000D 00  0.900000D 00  0.100000D 01
                 CDS    0.545000D-01  0.350000D-01  0.220000D-01  0.140000D-01  0.800000D-02  0.360000D-03  0.0
Z  =  0.0        MACH=  0.125000D 01
                 MFR    0.400000D 00  0.500000D 00  0.600000D 00  0.700000D 00  0.800000D 00  0.900000D 00  0.100000D 01
                 CDS    0.720000D-01  0.450000D-01  0.285000D-01  0.180000D-01  0.105000D-01  0.500000D-03  0.0
Z  =  0.0        MACH=  0.200000D 01
                 MFR    0.500000D 00  0.600000D 00  0.700000D 00  0.800000D 00  0.900000D 00  0.100000D 01
                 CDS    0.570000D-01  0.350000D-01  0.220000D-01  0.120000D-01  0.500000D-03  0.0
Z  =  0.0        MACH=  0.300000D 01
                 MFR    0.700000D 00  0.800000D 00  0.900000D 00  0.100000D 01
                 CDS    0.280000D-01  0.120000D-01  0.500000D-03  0.0
Z  =  0.0        MACH=  0.400000D 01
                 MFR    0.800000D 00  0.900000D 00  0.100000D 01
                 CDS    0.900000D-02  0.200000D-03  0.0
Z  =  0.0        MACH=  0.500000D 01
                 MFR    0.800000D 00  0.900000D 00  0.973000D 00  0.100000D 01
                 CDS    0.170000D-01  0.300000D-03  0.0           0.0
Z  =  0.0        MACH=  0.520000D 01
                 MFR    0.100000D 01
                 CDS    0.0
```

179 NOZZLE THRUST COEFFICIENT

X = 0.0 Y = 0.0

PR	0.30000D 01	0.40000D 01	0.50000D 01	0.60000D 01	0.80000D 01	0.10000D 02	0.12000D 02	0.14000D 02	
CV	0.94000D 00	0.91000D 00	0.89000D 00	0.90000D 00	0.93000D 00	0.95000D 00	0.96000D 00	0.97000D 00	
PR	0.16000D 02	0.18000D 02	0.20000D 02	0.22000D 02	0.24000D 02				
CV	0.97900D 00	0.99300D 00	0.98500D 00	0.98500D 00	0.98500D 00				

150 AFTERBODY DRAG

Z = 0.0	MACH=	0.15000D 01							
	NPR	0.40000D 01	0.60000D 01	0.80000D 01	0.10000D 02	0.12000D 02	0.14000D 02	0.16000D 02	0.18000D 02
	CDAB	0.13100D 00	0.12500D 00	0.10700D 00	0.77000D-01	0.54000D-01	0.38000D-01	0.27000D-01	0.20000D-01
	NPR	0.20000D 02	0.22000D 02	0.24000D 02					
	CDAB	0.15000D-01	0.11000D-01	0.90000D-02					
Z = 0.0	MACH=	0.18000D 01							
	NPR	0.60000D 01	0.80000D 01	0.10000D 02	0.12000D 02	0.14000D 02	0.16000D 02	0.18000D 02	0.20000D 02
	CDAB	0.79000D-01	0.70000D-01	0.55000D-01	0.37000D-01	0.23000D-01	0.13000D-01	0.50000D-02	0.0
	NPR	0.22000D 02	0.24000D 02						
	CDAB	-0.30000D-02	-0.50000D-02						
Z = 0.0	MACH=	0.20000D 01							
	NPR	0.50000D 01	0.60000D 01	0.80000D 01	0.10000D 02	0.12000D 02	0.14000D 02	0.16000D 02	0.18000D 02
	CDAB	0.61000D-01	0.59000D-01	0.52000D-01	0.40000D-01	0.25000D-01	0.10000D-01	-0.20000D-02	-0.90000D-02
	NPR	0.20000D 02	0.22000D 02	0.24000D 02					
	CDAB	-0.13000D-01	-0.17000D-01	-0.19000D-01					

ORIGINAL PAGE IS
OF POOR QUALITY

200 R VS. CORRECTED FLOW-FAN USED FOR BPR=1-2

Z = 0.0 Y = 0.10000D 01

R	0.0	0.50000D 00	0.11000D 01
WRA	0.0	0.50000D 00	0.11000D 01

205 R VS. EFFICIENCY-FAN USED FOR HPR=1-2

Z = 0.0 Y = 0.10000D 01

R	0.40000D 00	0.50000D 00	0.60000D 00	0.70000D 00	0.80000D 00	0.90000D 00	0.92500D 00	0.95200D 00
EFF	0.83100D 00	0.84200D 00	0.85100D 00	0.85600D 00	0.85800D 00	0.85800D 00	0.85000D 00	0.85450D 00
R	0.98000D 00	0.99000D 00	0.10000D 01	0.11000D 01				
EFF	0.85480D 00	0.85300D 00	0.85000D 00	0.66400D 00				

300 R VS. CORRECTED FLOW COMPRESSOR

Z = 0.0

Y =	0.10000D 01		
R	0.0	0.50000D 00	0.10110D 01
WRA	0.0	0.50000D 00	0.10110D 01

305 R VS. EFFECIENCY-COMPRESSOR

Z = 0.0

Y =	0.10000D 01								
R	0.41600D 00	0.52200D 00	0.63300D 00	0.76000D 00	0.88900D 00	0.94400D 00	0.96800D 00	0.10000D 01	
EFF	0.66600D 00	0.74000D 00	0.77400D 00	0.79400D 00	0.81300D 00	0.81300D 00	0.81300D 00	0.81000D 00	
R	0.10110D 01								
EFF	0.80400D 00								

TABLE DATA INPUT SUMMARY 9 TABLES

TABLE NUMBER	REFERENCE NUMBER	ARRAY LOCATION
1	500	1
2	75	79
3	100	241
4	120	445
5	150	499
6	200	622
7	205	646
8	300	697
9	305	721

DATA STORAGE ALLOCATION 3000
DATA STORAGE NOT USED 2237

AFT FAN ENGINE, DESIGN POINT
CONFIGURATION DATA 14 STATIONS 21 COMPONENTS

COMPONENT NUMBER	KIND	COMPONENT TYPE	UPSTREAM STATIONS		DOWNSTREAM STATIONS	
1	1	INLET	1	0	2	0
2	7	SPLITTER	2	0	3	10
3	4	COMPRESR	3	0	4	13
4	2	DUCT B	4	0	5	0
5	5	TURBINE	5	13	6	0
6	5	TURBINE	6	0	7	0
7	6	MIXER	7	12	8	0
8	9	NOZZLE	14	0	9	0
9	2	DUCT B	10	0	11	0
10	4	COMPRESR	11	0	12	0
11	11	SHAFT	3	5	0	0
12	11	SHAFT	6	10	0	0
13	2	DUCT B	8	0	14	0
14	12	CONTROL	14	0	6	0
15	12	CONTROL	11	0	2	0
16	12	CONTROL	6	0	5	0
17	12	CONTROL	5	0	3	0
18	12	CONTROL	3	0	1	0
19	12	CONTROL	11	0	3	0
20	12	CONTROL	12	0	10	0
21	12	CONTROL	7	0	10	0

CONTROL INFORMATION

20	VARY CDAT	8 OF COMPONENT	10 SO THAT	DATOUT	8 OF COMPONENT	12	EQUALS	0.0
21	VARY CDAT	1 OF COMPONENT	10 SO THAT	DATOUT	8 OF COMPONENT	7	EQUALS	0.0
14	VARY CDAT	1 OF COMPONENT	6 SO THAT	STATP	8 OF FLOW STATION	14	EQUALS	0.0
16	VARY CDAT	1 OF COMPONENT	5 SO THAT	STATP	8 OF FLOW STATION	6	EQUALS	0.0
17	VARY CDAT	1 OF COMPONENT	3 SO THAT	STATP	8 OF FLOW STATION	5	EQUALS	0.0
19	VARY CDAT	8 OF COMPONENT	3 SO THAT	DATOUT	8 OF COMPONENT	11	EQUALS	0.0
15	VARY CDAT	1 OF COMPONENT	2 SO THAT	STATP	8 OF FLOW STATION	11	EQUALS	0.0
18	VARY CDAT	1 OF COMPONENT	1 SO THAT	STATP	8 OF FLOW STATION	3	EQUALS	0.0

AFT FAN ENGINE, DESIGN POINT

DESIGN POINT MODE

CDAI(1,1-6)	0.900000D 03	0.0	0.146696D 02	0.0	0.0	0.0	0.0	0.0
CDAI(1,9-15)	0.0	0.0	0.100000D 01	0.0	0.0	0.100000D 01	0.100000D 02	
CDAI(2,1-6)	0.120000D 01	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CDAI(2,9-15)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
CDAI(3,1-6)	0.100000D 01	0.100000D 00	0.100000D 01	0.300000D 03	0.465465D 03	0.305000D 03	0.104960D 01	0.160000D 02
CDAI(3,9-15)	0.100000D 01	0.0	0.0	0.650000D 00	0.160000D 02	0.100000D 01	0.0	
CDAI(4,1-6)	0.0	0.0	0.277130-05	0.300000D 04	0.999000D 00	0.499000D 05	0.0	0.0
CDAI(4,9-15)	0.0	0.100000 04	0.0	0.0	0.0	0.0	0.0	
CDAI(5,1-6)	0.200000D 01	0.100000D 02	0.415630 00	0.100000D 01	0.615630D 02	0.000000D 00	0.100000D 01	0.207800D 01
CDAI(5,9-15)	0.350000D 00	0.0	0.660000 00	0.100000D 01	0.100000D 01	0.0	0.0	
CDAI(6,1-6)	0.200000D 01	0.0	0.754000 00	0.100000D 01	0.143890D 03	0.890000D 00	0.100000D 01	0.618940D 00
CDAI(6,9-15)	0.100000D 01	0.0	0.000000D 00	0.100000D 01	0.100000D 01	0.0	0.0	
CDAI(7,1-6)	0.290000 04	0.505120 03	0.100000D 01	0.100000D 01	0.0	0.0	0.0	0.0
CDAI(7,9-15)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
CDAI(8,1-6)	0.159000 04	0.100000D 03	0.0	0.0	0.985000 00	0.100000D 01	0.0	0.0
CDAI(8,9-15)	0.100000D 01	0.100000D 0.	0.0	0.0	0.0	0.0	0.0	
CDAI(9,1-6)	0.0	0.0	0.591450-07	0.0	0.0	0.0	0.0	0.0
CDAI(9,9-15)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
CDAI(10,1-6)	0.100000D 01	0.0	0.100000 01	0.200000D 03	0.545450D 03	0.205000D 03	0.988240D 00	0.310000D 01
CDAI(10,9-15)	0.100000D 01	0.0	0.0	0.640000D 00	0.310000D 01	0.100000D 01	0.0	
CDAI(11,1-6)	0.100000D 01	0.100000D 01	0.100000D 01	0.100000D 01	0.100000D 01	0.0	0.0	0.0
CDAI(11,9-15)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
CDAI(12,1-6)	0.100000D 01	0.100000D 01	0.100000D 01	0.100000D 01	0.100000D 01	0.0	0.0	0.0
CDAI(12,9-15)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
CDAI(13,1-6)	0.0	0.0	0.302570-07	0.0	0.0	0.0	0.0	0.0
CDAI(13,9-15)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
CDAI(14,1-6)	0.100000D 01	0.0	0.0	0.100000D 01	0.0	0.800000D 01	0.0	0.0
CDAI(14,9-15)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
CDAI(15,1-6)	0.100000D 01	0.0	0.0	0.100000D 01	0.0	0.800000D 01	0.0	0.0
CDAI(15,9-15)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
CDAI(16,1-6)	0.100000D 01	0.0	0.0	0.100000D 01	0.0	0.800000D 01	0.0	0.0
CDAI(16,9-15)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
CDAI(17,1-6)	0.100000D 01	0.0	0.0	0.100000D 01	0.0	0.800000D 01	0.0	0.0
CDAI(17,9-15)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
CDAI(18,1-6)	0.100000D 01	0.0	0.0	0.100000D 01	0.0	0.800000D 01	0.0	0.0
CDAI(18,9-15)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
CDAI(19,1-6)	0.100000D 01	0.0	0.0	0.800000D 01	0.0	0.100000D 02	0.0	0.0
CDAI(19,9-15)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
CDAI(20,1-6)	0.100000D 01	0.0	0.0	0.800000D 01	0.0	0.100000D 02	0.0	0.0
CDAI(20,9-15)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
CDAI(21,1-6)	0.100000D 01	0.0	0.0	0.100000D 01	0.0	0.100000D 02	0.0	0.0
CDAI(21,9-15)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	

AFT FAN ENGINE, DESIGN POINT

STATION PROPERTY OUTPUT DATA

FLOW STATION	WEIGHT FLOW STATP1	TOTAL PRESSURE STATP2	TOTAL TEMPERATURE STATP3	FUEL/AIR RATIO STATP4	REFERRED FLOW STATP5	MACH NUMBER STATP6	STATIC PRESSURE STATP7	INTERFACE RELATIVE FLOW ERROR STATP8
1	0.980000D 03	0.146960D 02	0.518670D 03	0.0	0.980000D 03	0.0	0.0	0.0
2	0.980000D 03	0.146960D 02	0.518670D 03	0.0	0.980000D 03	0.0	0.0	0.0
3	0.445450D 03	0.146960D 02	0.518670D 03	0.0	0.445450D 03	0.0	0.0	0.0
4	0.400910D 03	0.235140D 03	0.124120D 04	0.0	0.367020D 02	0.0	0.0	0.0
5	0.405470D 03	0.232760D 03	0.300000D 04	0.11387D-01	0.615630D 02	0.0	0.0	0.0
6	0.450020D 03	0.756080D 02	0.229500D 04	0.10248D-01	0.183990D 03	0.0	0.0	0.0
7	0.450020D 03	0.467020D 02	0.207660D 04	0.10248D-01	0.283350D 03	0.176050D 00	0.457870D 02	0.0
8	0.984570D 03	0.455260D 02	0.141330D 04	0.46583D-02	0.524830D 03	0.0	0.0	0.0
9	0.984570D 03	0.446150D 02	0.141330D 04	0.46583D-02	0.535340D 03	0.135070D 01	0.146960D 02	0.0
10	0.534550D 03	0.146960D 02	0.518670D 03	0.0	0.534550D 03	0.0	0.0	0.0
11	0.534550D 03	0.144020D 02	0.518670D 03	0.0	0.534550D 03	0.0	0.0	0.0
12	0.534550D 03	0.446460D 02	0.755930D 03	0.0	0.212420D 03	0.71061D-02	0.446450D 02	0.0
13	0.445450D 02	0.235140D 03	0.124120D 04	0.0	0.0	0.0	0.0	0.0
14	0.984570D 03	0.446150D 02	0.141330D 04	0.46583D-02	0.535340D 03	0.100000D 01	0.238290D 02	0.0

COMPONENT OUTPUT DATA

COMPONENT NO.	TYPE	DATOUT1	DATOUT2	DATOUT3	DATOUT4	DATOUT5	DATOUT6	DATOUT7	DATOUT8	DATOUT9
1	INLET	0.0	0.0	0.0	0.100000D 01	0.100000D 01	0.0	0.100000D 01	0.100000D 01	0.0
2	SPLITTER	0.120000D 01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	COMPRESR	-0.112230D 06	0.100000D 01	0.0	0.100000D 01	0.100000D 01	0.100000D 01	0.445450D 03	0.850000D 00	0.150000D 02
4	DUCT B	0.0	0.100000D-01	0.0	0.113870D-01	0.0	0.164350D 05	0.0	0.499000D 05	0.990000D 00
5	TURBINE	0.112230D 06	0.100000D 01	0.0	0.200000D 01	0.415800D 00	0.100000D 01	0.615630D 02	0.880000D 00	0.307880D 01
6	TURBINE	0.432380D 05	0.100000D 01	0.0	0.200000D 01	0.475400D 00	0.100000D 01	0.183990D 03	0.890000D 00	0.261890D 01
7	MIXER	0.293470D 04	0.505130D 05	0.102000D 01	0.100000D 01	0.392440D 03	0.935930D 01	0.184560D 03	-0.252510D-01	0.100690D 01
8	NOZZLE	0.660640D 05	0.215890D 04	0.303590D 01	0.219170D 04	0.159910D 04	0.100000D 01	0.985000D 00	0.0	0.303590D 01
9	DUCT B	0.0	0.200000D-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	COMPRESR	-0.432380D 05	0.100000D 01	0.0	0.100000D 01	0.100000D 01	0.100000D 01	0.545450D 03	0.940000D 00	0.310000D 01
11	SHAFT	0.0	0.100000D 01	0.100000D 01	0.100000D 01	0.0	0.0	0.0	0.0	0.0
12	SHAFT	0.0	0.100000D 01	0.100000D 01	0.100000D 01	0.0	0.0	0.0	0.0	0.0
13	DUCT B	0.0	0.200000D-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0

PERFORMANCE OUTPUTS

(1) NET THRUST (LBS)	66063.97	(2) NET BRAKE SHP	0.0	(3) AIRFLOW (LB/SEC)	980.00
(4) TSFC LB/HR/LB)	0.2488	(5) BSFC (LB/HR/HP)	0.0	(6) FUEL FLOW(LB/HR)	16434.59
(7) NT THRUST/AIRFLW	67.41	(8) NET BSHP/AIRFLOW	0.0	(9) INLET DRAG (LBS)	0.0

0 ITERATIONS 2 PASSES

AFT FAN ENGINE, DESIGN POINT

NAMELIST INPUT CARDS FOR NEXT SOLUTION

ALTITUDE	MACH	FN	BSHP	WF	TSFC	REF FLOW	BPR	BOT	T19	PR19	A19	T9	PR9	A9	DR	NIT

AFT FAN DESIGN POINT, CONTROLS ON

STATION PROPERTY OUTPUT DATA

FLOW STATION	WEIGHT FLOW STATP1	TOTAL PRESSURE STATP2	TOTAL TEMPERATURE STATP3	FUEL/AIR RATIO STATP4	REFERRED FLOW STATP5	MACH NUMBER STATP6	STATIC PRESSURE STATP7	INTERFACE RELATIVE FLOW ERROR STATP8
1	0.980320 03	0.146960 02	0.518670 03	0.0	0.980320 03	0.0	0.0	0.0
2	0.980320 03	0.146960 02	0.518670 03	0.0	0.980320 03	0.0	0.0	0.0
3	0.444430 03	0.146960 02	0.518670 03	0.0	0.444430 03	0.0	0.0	-0.391680-05
4	0.399990 03	0.234370 03	0.123970 04	0.0	0.387760 02	0.0	0.0	0.0
5	0.404530 03	0.232020 03	0.299430 04	0.113520-01	0.615630 02	0.0	0.0	-0.125540-05
6	0.446970 03	0.753560 02	0.229040 04	0.102170-01	0.163590 03	0.0	0.0	-0.331520-06
7	0.446970 03	0.460640 02	0.206610 04	0.102170-01	0.286020 03	0.177730 00	0.451450 02	0.0
8	0.984860 03	0.454560 02	0.140870 04	0.463200-02	0.527710 03	0.0	0.0	0.0
9	0.984850 03	0.445490 02	0.140870 04	0.463200-02	0.535420 03	0.134960 01	0.146960 02	0.0
10	0.535690 03	0.146960 02	0.518670 03	0.0	0.535690 03	0.0	0.0	0.0
11	0.535690 03	0.144010 02	0.518670 03	0.0	0.541680 03	0.0	0.0	0.359080-05
12	0.535690 03	0.451460 02	0.759010 03	0.0	0.211020 03	0.705960-02	0.451440 02	0.0
13	0.444430 02	0.234370 03	0.123970 04	0.0	0.0	0.0	0.0	0.0
14	0.984850 03	0.445490 02	0.140870 04	0.463200-02	0.535420 03	0.100000 01	0.237910 02	0.541810-05

COMPONENT OUTPUT DATA

COMPONENT NO.	TYPE	DATOUT1	DATOUT2	DATOUT3	DATOUT4	DATOUT5	DATOUT6	DATOUT7	DATOUT8	DATOUT9
1	INLET	0.0	0.0	0.0	0.100000 01	0.100000 01	0.0	0.100000 01	0.100000 01	0.0
2	SPLITTER	0.120580 01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	COMPRESSR	-0.111730 06	0.100000 01	0.0	0.997700 00	0.100000 01	0.100000 01	0.445450 03	0.850400 00	0.159480 02
4	DUCT 6	0.0	0.100070-01	0.0	0.113520-01	0.0	0.163470 05	0.0	0.499000 05	0.990000 00
5	TURBINE	0.111740 06	0.100000 01	0.0	0.200000 01	0.415800 00	0.100100 01	0.615630 02	0.880000 00	0.307890 01
6	TURBINE	0.439080 05	0.100000 01	0.0	0.202740 01	0.475400 00	0.100100 01	0.183990 03	0.690000 00	0.163590 01
7	MIXER	0.293470 04	0.505130 05	0.102040 01	0.100000 01	0.395360 03	0.951580 01	0.165410 03	-0.177260-04	0.100690 01
8	NOZZLE	0.659280 05	0.215380 04	0.303130 01	0.218660 04	0.159910 04	0.100000 01	0.985000 00	0.0	0.303130 01
9	DUCT 6	0.0	0.201010-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	COMPRESSR	-0.439100 05	0.100000 01	0.0	0.100260 01	0.100000 01	0.100000 01	0.545450 03	0.838820 00	0.313500 01
11	SHAFT	0.863430 01	0.100000 01	0.100000 01	0.100000 01	0.0	0.0	0.0	0.772770-04	0.0
12	SHAFT	-0.151800 01	0.100000 01	0.100000 01	0.100000 01	0.0	0.0	0.0	-0.345720-04	0.0
13	DUCT 6	0.0	0.200060-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0

PERFORMANCE OUTPUTS

(1) NET THRUST (LBS)	65926.29	(2) NET BRAKE SHP	0.0	(3) AIRFLOW (LB/SEC)	980.32
(4) TSFC LB/HR/LB)	0.2479	(5) BSFC (LB/HR/HP)	0.0	(6) FUEL FLOW(LB/HR)	16346.80
(7) NT THRUST/AIRFLOW	67.25	(8) NET BSHP/AIRFLOW	0.0	(9) INLET DRAG (LBS)	0.0

3 ITERATIONS 4 PASSES

0.	0.0	65926.	0.	16347.	0.248	980.3	1.206	2994.	0.	0.0	0.	1409.	3.031	1599.	1.000	3

NAMELIST INPUT CARDS FOR NEXT SOLUTION

ALTITUDE	MACH	FN	BSHP	WF	TSFC	REF FLOW	BPR	BOT	T19	PR19	A19	T9	PR9	A9	RR	NIT
0.	0.0	107135.	0.	64579.	0.601	981.2	1.205	2998.	0.	0.0	0.	3260.	3.037	2618.	1.000	4
0.	0.050	105642.	0.	6440[illegible].	0.610	981.1	1.205	2999.	0.	0.0	0.	3260.	3.041	2617.	1.000	4
0.	0.100	104602.	0.	64723.	0.619	981.0	1.205	3003.	0.	0.0	0.	3260.	3.057	2615.	1.000	4
0.	0.150	103990.	0.	65160.	0.627	980.9	1.205	3009.	0.	0.0	0.	3260.	3.083	2612.	1.000	4
0.	0.200	103795.	0.	65774.	0.634	980.6	1.205	3017.	0.	0.0	0.	3260.	3.119	2607.	1.000	4
0.	0.250	103936.	0.	66529.	0.640	979.9	1.205	3026.	0.	0.0	0.	3260.	3.164	2602.	1.000	3
0.	0.300	104564.	0.	67517.	0.646	979.5	1.205	3038.	0.	0.0	0.	3260.	3.223	2595.	1.000	3
0.	0.350	105541.	0.	68600.	0.651	978.8	1.205	3050.	0.	0.0	0.	3260.	3.289	2588.	1.000	4

C2.1C

0.	0.400	107514.	0.	70202.	0.653	980.9	1.203	3076.	0.	0.0	0.	3260.	3.387	2573.	1.000	2
0.	0.450	109424.	0.	71778.	0.656	980.5	1.206	3099.	0.	0.0	0.	3260.	3.484	2562.	1.000	3
0.	0.500	111886.	0.	73621.	0.658	980.7	1.204	3122.	0.	0.0	0.	3260.	3.597	2549.	1.000	3
0.	0.550	114803.	0.	75621.	0.659	980.2	1.199	3150.	0.	0.0	0.	3260.	3.734	2526.	1.000	1

NAMELIST INPUT CARDS FOR NEXT SOLUTION

ALTITUDE	MACH	FN	BSHP	WF	TSFC	REF FLOW	BPR	BOT	T19	PR19	A19	T9	PR9	A9	RR	NIT
2000.	0.200	97756.	0.	62934.	0.634	983.8	1.204	2992.	0.	0.0	0.	3260.	3.134	2622.	1.000	3
2000.	0.300	98247.	0.	63464.	0.646	981.3	1.205	3008.	0.	0.0	0.	3260.	3.229	2612.	1.000	3
2000.	0.400	100549.	0.	65818.	0.655	979.6	1.205	3038.	0.	0.0	0.	3260.	3.378	2595.	1.000	3
2000.	0.500	104979.	0.	69149.	0.659	981.3	1.202	3087.	0.	0.0	0.	3260.	3.598	2567.	1.000	2
2000.	0.600	110779.	0.	73136.	0.660	980.2	1.199	3143.	0.	0.0	0.	3260.	3.877	2530.	1.000	3
2000.	0.700	115021.	0.	76746.	0.667	962.7	1.207	3150.	0.	0.0	0.	3260.	4.094	2524.	1.000	3
2000.	0.800	118706.	0.	80214.	0.676	934.0	1.219	3150.	0.	0.0	0.	3260.	4.303	2521.	1.000	2
2000.	0.900	123203.	0.	84173.	0.683	903.0	1.233	3150.	0.	0.0	0.	3260.	4.545	2518.	1.000	2
2000.	1.000	128757.	0.	88626.	0.690	869.5	1.250	3150.	0.	0.0	0.	3260.	4.820	2515.	1.000	2
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED																
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED																
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED																
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED																
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED																
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED																
2000.	1.100	132206.	0.	92470.	0.699	827.2	1.279	3150.	0.	0.0	0.	3260.	5.062	2515.	0.997	3
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED																
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED																
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED																
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED																
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED																
2000.	1.200	136141.	0.	96519.	0.709	784.6	1.314	3150.	0.	0.0	0.	3260.	5.321	2515.	0.991	3
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED																
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED																
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED																
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED																
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED																
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED																
2000.	1.300	142006.	0.	101667.	0.716	748.6	1.346	3150.	0.	0.0	0.	3260.	5.655	2512.	0.985	3

NAMELIST INPUT CARDS FOR NEXT SOLUTION

ALTITUDE	MACH	FN	BSHP	WF	TSFC	REF FLOW	BPR	BOT	T19	PR19	A19	T9	PR9	A9	RR	NIT
4000.	0.200	92604.	0.	58463.	0.631	990.5	1.202	2990.	0.	0.0	0.	3260.	3.174	2626.	1.000	4
4000.	0.300	92453.	0.	59716.	0.646	984.4	1.204	2982.	0.	0.0	0.	3260.	3.244	2621.	1.000	2
4000.	0.400	94414.	0.	61832.	0.655	981.3	1.205	3007.	0.	0.0	0.	3260.	3.386	2613.	1.000	3
4000.	0.500	98302.	0.	64851.	0.660	981.3	1.203	3050.	0.	0.0	0.	3260.	3.595	2588.	1.000	4
4000.	0.600	103675.	0.	68617.	0.662	990.5	1.206	3104.	0.	0.0	0.	3260.	3.861	2559.	1.000	3
4000.	0.700	109908.	0.	72859.	0.663	974.5	1.201	3150.	0.	0.0	0.	3260.	4.172	2525.	1.000	2
4000.	0.800	114028.	0.	76437.	0.670	949.0	1.213	3150.	0.	0.0	0.	3260.	4.401	2523.	1.000	3
4000.	0.900	116327.	0.	80196.	0.678	917.3	1.227	3150.	0.	0.0	0.	3260.	4.647	2519.	1.000	2
4000.	1.000	123587.	0.	84139.	0.684	884.7	1.242	3150.	0.	0.0	0.	3260.	4.935	2516.	1.000	2
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED																
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED																
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED																
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED																
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED																
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED																
4000.	1.100	127992.	0.	88589.	0.692	845.2	1.266	3150.	0.	0.0	0.	3260.	5.207	2514.	0.997	3
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED																
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED																
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED																

```
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
 4000.  1.200 131351.  0.  92219.  0.702  799.4  1.302 3150.    0.  0.0      0. 3260. 5.459 2514.  0.991   2
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
 4000.  1.300 136716.  0.  97002.  0.710  761.6  1.334 3150.    0.  0.0      0. 3260. 5.789 2513.  0.985   3

NAMELIST INPUT CARDS FOR NEXT SOLUTION

ALTITUDE  MACH    FN     HSHP    XP    TSEC  REF FLOW BPR   BOT  T19    PR19  A19    T9    PR9   A9     RR    NIT
 6000.  0.200  97529.  0.  55085.  0.629  996.9  1.200 2990.    0.  0.0      0. 3260. 3.212 2628.  1.000   2
 6000.  0.300  87828.  0.  56413.  0.642  992.8  1.201 2993.    0.  0.0      0. 3260. 3.299 2625.  1.000   1
 6000.  0.400  88842.  0.  58111.  0.654  984.9  1.204 2983.    0.  0.0      0. 3260. 3.404 2627.  1.000   2
 6000.  0.500  91919.  0.  60740.  0.661  980.9  1.205 3014.    0.  0.0      0. 3260. 3.591 2609.  1.000   3
 6000.  0.600  97226.  0.  64376.  0.662  981.7  1.203 3071.    0.  0.0      0. 3260. 3.867 2577.  1.000   4
 6000.  0.700 103742.  0.  68682.  0.662  980.4  1.204 3128.    0.  0.0      0. 3260. 4.195 2545.  1.000   1
 6000.  0.800 109357.  0.  72741.  0.665  963.9  1.207 3150.    0.  0.0      0. 3260. 4.501 2524.  1.000   2
 6000.  0.900 113637.  0.  76394.  0.672  932.6  1.220 3150.    0.  0.0      0. 3260. 4.756 2521.  1.000   2
 6000.  1.000 118607.  0.  80486.  0.679  899.1  1.235 3150.    0.  0.0      0. 3260. 5.047 2518.  1.000   2
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
 6000.  1.100 123557.  0.  84685.  0.685  862.6  1.254 3150.    0.  0.0      0. 3260. 5.350 2514.  0.997   2
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
 6000.  1.200 127114.  0.  88313.  0.695  817.3  1.286 3150.    0.  0.0      0. 3260. 5.618 2515.  0.991   2
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
 6000.  1.300 131514.  0.  92462.  0.703  774.9  1.322 3150.    0.  0.0      0. 3260. 5.929 2514.  0.985   3

NAMELIST INPUT CARDS FOR NEXT SOLUTION
```

ORIGINAL PAGE IS
OF POOR QUALITY

AUGMENTED AFT FAN

ALTITUDE	MACH	FN	HSHP	WF	TSFC	REF FLOW	BPR	BOT	T19	PR19	A19	T9	PR9	A9	RR	NIT
8000.	0.200	62315.	0.	51742.	0.629	1000.6	1.199	2976.	0.	0.0	0.	3260.	3.236	2638.	1.000	2
8000.	0.300	82888.	0.	53071.	0.640	996.1	1.199	2988.	0.	0.0	0.	3260.	3.336	2629.	1.000	1
8000.	0.400	84300.	0.	54658.	0.651	993.2	1.201	2993.	0.	0.0	0.	3260.	3.461	2625.	1.000	2
8000.	0.500	88148.	0.	56946.	0.661	982.5	1.205	2960.	0.	0.0	0.	3260.	3.598	2628.	1.000	3
8000.	0.600	90653.	0.	60164.	0.664	980.1	1.205	3028.	0.	0.0	0.	3260.	3.854	2601.	1.000	4
8000.	0.700	97007.	0.	64288.	0.663	980.3	1.207	3092.	0.	0.0	0.	3260.	4.192	2566.	1.000	3
8000.	0.800	104326.	0.	68945.	0.661	976.0	1.200	3150.	0.	0.0	0.	3260.	4.585	2525.	1.000	2
8000.	0.900	108996.	0.	72692.	0.667	947.9	1.213	3150.	0.	0.0	0.	3260.	4.868	2522.	1.000	3
8000.	1.000	113752.	0.	76578.	0.673	913.7	1.226	3150.	0.	0.0	0.	3260.	5.164	2519.	1.000	2
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED																
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED																
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED																
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED																
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED																
8000.	[illegible]	118824.	0.	80726.	0.679	878.7	1.245	3150.	0.	0.0	0.	3260.	5.486	2515.	0.997	2
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED																
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED																
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED																
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED																
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED																
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED																
8000.	1.200	122654.	0.	84483.	0.688	835.4	1.273	3150.	0.	0.0	0.	3260.	5.782	2514.	0.991	3
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED																
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED																
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED																
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED																
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED																
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED																
8000.	1.300	126558.	0.	88176.	0.697	789.4	1.310	3150.	0.	0.0	0.	3260.	6.080	2515.	0.985	3

NAMELIST INPUT CARDS FOR NEXT SOLUTION

ALTITUDE	MACH	FN	HSHP	WF	TSFC	REF FLOW	BPR	BOT	T19	PR19	A19	T9	PR9	A9	RR	NIT
10000.	0.400	79313.	0.	51507.	0.649	997.9	1.200	2981.	0.	0.0	0.	3260.	3.490	2634.	1.000	2
10000.	0.500	81805.	0.	53744.	0.657	991.9	1.201	2992.	0.	0.0	0.	3260.	3.663	2625.	1.000	2
10000.	0.600	84962.	0.	56379.	0.664	982.1	1.205	2997.	0.	0.0	0.	3260.	3.864	2619.	1.000	4
10000.	0.700	90614.	0.	60121.	0.663	980.3	1.204	3050.	0.	0.0	0.	3260.	4.187	2588.	1.000	4
10000.	0.800	96129.	0.	64799.	0.660	980.6	1.204	3123.	0.	0.0	0.	3260.	4.605	2548.	1.000	2
10000.	0.900	103365.	0.	69072.	0.662	963.1	1.207	3150.	0.	0.0	0.	3260.	4.981	2524.	1.000	3
10000.	1.000	109066.	0.	72835.	0.668	929.3	1.221	3150.	0.	0.0	0.	3260.	5.288	2521.	1.000	2
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED																
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED																
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED																
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED																
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED																
10000.	1.100	113909.	0.	76764.	0.674	893.6	1.237	3150.	0.	0.0	0.	3260.	5.616	2517.	0.997	2
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED																
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED																
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED																
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED																
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED																
10000.	1.200	118653.	0.	80756.	0.681	854.1	1.259	3150.	0.	0.0	0.	3260.	5.955	2514.	0.991	2
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED																
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED																
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED																
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED																
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED																
10000.	1.300	121995.	0.	84161.	0.690	805.8	1.296	3150.	0.	0.0	0.	3260.	6.250	2515.	0.985	2
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED																

ORIGINAL PAGE IS OF POOR QUALITY

```
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
10000.  1.400 127000.  0.  88523.  0.697  765.0  1.331 3150.    0.  0.0      0. 3260. 6.629 2514.  0.978   3
10000.  1.500 152199.  0.  95481.  0.627  728.2  1.366 3150.    0.  0.0      0. 3260. 7.222 2510.  0.996   3
```

NAMELIST INPUT CARDS FOR NEXT SOLUTION

```
ALTITUDE  MACH    FN    BSHP     WF   ISPC  REF FLOW BPR   BOT  T19    PR19  A19    T9    PR9    AV     HR   NIT
 20000.  0.600  62013.  0.  40603.  0.655 1006.3  1.197 2936.    0.  0.0      0. 3260. 4.048 2664.  1.000   3
 20000.  0.800  70441.  0.  46247.  0.657  994.5  1.201 2995.    0.  0.0      0. 3260. 4.714 2625.  1.000   2
 20000.  0.900  75326.  0.  49553.  0.658  981.0  1.205 3003.    0.  0.0      0. 3260. 5.093 2615.  1.000   4
 20000.  1.000  83158.  0.  54174.  0.652  961.4  1.202 3086.    0.  0.0      0. 3260. 5.701 2568.  1.000   2
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
 20000.  1.100  90765.  0.  58633.  0.648  972.5  1.203 3150.    0.  0.0      0. 3260. 6.335 2525.  0.997   2
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
 20000.  1.200  95294.  0.  62245.  0.653  935.6  1.219 3150.    0.  0.0      0. 3260. 6.754 2521.  0.991   3
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
 20000.  1.300  99994.  0.  65814.  0.658  896.1  1.236 3150.    0.  0.0      0. 3260. 7.203 2517.  0.985   2
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
 20000.  1.400 104607.  0.  69446.  0.664  853.0  1.260 3150.    0.  0.0      0. 3260. 7.665 2514.  0.978   2
 20000.  1.500 122106.  0.  74001.  0.606  801.4  1.300 3150.    0.  0.0      0. 3260. 8.230 2515.  0.996   2
 20000.  1.600 126990.  0.  78270.  0.616  759.5  1.336 3150.    0.  0.0      0. 3260. 8.783 2513.  0.989   3
 20000.  1.700 133217.  0.  83026.  0.623  721.5  1.373 3150.    0.  0.0      0. 3260. 9.417 2510.  0.982   3
 20000.  1.800 140713.  0.  88396.  0.628  687.4  1.412 3150.    0.  0.0      0. 3260.10.142 2506.  0.975   3
```

NAMELIST INPUT CARDS FOR NEXT SOLUTION

```
ALTITUDE  MACH    FN    BSHP     WF   ISPC  REF FLOW BPR   BOT  T19    PR19  A19    T9    PR9    AV     HR   NIT
 30000.  0.600  43156.  0.  28085.  0.651 1020.6  1.193 2816.    0.  0.0      0. 3260. 4.162 2741.  1.000   2
 30000.  0.800  49409.  0.  32121.  0.650 1011.8  1.195 2893.    0.  0.0      0. 3260. 4.882 2691.  1.000   2
 30000.  0.900  53652.  0.  34738.  0.647 1007.2  1.197 2937.    0.  0.0      0. 3260. 5.360 2662.  1.000   1
 30000.  1.000  56532.  0.  37743.  0.645 1000.6  1.199 2978.    0.  0.0      0. 3260. 5.907 2637.  1.000   2
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
```

ORIGINAL PAGE IS
OF POOR QUALITY

```
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
30000.  1.100  63401.  0.  40851.  0.644  987.3  1.203 2986.   0.  0.0     0. 3260. 6.453 2626.  0.997   2
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
30000.  1.200  69683.  0.  44624.  0.640  980.3  1.204 3050.   0.  0.0     0. 3260. 7.196 2588.  0.991   2
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
30000.  1.400  67183.  0.  52377.  0.637  941.1  1.216 3150.   0.  0.0     0. 3260. 8.785 2522.  0.979   4
30000.  1.600 101412.  0.  60106.  0.593  853.4  1.260 3150.   0.  0.0     0. 3260.10.268 2514.  0.989   3
30000.  1.700 104597.  0.  62941.  0.602  799.6  1.302 3150.   0.  0.0     0. 3260.10.834 2515.  0.982   6
30000.  1.800 109730.  0.  66655.  0.607  757.0  1.339 3150.   0.  0.0     0. 3260.11.581 2514.  0.975  10
30000.  2.000 122274.  0.  75351.  0.616  683.7  1.417 3150.   0.  0.0     0. 3260.13.398 2505.  0.959   6
30000.  2.200 136495.  0.  85199.  0.624  618.5  1.523 3150.   0.  0.0     0. 3260.15.531 2498.  0.942   6

NAMELIST INPUT CARDS FOR NEXT SOLUTION

ALTITUDE  MACH   PA    QSHP    WT   ISEC  REF FLOW DPR   DOT  TIN    PRIN  AIN    TY    PRY    AY     RN   NIT
 40000.  0.800  32491.  0.  21002.  0.646 1020.5  1.193 2810.   0.  0.0     0. 3260. 4.984 2544.  1.000   3
 40000.  0.900  35261.  0.  22705.  0.644 1015.1  1.194 2852.   0.  0.0     0. 3260. 5.466 2716.  1.000   2
 40000.  1.000  38660.  0.  24739.  0.640 1010.9  1.195 2906.   0.  0.0     0. 3260. 6.058 2683.  1.000   2
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
40000.  1.100  42370.  0.  26973.  0.637 1004.8  1.197 2954.   0.  0.0     0. 3260. 6.713 2653.  0.997   2
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
40000.  1.200  46440.  0.  29435.  0.634  996.1  1.200 2993.   0.  0.0     0. 3260. 7.440 2627.  0.991   2
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
```

```
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
40000.  1.400  56619.  0.  35453.  0.626  980.7  1.205 3114.   0.  0.0   0. 3260. 9.337 2553.  0.978  3
40000.  1.800  77939.  0.  46285.  0.594  813.0  1.230 3150.   0.  0.0   0. 3260.12.755 2515.  0.975  7
40000.  2.200  96268.  0.  58791.  0.611  658.1  1.452 3150.   0.  0.0   0. 3260.16.940 2501.  0.942  8
40000.  2.400 107128.  0.  66255.  0.618  595.1  1.579 3150.   0.  0.0   0. 3260.19.573 2497.  0.925  5
40000.  2.500 111661.  0.  69639.  0.624  561.5  1.683 3150.   0.  0.0   0. 3260.20.812 2500.  0.916  4
40000.  2.600 114515.  0.  72301.  0.631  524.1  1.861 3150.   0.  0.0   0. 3260.21.721 2519.  0.907  8
40000.  2.800 127561.  0.  81529.  0.639  460.6  2.154 3150.   0.  0.0   0. 3260.25.206 2520.  0.869  7
```

NAMELIST INPUT CARDS FOR NEXT SOLUTION

```
ALTITUDE  MACH   PR    BSHP    WF   TSEC  REF FLOW RFR   BOT  T19   PR19  A19   T9    PR9   A9    RR   NIT
 50000.  0.800  20092.  0.  12988.  0.646 1020.9  1.193 2810.   0.  0.0   0. 3260. 4.985 2744.  1.000  2
 50000.  0.900  21805.  0.  14040.  0.644 1015.1  1.194 2852.   0.  0.0   0. 3260. 5.466 2716.  1.000  2
 DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
 DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
 DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
 DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
 DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
 DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
 DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
 DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
 DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
 DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
 50000.  1.100  26202.  0.  16680.  0.637 1004.8  1.198 2953.   0.  0.0   0. 3260. 6.713 2653.  0.997  2
 DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
 DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
 DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
 DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
 DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
 DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
 DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
 DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
 DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
 DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
 DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
 DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
 DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
 DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
```

```
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
 50000.  1.400  35014.  0.  21925.  0.676  980.7  1.205 3114.   0.  0.0     0. 3260. 9.337 2553.  0.978   3
 50000.  1.600  44127.  0.  25651.  0.581  911.3  1.230 3150.   0.  0.0     0. 3260.11.231 2519.  0.989   4
 50000.  1.800  48193.  0.  28622.  0.594  813.0  1.290 3150.   0.  0.0     0. 3260.12.754 2515.  0.975   4
 50000.  2.200  59531.  0.  36356.  0.611  658.1  1.452 3150.   0.  0.0     0. 3260.16.940 2501.  0.942   5
 50000.  2.400  66247.  0.  40971.  0.618  595.1  1.579 3150.   0.  0.0     0. 3260.19.573 2497.  0.925   5
 50000.  2.600  70820.  0.  44712.  0.631  524.1  1.861 3150.   0.  0.0     0. 3260.21.722 2519.  0.907   6
 50000.  2.800  78882.  0.  50317.  0.639  480.6  2.154 3150.   0.  0.0     0. 3260.25.206 2520.  0.889   7
 50000.  3.000  92355.  0.  59136.  0.640  460.2  2.406 3150.   0.  0.0     0. 3260.30.792 2499.  0.870  10
MATRIX NO GO
MATRIX NO GO
MATRIX NO GO
MATRIX NO GO
MATRIX NO GO
MATRIX NO GO
MATRIX NO GO
MATRIX NO GO
MATRIX NO GO
MATRIX NO GO
MATRIX NO GO
MATRIX NO GO
MATRIX NO GO
MATRIX NO GO
MATRIX NO GO
MATRIX NO GO
 50000.  3.200 134494.  0.  77436.  0.576  471.2  2.316 3150.   0.  0.0     0. 3260.31.423 3473.  0.850  50

NAMELIST INPUT CARDS FOR NEXT SOLUTION
```

AUGMENTED AFT FAN

ALTITUDE	MACH	FN	BSHF	WF	TSFC	REF FLOW	BPR	BOT	T19	PR19	A19	T9	PR9	A9	RR	NIT
60000.	0.800	12425.	0.	8032.	0.646	1020.5	1.193	2810.	0.	0.0	0.	3260.	4.985	2744.	1.000	3
60000.	0.900	13484.	0.	8683.	0.644	1015.1	1.194	2652.	0.	0.0	0.	3260.	5.466	2716.	1.000	2

DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED

60000.	1.100	16203.	0.	10315.	0.637	1004.8	1.198	2953.	0.	0.0	0.	3260.	6.713	2653.	0.997	2

DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED

60000.	1.400	21652.	0.	13558.	0.626	980.7	1.205	3114.	0.	0.0	0.	3260.	9.337	2553.	0.978	3
60000.	1.600	27284.	0.	15852.	0.581	911.3	1.230	3150.	0.	0.0	0.	3260.	11.231	2519.	0.989	4
60000.	1.800	29802.	0.	17700.	0.594	813.0	1.290	3150.	0.	0.0	0.	3260.	12.754	2515.	0.975	4
60000.	2.200	36814.	0.	22462.	0.611	658.1	1.452	3150.	0.	0.0	0.	3260.	16.940	2501.	0.942	8
60000.	2.400	40967.	0.	25336.	0.618	595.1	1.579	3150.	0.	0.0	0.	3260.	19.573	2497.	0.925	5
60000.	2.600	43792.	0.	27649.	0.631	524.1	1.861	3150.	0.	0.0	0.	3260.	21.721	2520.	0.907	6
60000.	2.800	48780.	0.	31177.	0.639	480.6	2.154	3150.	0.	0.0	0.	3260.	25.206	2520.	0.889	7
60000.	3.000	57112.	0.	36569.	0.640	460.2	2.406	3150.	0.	0.0	0.	3260.	30.792	2499.	0.870	10

MATRIX NO GO
MATRIX NO GO
MATRIX NO GO
MATRIX NO GO
MATRIX NO GO
MATRIX NO GO
MATRIX NO GO
MATRIX NO GO
MATRIX NO GO
MATRIX NO GO
MATRIX NO GO
MATRIX NO GO

```
MATRIX NO GO
MATRIX NO GO
MATRIX NO GO
MATRIX NO GO
MATRIX NO GO
  60000.  3.200  88145.  0.  49831.  0.565  489.5  2.435 3150.    0.  0.0      0. 3260.33.252 3425.  0.850  50

NAMELIST INPUT CARDS FOR NEXT SOLUTION

 ALTITUDE  MACH   FN    BSHP    WF   ISEC  REF FLOW BPR   BOT  T19    PR19  A19    T9    PR9   A9     RR   NIT
  70000.  0.900  7640.  0.   4942.  0.647 1020.2  1.193 2820.    0.  0.0      0. 3260. 4.973 2738.  1.000   2
  70000.  1.000  9086.  0.   5819.  0.640 1010.1  1.196 2915.    0.  0.0      0. 3260. 6.040 2677.  1.000   2
  DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
  DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
  DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
  DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
  DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
  DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
  DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
  DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
  DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
  DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
  DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
  70000.  1.200  10675.  0.   6908.  0.635  993.0  1.201 2989.    0.  0.0      0. 3260. 7.384 2627.  0.991   2
  70000.  1.600  16659.  0.   9710.  0.583  905.4  1.232 3150.    0.  0.0      0. 3260.11.126 2518.  0.989  10
  70000.  2.000  20934.  0.  12124.  0.605  721.0  1.374 3150.    0.  0.0      0. 3260.14.428 2510.  0.959  10
  70000.  2.200  22465.  0.  13753.  0.612  653.6  1.459 3150.    0.  0.0      0. 3260.16.773 2501.  0.942   6
  70000.  2.400  24994.  0.  15497.  0.620  591.0  1.590 3150.    0.  0.0      0. 3260.19.380 2497.  0.925   5
  70000.  2.800  29861.  0.  19122.  0.640  478.7  2.171 3150.    0.  0.0      0. 3260.25.053 2518.  0.889  12
  70000.  3.000  35036.  0.  22468.  0.641  459.3  2.423 3150.    0.  0.0      0. 3260.30.672 2498.  0.870   6
  70000.  3.200  41676.  0.  26665.  0.640  449.7  2.644 3150.    0.  0.0      0. 3260.36.292 2465.  0.850  10
  70000.  3.400  49655.  0.  31715.  0.639  445.3  2.834 3150.    0.  0.0      0. 3260.48.240 2422.  0.831  11
  70000.  3.500  54127.  0.  34549.  0.638  444.6  2.926 3150.    0.  0.0      0. 3260.54.254 2398.  0.821   4

NAMELIST INPUT CARDS FOR NEXT SOLUTION

 ALTITUDE  MACH   FN    BSHP    WF   ISEC  REF FLOW BPR   BOT  T19    PR19  A19    T9    PR9   A9     RR   NIT
  85000.  0.800  3672.  0.   2382.  0.649 1016.1  1.193 2850.    0.  0.0      0. 3260. 4.921 2718.  1.000   4
  85000.  1.000  4359.  0.   2602.  0.643 1005.3  1.198 2937.    0.  0.0      0. 3260. 5.961 2663.  1.000   2
  DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
  DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
  DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
  DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
  DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
  DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
  DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
  DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
  DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
  DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
  DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
  DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
  DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
  DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
  DETACHED SHOCK, DEFLECTION = 0 IS ASSUMED
  85000   1.200  5184.  0.   3313.  0.639  984.3  1.304 2996.    0.  0.0      0. 3260. 7.238 2620.  0.991   4
  85000.  1.600  7641.  0.   4602.  0.567  884.3  1.242 3150.    0.  0.0      0. 3260.10.766 2516.  0.989   7
  85000.  2.000  9416.  0.   5743.  0.610  704.2  1.392 3150.    0.  0.0      0. 3260.13.966 2508.  0.959  12
  85000.  2.200  10548.  0.  6510.  0.617  638.2  1.485 3150.    0.  0.0      0. 3260.16.230 2500.  0.942   5
```

85000.	2.400	11689.	0.	7314.	0.626	575.9	1.634	3150.	0.	0.0	0.	3260.18.690	2498.	0.925	5
85000.	2.800	14187.	0.	9143.	0.644	472.8	2.234	3150.	0.	0.0	0.	3260.24.543	2515.	0.889	13
85000.	3.000	16754.	0.	10799.	0.645	456.3	2.479	3150.	0.	0.0	0.	3260.30.300	2491.	0.870	7
85000.	3.200	19999.	0.	12859.	0.643	446.4	2.691	3150.	0.	0.0	0.	3260.36.020	2454.	0.850	6
85000.	3.400	23845.	0.	15286.	0.641	444.7	2.879	3150.	0.	0.0	0.	3260.40.019	2410.	0.831	13
85000.	3.500	25949.	0.	16650.	0.641	444.1	2.968	3150.	0.	0.0	0.	3260.54.057	2386.	0.821	4

NAMELIST INPUT CARDS FOR NEXT SOLUTION

ORIGINAL PAGE IS
OF POOR QUALITY

PRECEDING PAGE BLANK NOT FILMED

C3. RAMJET ENGINE

SAMPLE INPUT AND OUTPUT

FOR THE

ENGINE PERFORMANCE CALCULATION

WITH INSTALLATION EFFECTS AND H_2 FUEL

```
&D NCOMP=5,NDSTAT=5,IDESN=1,IPRINT=1,TITLE=1.,TABLES=2.,
JFIG(1,1)=1,1,0,2,0,
JFIG(1,2)=2,2,0,3,0
JFIG(1,3)=2,3,0,4,0,
JFIG(1,4)=9,4,0,5,0
JFIG(1,5)=12,4,0,1,0
CDAT(1,1)=1000.,0.,0.,100.,3.5,75.,2000.,1.,50000.,0.,1.,-8500.,1.,1.,10.,
CDAT(1,2)=.05
CDAT(1,3)=.2,0.,0.,4750.,.99,49900.,0.,0.,0.,1000.,0.0,
CDAT(1,4)=1.,1.,0.,0.,120.,1.,0.0,0.,1.,1.,0.,
CDAT(1,5)=0.,0.,0.,1.,0.,08.,
WMAX=1000.,JCB=3,
JN1=4,JN2=0,JCAB1=0,JCAB2=0,
FIGSET=1, &END
```

```
                RAMJET ENGINE DESIGN POINT
   75           RAM RECOVERY
Z      1        0.
MACH  17        0.          .25         .5          .75         1.0         1.25        1.5
                1.75        1.95        2.0         2.5         3.0         3.5         4.0
                4.5         5.0         5.2
WCOR   1        2000.
RR     1        1.0
RR     1        1.0
RR     1        1.0
RR     1        1.0
RR     1        1.0
RR     1        .98
RR     1        .94
RR     1        .88
RR     1        .82
RR     1        .925
RR     1        .87
RR     1        .81
RR     1        .74
RR     1        .67
RR     1        .59
RR     1        .51
RR     1        .48
EOT
  100           SPILLAGE DRAG
Z      1        0.
MACH   9        .8          .9          1.          1.25        2.          3.          4.
                5.          5.2
MFR    8        .35         .4          .5          .6          .7          .8          .9
                1.
CDS    8        .0275       .022        .014        .0095       .006        .0035       .0002
                0.
MFR    7        .4          .5          .6          .7          .8          .9          1.
CDS    7        .045        .0265       .017        .0105       .006        .0002       0.
MFR    7        .4          .5          .6          .7          .8          .9          1.
CDS    7        .0545       .033        .022        .014        .008        .0003       0.
MFR    7        .4          .5          .6          .7          .8          .9          1.
CDS    7        .072        .045        .0285       .018        .0105       .0005       0.
MFR    6        .5          .6          .7          .8          .9          1.
CDS    6        .057        .035        .022        .012        .0005       0.
MFR    4        .7          .8          .9          1.
CDS    4        .028        .013        .0005       0.
MFR    3        .8          .9          1.
CDS    3        .009        .0002       0.
MFR    4        .8          .9          .973        1.
CDS    4        .017        .0003       0.          0.
MFR    1        1.
CDS    1        0.
```

```
EOT
  120      NOZZLE THRUST COEFFICIENT
Z      1   0.
Y      1   0.
PR    13   3.        4.        5.        6.        8.        10.       12.
           14.       16.       18.       20.       22.       24.
CV    13   .94       .91       .89       .9        .93       .95       .96
           .97       .979      .983      .985      .985      .985
EOT
           END OF TABLE DATA
 &D NM=1,XMA=3.5,ALT=50000.,NP=1,IDEL=0.,IPRINT=1,TITLE=1.,
 CDAT(1,5)=1., &END
           RAMJET DESIGN POINT, CONTROLS ON
 &D ALT=50000.,NM=6,XMA=3.,3.5,4.,5.,6.,7.,
 TITLE=1.,IPRINT=1, &END
           RAMJET ENGINE, OFF DESIGN
 &D ALT=60000., &END
 &D ALT=70000., &END
 &D ALT=80000., &END
 &D ALT=90000., &END
 &D ALT=100000., &END
 &D ENDRUN=1 &END
```

NAVAL AIR DEVELOPMENT CENTER

NEP11 NAVY ENGINE PERFORMANCE COMPUTER CODE
VERSION II FOR IBM 360

MODIFIED A1

THE UNIVERSITY OF TENNESSEE SPACE INSTITUTE

FEBRUARY 1979

NAMELIST INPUT CARDS FOR NEXT SOLUTION

RAMJET ENGINE PERFORMANCE CALCULATION WITH INSTALLATIONAL EFFECTS AND H_2 FUEL; DISSOCIATION ARTIFICIALLY PRECLUDED

```
Z  =  0.0        MACH=  0.0
                 WCOR   0.20000D 04
                 RR     0.10000D 01
Z  =  0.0        MACH=  0.25000D 00
                 WCOR   0.20000D 04
                 RR     0.10000D 01
Z  =  0.0        MACH=  0.50000D 00
                 WCOR   0.20000D 04
                 RR     0.10000D 01
Z  =  0.0        MACH=  0.75000D 00
                 WCOR   0.20000D 04
                 RR     0.10000D 01
Z  =  0.0        MACH=  0.10000D 01
                 WCOR   0.20000D 04
                 RR     0.10000D 01
Z  =  0.0        MACH=  0.12500D 01
                 WCOR   0.20000D 04
                 RR     0.98000D 00
Z  =  0.0        MACH=  0.15000D 01
                 WCOR   0.20000D 04
                 RR     0.94000D 00
Z  =  0.0        MACH=  0.17500D 01
                 WCOR   0.20000D 04
                 RR     0.88000D 00
Z  =  0.0        MACH=  0.19500D 01
                 WCOR   0.20000D 04
                 RR     0.82000D 00
Z  =  0.0        MACH=  0.20000D 01
                 WCOR   0.20000D 04
                 RR     0.92500D 00
Z  =  0.0        MACH=  0.25000D 01
                 WCOR   0.20000D 04
                 RR     0.87000D 00
Z  =  0.0        MACH=  0.30000D 01
                 WCOR   0.20000D 04
                 RR     0.81000D 00
Z  =  0.0        MACH=  0.35000D 01
                 WCOR   0.20000D 04
                 RR     0.74000D 00
Z  =  0.0        MACH=  0.40000D 01
                 WCOR   0.20000D 04
                 RR     0.67000D 00
Z  =  0.0        MACH=  0.45000D 01
                 WCOR   0.20000D 04
                 RR     0.59000D 00
Z  =  0.0        MACH=  0.50000D 01
                 WCOR   0.20000D 04
                 RR     0.51000D 00
   =  0.0        MACH=  0.52000D 01
                 WCOR   0.20000D 04
                 RR     0.48000D 00
```

C34

Z = 0.0	MACH=	0.80000D 00							
	MFR	0.35000D 00	0.40000D 00	0.50000D 00	0.60000D 00	0.70000D 00	0.80000D 00	0.90000D 00	0.10000D 01
	CDS	0.27500D-01	0.22000D-01	0.14000D-01	0.95000D-02	0.60000D-02	0.35000D-02	0.20000D-03	0.0
Z = 0.0	MACH=	0.90000D 00							
	MFR	0.40000D 00	0.50000D 00	0.60000D 00	0.70000D 00	0.80000D 00	0.90000D 00	0.10000D 01	
	CDS	0.45000D-01	0.26500D-01	0.17000D-01	0.10500D-01	0.60000D-02	0.20000D-03	0.0	
Z = 0.0	MACH=	0.10000D 01							
	MFR	0.40000D 00	0.50000D 00	0.60000D 00	0.70000D 00	0.80000D 00	0.90000D 00	0.10000D 01	
	CDS	0.54500D-01	0.33000D-01	0.22000D-01	0.14000D-01	0.80000D-02	0.30000D-03	0.0	
Z = 0.0	MACH=	0.17500D 01							
	MFR	0.40000D 00	0.50000D 00	0.60000D 00	0.70000D 00	0.80000D 00	0.90000D 00	0.10000D 01	
	CDS	0.72000D-01	0.45000D-01	0.28500D-01	0.16000D-01	0.10500D-01	0.50000D-03	0.0	
Z = 0.0	MACH=	0.20000D 01							
	MFR	0.50000D 00	0.60000D 00	0.70000D 00	0.80000D 00	0.90000D 00	0.10000D 01		
	CDS	0.57000D-01	0.35000D-01	0.22000D-01	0.12000D-01	0.50000D-03	0.0		
Z = 0.0	MACH=	0.30000D 01							
	MFR	0.70000D 00	0.80000D 00	0.90000D 00	0.10000D 01				
	CDS	0.28000D-01	0.13000D-01	0.50000D-03	0.0				
Z = 0.0	MACH=	0.40000D 01							
	MFR	0.80000D 00	0.90000D 00	0.10000D 01					
	CDS	0.90000D-02	0.20000D-03	0.0					
Z = 0.0	MACH=	0.50000D 01							
	MFR	0.80000D 00	0.90000D 00	0.97300D 00	0.10000D 01				
	CDS	0.17000D-01	0.30000D-03	0.0	0.0				
Z = 0.0	MACH=	0.57000D 01							
	MFR	0.10000D 01							
	CDS	0.0							

ORIGINAL PAGE IS OF POOR QUALITY

Z = 0.0 Y = 0.0

PR	0.300000D 01	0.400000D 01	0.500000D 01	0.600000D 01	0.800000D 01	0.100000D 02	0.120000D 02	0.140000D 02
CV	0.940000D 00	0.910000D 00	0.890000D 00	0.900000D 00	0.930000D 00	0.950000D 00	0.960000D 00	0.970000D 00
PR	0.160000D 02	0.180000D 02	0.200000D 02	0.220000D 02	0.240000D 02			
CV	0.979000D 00	0.983000D 00	0.985000D 0	0.985000D 00	0.985000D 00			

ORIGINAL PAGE IS
OF POOR QUALITY

C36

TABLE DATA INPUT SUMMARY 3 TABLES

TABLE NUMBER	REFERENCE NUMBER	ARRAY LOCATION
1	75	1
2	100	163
3	120	367

DATA STORAGE ALLOCATION 3000
DATA STORAGE NOT USED 2579

ORIGINAL PAGE IS
OF POOR QUALITY

RAMJET ENGINE DESIGN POINT
CONFIGURATION DATA 5 STATIONS 5 COMPONENTS

COMPONENT NUMBER	NKIND	COMPONENT TYPE	UPSTREAM STATIONS		DOWNSTREAM STATIONS	
1	1	INLET	1	0	2	0
2	2	DUCT B	2	0	3	0
3	2	DUCT B	3	0	4	0
4	9	NOZZLE	4	0	5	0
5	12	CONTROL	4	0	1	0

CONTROL INFORMATION

5 VARY CDAT 1 OF COMPONENT 1 SO THAT STATP 8 OF FLOW STATION 4 EQUALS 0.0

ORIGINAL PAGE IS
OF POOR QUALITY

RAMJET ENGINE DESIGN POINT

DESIGN POINT MODE

CDAT(1,1-8)	0.10000D 04	0.0	0.16820D 01	0.10000D 03	0.35000D 01	0.75000D 02	0.20000D 04	0.10000D 01
CDAT(1,9-15)	0.50000D 05	0.0	0.10000D 01	-0.85000D 04	0.10000D 01	0.10000D 01	0.10000D 02	
CDAT(2,1-8)	0.0	0.0	0.37361D-06	0.0	0.0	0.0	0.0	0.0
CDAT(2,9-15)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
CDAT(3,1-8)	0.0	0.0	0.13487D-05	0.47500D 04	0.99000D 00	0.49900D 05	0.0	0.0
CDAT(3,9-15)	0.0	0.10000D 04	0.0	0.0	0.0	0.0	0.0	
CDAT(4,1-8)	0.19862D 04	0.10000D 01	0.0	0.0	0.12000D 03	0.10000D 01	0.0	0.0
CDAT(4,9-15)	0.10000D 01	0.10000D 01	0.0	0.0	0.0	0.0	0.0	
CDAT(5,1-8)	0.10000D 01	0.0	0.0	0.10000D 01	0.0	0.80000D 01	0.0	0.0
CDAT(5,9-15)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	

R[illegible] T [illegible] DE[illegible] PU[illegible]

STATION PROPERTY OUTPUT DATA

FLOW STATION	WEIGHT FLOW STATP1	TOTAL PRESSURE STATP2	TOTAL TEMPERATURE STATP3	FUEL/AIR RATIO STATP4	REFERRED FLOW STATP5	MACH NUMBER STATP6	STATIC PRESSURE STATP7	INTERFACE RELATIVE FLOW ERROR STATP8
1	0.10000D 04	0.16820D 01	0.38997D 03	0.0	0.37828D 04	0.29044D 01	0.0	0.0
2	0.10000D 04	0.99345D 02	0.13208D 04	0.0	0.23606D 03	0.0	0.0	0.0
3	0.10000D 04	0.94378D 02	0.13208D 04	0.0	0.24849D 03	0.0	0.0	0.0
4	0.10276D 04	0.75502D 02	0.47500D 04	0.27555D-01	0.60526D 03	0.10000D 01	0.41723D 02	0.0
5	0.10276D 04	0.75502D 02	0.47500D 04	0.27555D-01	0.60526D 03	0.29658D 01	0.16820D 01	0.0

COMPONENT OUTPUT DATA

COMPONENT NO.	TYPE	DATOUT1	DATOUT2	DATOUT3	DATOUT4	DATOUT5	DATOUT6	DATOUT7	DATOUT8	DATOUT9
1	INLET	0.11852D 06	0.31859D 04	0.32456D 04	0.26380D 01	0.31635D 02	0.29044D 01	0.82273D 00	0.25466D 01	0.50000D 05
2	DUCT B	0.0	0.50000D-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	DUCT B	0.0	0.20000D 00	0.0	0.27555D-01	0.0	0.99197D 05	0.0	0.49900D 05	0.99000D 00
4	NOZZLE	0.22345D 06	0.69964D 04	0.44887D 02	0.71030D 04	0.19862D 04	0.10000D 01	0.98500D 00	0.0	0.44887D 02

PERFORMANCE OUTPUTS

(1) NET THRUST (LBS)	104930.10	(2) NET BRAKE SHP	0.0	(3) AIRFLOW (LB/SEC)	1000.00
(4) TSFC LB/HR/LB)	0.9454	(5) BSFC (LB/HR/HP)	0.0	(6) FUEL FLOW(LB/HR)	99196.59
(7) NT THRUST/AIRFLW	104.93	(8) NET BSHP/AIRFLOW	0.0	(9) INLET DRAG (LBS)	118517.46

0 ITERATIONS 2 PASSES

ORIGINAL PAGE IS
OF POOR QUALITY

JET ENE . . GN . . T

NAMELIST INPUT CARDS FOR NEXT SOLUTION

ALTITUDE MACH FN BSHP WF TSFC REF FLOW BPR BOT T19 PR19 A19 T9 PR9 A9 RR NIT

C3.11.

RAMJET DESIGN POINT; CONTROLS ON

S ON ERT FRC FA

FLOW STATION	WEIGHT FLOW STATP1	TOTAL PRESSURE STATP2	TOTAL TEMPERATURE STATP3	FUEL/AIR RATIO STATP4	REFERRED FLOW STATP5	MACH NUMBER STATP6	STATIC PRESSURE STATP7	INTERFACE RELATIVE FLOW ERROR STATP8
1	0.10000D 04	0.16820D 01	0.38997D 03	0.0	0.37628D 04	0.29044D 01	0.0	0.0
2	0.10000D 04	0.99345D 02	0.13206D 04	0.0	0.73806D 03	0.0	0.0	0.0
3	0.10000D 04	0.94376D 02	0.13208D 04	0.0	0.74549D 03	0.0	0.0	0.0
4	0.10276D 04	0.75502D 02	0.47500D 04	0.27555D-01	0.60576D 03	0.10000D 01	0.41723D 02	0.0
5	0.10276D 04	0.75502D 02	0.47500D 04	0.27555D-01	0.60576D 03	0.29658D 01	0.16820D 01	0.0

COMPONENT OUTPUT DATA

COMPONENT NO.	TYPE	DATOUT1	DATOUT2	DATOUT3	DATOUT4	DATOUT5	DATOUT6	DATOUT7	DATOUT8	DATOUT9
1	INLET	0.11852D 06	0.31659D 04	0.32456D 04	0.26380D 01	0.31635D 02	0.29044D 01	0.82273D 00	0.25466D 01	0.50000D 05
2	DUCT B	0.0	0.50000D-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	DUCT B	0.0	0.20500D 00	0.0	0.27555D-01	0.0	0.99197D 05	0.0	0.49900D 05	0.99000D 00
4	NOZZLE	0.22345D 06	0.69964D 04	0.44887D 02	0.71030D 04	0.19662D 04	0.10000D 01	0.96500D 00	0.0	0.44887D 02

PERFORMANCE OUTPUTS

(1) NET THRUST (LBS)	104930.10	(2) NET BRAKE SHP	0.0	(3) AIRFLOW (LB/SEC)	1000.00
(4) TSFC LB/HR/LB)	0.9454	(5) BSFC (LB/HR/HP)	0.0	(6) FUEL FLOW(LB/HR)	99196.59
(7) NT THRUST/AIRFLW	104.93	(8) NET BSHP/AIRFLOW	0.0	(9) INLET DRAG (LBS)	118517.46

0 ITERATIONS 1 PASSES

50000. 3.500 104930. 0. 99197.0.945 236.1 0.0 4750. 0. 0.0 0. 4750. 44.89 1986. 0.823 0

NAMELIST INPUT CARDS FOR NEXT SOLUTION

ALTITUDE	MACH	FN	BSHP	WF	TSFC	REF FLOW	BPR	BOT	T19	PR19	A19	T9	PR9	A9	RR	NIT
50000.	3.000	50838.	0.	55665.	1.095	220.8	0.0	4750.	0.	0.0	0.	4750.	23.89	1986.	0.869	3
50000.	3.500	104918.	0.	99201.	0.946	236.1	0.0	4750.	0.	0.0	0.	4750.	44.89	1986.	0.823	3
50000.	4.000	190244.	0.	165366.	0.869	250.2	0.0	4750.	0.	0.0	0.	4750.	79.90	1986.	0.770	3
50000.	5.000	465728.	0.	364352.	0.791	275.2	0.0	4750.	0.	0.0	0.	4750.	222.94	1986.	0.670	1
50000.	6.000	834655.	0.	667567.	0.800	296.6	0.0	4750.	0.	0.0	0.	4750.	520.13	1986.	0.566	4
50000.	7.000	920797.	0.	776349.	0.843	315.2	0.0	4750.	0.	0.0	0.	4750.	1054.46	1986.	0.475	4

NAMELIST INPUT CARDS FOR NEXT SOLUTION

ALTITUDE	MACH	FN	BSHP	WF	TSFC	REF FLOW	BPR	BOT	T19	PR19	A19	T9	PR9	A9	RR	NIT
60000.	3.000	31422.	0.	34431.	1.096	220.9	0.0	4750.	0.	0.0	0.	4750.	23.89	1986.	0.869	14
60000.	3.500	64841.	0.	61345.	0.946	236.1	0.0	4750.	0.	0.0	0.	4750.	44.89	1986.	0.823	3
60000.	4.000	117645.	0.	102261.	0.869	250.2	0.0	4750.	0.	0.0	0.	4750.	79.90	1986.	0.770	3
60000.	5.000	300370.	0.	237660.	0.791	275.2	0.0	4750.	0.	0.0	0.	4750.	222.94	1986.	0.670	1
60000.	6.000	516144.	0.	412830.	0.800	296.6	0.0	4750.	0.	0.0	0.	4750.	520.13	1986.	0.566	4
60000.	7.000	569413.	0.	480067.	0.843	315.2	0.0	4750.	0.	0.0	0.	4750.	1054.46	1986.	0.475	4

NAMELIST INPUT CARDS FOR NEXT SOLUTION

ALTITUDE	MACH	FN	BSHP	WF	TSFC	REF FLOW	BPR	BOT	T19	PR19	A19	T9	PR9	A9	RR	NIT
70000.	3.000	19374.	0.	21264.	1.098	221.4	0.0	4750.	0.	0.0	0.	4750.	23.87	1986.	0.869	14
70000.	3.500	40002.	0.	37872.	0.947	236.5	0.0	4750.	0.	0.0	0.	4750.	44.86	1986.	0.823	3
70000.	4.000	72512.	0.	63102.	0.870	250.6	0.0	4750.	0.	0.0	0.	4750.	79.87	1986.	0.770	3
70000.	5.000	185029.	0.	146445.	0.791	275.6	0.0	4750.	0.	0.0	0.	4750.	222.98	1986.	0.670	2
70000.	6.000	316384.	0.	253424.	0.801	297.1	0.0	4750.	0.	0.0	0.	4750.	520.20	1986.	0.566	4
70000.	7.000	344622.	0.	291376.	0.845	315.6	0.0	4750.	0.	0.0	0.	4750.	1054.94	1986.	0.475	4

ORIGINAL PAGE IS OF POOR QUALITY

NAMELIST INPUT CARDS FOR NEXT SOLUTION

ALTITUDE	MACH	FN	BSHP	WF	ISFC	REF FLOW	BPR	BOT	T19	PR19	A19	T9	PR9	A9	RR	NIT
80000.	3.000	11961.	0.	13174.	1.101	222.4	0.0	4750.	0.	0.0	0.	4750.	23.84	1986.	0.869	14
80000.	3.500	24686.	0.	23443.	0.950	237.5	0.0	4750.	0.	0.0	0.	4750.	44.81	1986.	0.823	3
80000.	4.000	44730.	0.	39026.	0.872	251.6	0.0	4750.	0.	0.0	0.	4750.	79.81	1986.	0.770	3
80000.	5.000	113892.	0.	90254.	0.792	276.5	0.0	4750.	0.	0.0	0.	4750.	223.03	1986.	0.670	2
80000.	6.000	192626.	0.	154809.	0.804	298.0	0.0	4750.	0.	0.0	0.	4750.	520.36	1986.	0.566	4
80000.	7.000	203479.	0.	173195.	0.851	316.5	0.0	4750.	0.	0.0	0.	4750.	1056.05	1986.	0.475	4

NAMELIST INPUT CARDS FOR NEXT SOLUTION

ORIGINAL PAGE IS
OF POOR QUALITY

RAMJET ENGINE, OFF DESIGN

ALTITUDE	MACH	FN	BSHP	WF	TSFC	REF FLOW	BPR	BOT	T19	PR19	A19	T9	PR9	A9	RR	NI.
90000.	3.000	7433.	0.	8216.	1.105	223.4	0.0	4750.	0.	0.0	0.	4750.	23.81	1986.	0.869	14
90000.	3.500	15337.	0.	14607.	0.952	238.5	0.0	4750.	0.	0.0	0.	4750.	44.76	1986.	0.823	3
90000.	4.000	27773.	0.	24293.	0.875	252.6	0.0	4750.	0.	0.0	0.	4750.	79.75	1986.	0.770	3
90000.	5.000	70452.	0.	56001.	0.795	277.6	0.0	4750.	0.	0.0	0.	4750.	223.01	1986.	0.670	3
90000.	6.000	116000.	0.	95156.	0.806	298.9	0.0	4750.	0.	0.0	0.	4750.	520.57	1986.	0.566	4
90000.	7.000	120571.	0.	103304.	0.857	317.5	0.0	4750.	0.	0.0	0.	4750.	1057.17	1986.	0.475	4

NAMELIST INPUT CARDS FOR NEXT SOLUTION

ALTITUDE	MACH	FN	BSHP	WF	TSFC	REF FLOW	BPR	BOT	T19	PR19	A19	T9	PR9	A9	RR	NIT
100000.	3.000	4648.	0.	5156.	1.109	224.3	0.0	4750.	0.	0.0	0.	4750.	23.79	1986.	0.869	14
100000.	3.500	9588.	0.	9159.	0.955	239.4	0.0	4750.	0.	0.0	0.	4750.	44.71	1986.	0.823	3
100000.	4.000	17355.	0.	15218.	0.877	253.5	0.0	4750.	0.	0.0	0.	4750.	79.70	1986.	0.770	3
100000.	5.000	43895.	0.	34958.	0.796	278.5	0.0	4750.	0.	0.0	0.	4750.	223.05	1986.	0.670	3
100000.	6.000	72723.	0.	58844.	0.809	299.9	0.0	4750.	0.	0.0	0.	4750.	520.85	1986.	0.566	4
100000.	7.000	71662.	0.	61910.	0.864	316.4	0.0	4750.	0.	0.0	0.	4750.	1058.31	1986.	0.475	4

NAMELIST INPUT CARDS FOR NEXT SOLUTION

ORIGINAL PAGE IS
OF POOR QUALITY

END

DATE

FILMED

MAY 23 1979