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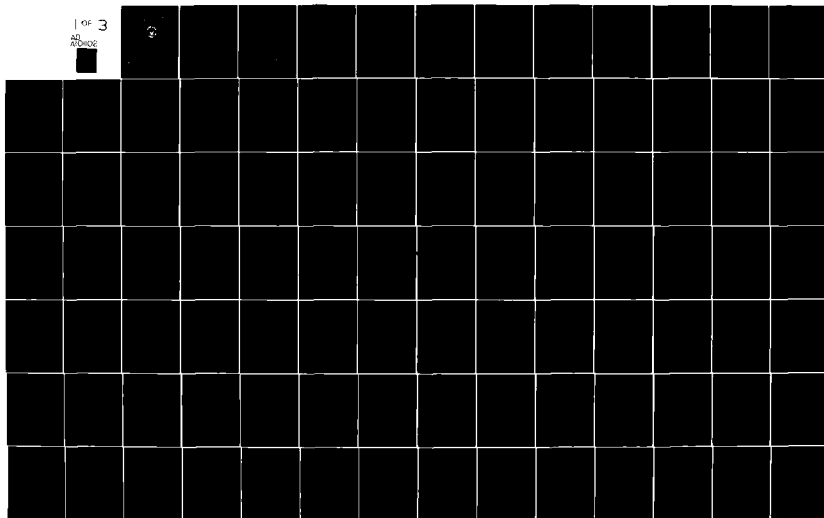
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COMPUTER EVALUATION OF THE ON-AND-OFF-DESIGN
PERFORMANCE OF AN AXIAL AIR TURBINE

by

Robert Cirone

March 1981

Thesis Advisor

R. P. Shreeve

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Computer Evaluation of the On-and-Off-Design
Performance of an Axial Air Turbine

by

Robert Cirone
Lieutenant, United States Navy
B.S.M.E., University of Notre Dame, 1973

Submitted in partial fulfillment of the
requirements for the degree of

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Author:

Robert Cirone

Approved by:

Raymond L. Shreve
Thesis Advisor

Paul J. Ricci
Second Reader

P. J. Marts
Chairman, Department of Mechanical Engineering

William M. Folles
Dean of Science and Engineering

ABSTRACT

An existing code for calculating axial turbine performance using multiple stream surfaces was modified and made to run on the equivalent of an HP-1000 computer system. Calculations were made for the geometry of a 485 horsepower dual-discharge air-drive turbine for both on and off-design conditions. The results were compared with available data obtained at off-design speeds. Agreement of the flow rate and horsepower to within 5% was obtained.

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LIST OF SYMBOLS

A	Cross sectional area
a	Blade opening
c	Blade chord
c_p	Specific heat at constant pressure
D	Diameter
E	Kinetic energy
g_c	Universal gravitational constant
H	Total enthalpy
H***	Energy parameter, boundary layer
h	Static enthalpy
h	Blade height
HP	Horsepower
I	Integrand
J	Conversion factor
K_{is}	Head coefficient
L	Distance between stations
M	Mach number
$\dot{m}$	Mass flow rate
m	Exponent used in boundary layer calculations
$\dot{m}_{ref}$	Reference flow rate
N	Rotational speed
P	Pressure (Psia)
R	Gas constant for air

R	Radius
r	Radius
r*	Theoretical degree of reaction
s	Entropy
s*	Non-dimensional entropy
T	Temperature ($^{\circ}\text{R}$)
t	Maximum blade thickness
t _e	Trailing edge thickness
U	Peripheral velocity
u	Velocity within the boundary layer
V	Absolute velocity
W	Relative velocity
X	Non-dimensional radius (r/r_m)
Y	Non-dimensional axial velocity ratio (V_a/V_{am})
y	Pressure loss coefficient

GREEK LETTERS

α	Absolute gas outlet angle
β	Relative gas outlet angle
γ	Specific heat ratio, c_p/c_v
δ	Boundary layer thickness
δ	Referred pressure ratio ($P_{to}/14.7$)
δ^*	Boundary layer displacement thickness
δ^{***}	Boundary layer energy thickness
ξ	Loss coefficient
η	Efficiency

θ	Referred temperature ratio, $\frac{T_{TO}}{518.4}$
κ	Curvature factor
λ	Angle of flow in a meridional plane
ξ	Area restriction factor
ρ	Density
ϕ	Non-dimensional flow function
ω	Angular velocity

SUBSCRIPTS

a	Axial
ACT	Actual or computed value
E	An equivalent thermodynamic quantity
eff	Effective
H	Hub
is	Isentropic
m	Mean streamline value
p	Profile
R	Relative flow value
r	radial
ref	Referred value
req	Required
s	secondary
TH	Theoretical value
TO	Total conditions
u	Tangential
o	Station at the stator inlet

- 1 Station between the stator and the rotor
- 2 Station at the rotor outlet

I. INTRODUCTION

A. DESCRIPTION OF THE TRANSONIC COMPRESSOR TEST RIG

The Transonic Compressor Test Rig at the Turbopropulsion Laboratory (TPL) of the Naval Postgraduate School is shown schematically in Fig. 1 and consists of the following major components:

1. Air drive turbine.
2. Air supply system.
3. Associated piping including throttling valves at the turbine and compressor inlets.
4. Test compressor.

The drive turbine is a dual-flow axial air turbine with 50% reaction. The geometry is given in Table 1. The profile shapes of the turbine rotor and of the stator blades are identical and the blades are of constant section along the radius as shown in Fig. 2. The stator has 31 blades while the rotor has 32 (to avoid resonant excitation from wake interference). The two parallel stages of the turbine are designed for the following output and total inlet conditions:

Pressure Ratio: 2.8

Total Inlet Temperature: 640°R

Flow rate: 10.85 LBM/SEC

Horsepower: 485 HP

The compressor presently under test is a transonic single stage, axial flow compressor. It is instrumented for measurements of torque, mass flow rate, stagnation temperatures and pressures, case and hub wall pressures, and for unsteady pressure measurements in the flow field and at the walls.

The Air Supply System incorporates an electric motor-driven multi-stage axial flow compressor manufactured by Allis-Chalmers. It can presently supply up to 12 lbs/sec of air at 3 atmospheres, at temperatures between 560°R and 660°R. The compressor is rated at 1250 HP and has a controlled variable speed drive.

B. STATEMENT OF THE TASK

The Transonic Compressor Test Rig was designed to provide the means for obtaining experimental data in fundamental compressor phenomena. Following the present experiments, an experiment to investigate the onset of supersonic unstalled blade flutter is planned which would involve replacing at least the present compressor rotor by a rotating cascade of flat-plate blades. Such a rotor would not be able to produce the pressure ratios required to pump the required flow rates through the system. Therefore, it has been proposed, that a turbocharger compressor be fitted in series with the rotating cascade to provide the required flow through it. The turbocharger would also be driven using air from the Allis-Charmers air supply system.

In order to evaluate the feasibility of the turbocharger installation, it is necessary to determine the mass flow rate required by the drive turbine to drive the test compressor at a given power and speed. The remaining air to drive the turbocharger turbine is then known and the selection of a commercially available turbocharger suitable for this application can be made.

Thus, the performance of the air drive turbine must be known over the complete speed range. Of particular importance, are the required mass flow rates for given values of horsepower. The problem, therefore, is to obtain the turbine performance map for all pressure ratios and speeds.

II. APPROACH

A. BACKGROUND

A search of the most recent literature revealed a number of analytical methods for the calculation of turbine off-design performance. The majority of these used in a finite element approach but little information on the relative success of these methods in practice was available. Two alternate methods, both used at the Turbopropulsion Laboratory, were those of M. H. Vavra and E. Macchi. Each was examined in detail.

The method of Vavra, given in Ref. [1] is a one-dimensional (meanline) approach using mathematical modelling and experimental data to express flow angles and losses. It is primarily a method to design turbine blading but may also be used to predict turbine performance for a given set of gas inlet and operating conditions when the blading geometries are specified. It is assumed that the axial velocity is constant along the blading from hub to tip. Vavra states that this assumption is reasonable for blading in which the tip-to-hub ratio is equal to or less than 1.15. The ratio is 1.312 and 1.424 for the drive turbine stator and rotor blading respectively. It was thought therefore, that the method of Macchi might yield more accurate predictions.

Macchi's method is given in Ref. [2]. The method, implemented by Macchi in a computer program written for the IBM 360, was an extension of the work done by R. Eckert [Ref. 3] and R. Harrison [Ref. 4]. Eckert wrote a program, following a simplified three-dimensional analysis, which could be used to predict the performance of a single-stage axial flow turbine. Harrison improved the program by modifying the analysis to take into account streamline curvature. Both programs were based on the three-dimensional method developed by Vavra in Ref. [5]. Macchi's principle improvements to the program were to introduce the choice of various methods to calculate gas outlet angles and loss coefficients. Two methods of calculating gas outlet angles are included; those of Ainley and Mathieson [Ref. 6] and Traupel [Ref. 7]. Five methods for calculating the loss coefficients can be selected; those due to Ainley and Mathieson [Ref. 6], Dunham and Came [Ref. 8], Balje [Ref. 9], Lohmeyer and Carter [Ref. 10] and Traupel [Ref. 7].

Macchi's computer program, as documented in Ref. [2], was selected for performance predictions of the drive turbine. It should be noted that no card deck of the program was available, and no results of using the program were available other than those included in Ref. [2].

B. ANALYSIS

The method requires the following assumptions;

1. There are an infinite number of blades in each blade row so that blades downstream do not affect upstream conditions.

2. The flow is axisymmetric at locations where the equation of motion is solved.

3. The flow is steady and adiabatic. Thus, the total enthalpy through the stator remains constant along a streamline and the relative total enthalpy through the rotor remains constant along a streamline.

4. All equations are solved at between blade row locations. Increases in entropy occur in the blade row upstream of the stations where equations are solved and the entropy change along a streamline between blade rows is zero.

5. The boundary layers on the turbine casing are not accounted for.

The method of solution is as follows:

1. Assume initial radial positions of the streamlines.

2. Obtain the axial velocity distribution by solving the equation of motion at the stator outlet. The velocity distribution into the stator is assumed to be axial, and uniform

3. Obtain stator loss coefficients.

4. Check overall continuity and adjust the inlet Mach number as necessary.

5. Check the between-streamline continuity, and adjust streamline radial positions as necessary.

6. Repeat this process for the rotor.

7. Re-cycle all the above calculations, accounting for streamline curvature, and repeat until convergence is reached.

C. METHOD OF SOLUTION

The computer code written by Macchi was originally run on the IBM 360 computer. The program consisted of a deck of over 2000 program cards plus over 60 data cards. Since the deck could not be located, it was necessary to re-type the program from the listing in Macchi's paper. However, since the IBM 360 computer was soon to be replaced in the period in which the work was to be carried out, an alternate computer was sought.

The HP-1000 series mini-computer located at TPL was selected for two reasons. First, the machine used FORTRAN as did Macchi's program. Secondly, it would be a benefit to TPL to have the program immediately available on the laboratory computer.

The first steps were to analyze Macchi's program, in detail, and then to run it using his example input/output. In analyzing the program it became obvious that the computer program listing given in Ref. 2, was not the one used to obtain the listed output. Numerous discrepancies were found in the listing, some of which would have prevented the program from running; others would have caused incorrect results to be obtained. A listing of these discrepancies is contained in Appendix E. When the program was understood and flow-charted, it was keyed-in at the HP-1000 computer terminal. However, modifications were required to accomodate

the program within the mini-computer disc-based operating system.

D. MODIFICATION TO THE COMPUTER CODE

Since there was no card reader, variable input data such as turbine speed had to be entered using data or specification statements. This contributed in part to the most difficult problem, that of program size. The HP-1000 mini-computer uses a disc with a storage capability of 19.5 mega-bytes. However, the machine memory is only 124 K Bytes, of which only 29 K Bytes is available to a programmer. Also, the available memory is divided up, or partitioned into two 18 K and one 11 K partitions, so that no single program can exceed 18 K. It was estimated that Macchi's program was over 100 K. So it was clear that the program would have to be modified if it were to run on the mini-computer.

The first modification was to remove all subroutines from the program that were not actually used. It will be recalled that Macchi's program contained five methods for calculating loss coefficients and two methods for calculating gas outlet angles. It was decided that only the Traupel method of calculating loss coefficients would be retained. Traupel was selected for two reasons. Firstly, it was the method used by Macchi in his example calculations and therefore the modified program should still reproduce Macchi's results. Secondly, the method of Traupel is widely respected.

The method of calculating gas outlet angles was totally changed. Neither Ainley and Mathieson [Ref. 6] nor Traupel [Ref. 7] was used. Both methods required prohibitively large sections of computer code. The method selected was that of Vavra [Ref. 1].

Use of Vavra's method greatly simplified the program because this method predicts gas outlet angles independently of the inlet Mach number. Macchi's approach was to use Traupel's method which is dependent on the Mach number of the flow into the blade.

The above simplifications reduced the program size from 2257 lines to less than 1800 lines. However, this was still too large and the program could not be loaded without overflowing the memory.

The solution to the problem was found in program segmentation. In this process, the computer code is divided into a main program and several segments. Each segment is a "piece" of the original program. The segments are individually compiled and loaded. However, the segments are placed into memory only as they are needed to execute the overall program. Thus, a very large program can be made to run in the available 18 K partition. Since the present program was not originally intended for a mini-computer, segmentation was not straight forward. The method finally arrived at is detailed in Appendix C. Basically, the main

program consists of all the subroutines, while the three other segments contain coding which enables program flow to proceed in a logical manner.

Successfully segmented, the program was run using Macchi's input. An output was obtained which agreed almost exactly with Macchi's results. All output quantities were within 1% of Macchi's quantities. The differences were, in all probability, due to the different method of calculating gas outlet angles.

After verifying Macchi's program, the drive turbine geometry was input and the program was run for a given set of operating conditions. The results are discussed in the following section. Note: The "verification" of Macchi's program amounted to verifying that the computer code now loaded into the HP-1000, was indeed Macchi's code. It was not known whether Macchi's output data were a good or bad prediction of performance since they were not compared with test results.

III. RESULTS OF AXIAL TURBINE PREDICTIONS

A. USING BOTH COMPLETE AND MODIFIED PROGRAMS

The drive turbine geometry was input and the following solution flow path was selected:

1. Stator and rotor loss coefficients were functions of pressure ratio.
2. The blockage factor, ξ^* , used in the equation of continuity was equal to the total loss coefficient.

Four operating points were selected to test the validity of the program. Three were off-design points at which measured data were available and the fourth was the design point itself. Table II contains details of the selected test points for Run 1.

The program variables were then changed and the following new solution flow path was selected:

1. Stator and rotor loss coefficients were those calculated by Traupel's method.
2. The blockage factor, ξ^* , was equal to the profile loss coefficient.

After reviewing the results of Runs 1 and 2, a further modification was made to the program. The original program contained a subroutine which checked between-streamline continuity. If the total mass flow rate at the stator and rotor exits was not evenly divided between the five streamlines,

the radial positions of the streamlines were adjusted and all steps were recalculated using the new streamline positions. Hence, for Run 3, a subroutine was removed and the main program was modified so that between-streamline continuity was not examined.

B. COMPARISON WITH MEASURED DATA

The results of Run 1, 2, and 3 are tabulated in Table III. Run 1 showed predictions of mass flow rate which departed about 6% from the measured data. However, the horsepower predictions were off by as much as 16.17%. Furthermore, the computer program was unable to reach a solution for the design point.

Run 2 produced worse results as is evident from the table. Again, the program was unable to converge to a solution at the design point.

Run 3 produced more acceptable data. Additionally, convergence to a solution was noticeably faster and a solution was obtained at the design point. Because of this, the method used in Run 3 was used to map the drive turbine performance. The computer program used to obtain the results of Run 3 is described in detail in Appendix A and is listed in Appendix G. The results of Run 3 are shown plotted in Figures 3 through 8.

To obtain the plots in Figures 3 and 6, a value of the total inlet temperature was approximated by the method of Vavra as contained in Ref. [14]. It was assumed that the static turbine discharge temperature should not be less than

45°F (505°R). This corresponds to the approximate temperature at which condensation of moisture in the air, assuming 100% relative humidity, will occur. The inlet temperature was given by

$$\text{Total Inlet Temperature} = \frac{\text{Static Outlet Temperature}}{1 - \eta_s \left[1 - \left(\frac{1}{\delta_T} \right)^{\frac{\gamma-1}{\gamma}} \right]}$$

where η_s , the total-static turbine efficiency was assumed to be 81%, and δ_T , was the total to static pressure ratio. The total inlet temperature corresponding to each pressure ratio is given in Table IV.

The computer output corresponding to each point on Figures 3 through 8 is contained in Appendix F. Only one side of the dual flow turbine was analyzed, thus, the resulting printed values of horsepower, referred horsepower, moment, referred moment, flow rate and referred flow rate must be doubled to obtain the actual turbine characteristics which have been plotted in Figures 3 through 8.

IV. DISCUSSION

The agreement of both the predicted flow rate and the horsepower obtained in Run 3 with turbine test data was encouraging. It is to be noted however, that this agreement was obtained using a procedure which was conceptually incorrect. In Runs 1 and 2, between-streamline continuity was checked and the streamlines were adjusted as necessary. In Run 3, between-streamline continuity was not checked, and as a result, the mass flow rate between streamlines was not precisely 25% of the total flow rate. It is noted however, that the deviations were less than 10.0% and while the radial positions of the streamlines varied by 10.%, the differences between predicted and measured output horsepower decreased from 24% to 4.5%. Since the enthalpy change on each streamline was computed using Euler's turbine equation, the total horsepower obtained by integration is sensitive to the streamline radial positions. On the other hand, the calculation of the overall mass flow rate is primarily a function of the blade throat openings and inlet conditions of the flow. Consequently, in relaxing the requirement for between-streamline continuity, the output horsepower was changed significantly, while the overall flow rate was not.

Using this procedure, which preserves overall continuity, a performance map for the turbine was produced (Fig. 3-8) which agreed well with the off-design performance measurements made at lower speeds (Table III). It is noted however, that the inability of the program in its original form to predict the measured turbine performance is not explained, and both the program itself and the data input for the geometry should be closely re-examined.

The difficulty in obtaining convergence to a solution at some operating points above the pressure ratio of 2.0 is likely to be the result of choking occurring on one or more of the streamlines. This was suspected but not fully explored.

Finally, although the program was eventually made to run on the mini-computer, the time required to put the program into its final form was excessive since the original program was not written with segmentation in mind. When the segmented program was completed, only one operating point per run could be obtained. Thus, excessive time was spent compiling and loading the program. The execution time for the program averaged 2 minutes at the lower pressure ratios and up to 30 minutes at the higher ones. This would be unacceptable if many points were to be examined.

V. CONCLUSIONS

The program for calculating the performance of a single stage axial turbine reported by Macchi was revised, corrected and segmented and made to run on the Laboratory mini-computer. When applied to the geometry of the air-drive turbine of the compressor test rig, selecting specific options for the representation of loss coefficients, the revised program failed to converge when design-point test conditions were input. Also, the computed horsepower was in error by as much as 24% when the program predictions were compared with specific test data obtained from the rig at off-design (lower speed) conditions. The revised program did however closely reproduce the results given by Macchi in his original report for a specific turbine geometry.

When the requirement that the computed stream surfaces be such that they divided the flow exactly into equal 25% increments was removed, the program converged satisfactorily for design point conditions and gave agreement with test data to within 5% in flow rate and horsepower at off-design conditions.

The complete performance map for the air drive turbine was obtained with the program following this revision. Based on the favorable comparison with data so far obtained, the map is likely to describe the performance to better than a 10% uncertainty. This is considered to be satisfactory for

sizing the turbocharger for the proposed compressor rig modification.

The following recommendations are made concerning further application or development of the computer program:

1. The failure of the program to converge before the final revision was made should be analysed closely, and the final revision removed if possible.
2. The geometrical input for the air drive turbine (which was taken from drawings) should be reexamined and the physical dimensions of the blade rows themselves should be measured.
3. Consideration should be given to putting the corrected original version of the program onto the IBM 370 computer so that, when successfully operating, a turbine map can be calculated with a single load.

TABLE I

TURBINE GEOMETRY

(see Figure 2; Dimensions in inches)

STATOR:

Hub Radius	2.764
Mean Radius	3.196
Tip Radius	3.627
Blade Chord	1.003
Blade Suction Side Radius of Curvature	2.8065
Maximum Blade Thickness	.2252
T.E. Projected Thickness	.03
T.E. Normal Thickness	.0186

ROTOR:

Hub Radius	2.693
Mean Radius	3.265
Tip Radius	3.837
Blade Chord	1.003
Blade Suction Side Radius of Curvature	2.8065
Maximum Blade Thickness	.2252
T.E. Projected Thickness	.03
T.E. Normal Thickness	.0186
Tip Clearance	.01(estimated)

TABLE II

MEASURED/DESIGN DATA USED TO VERIFY THE PROGRAM

POINT	RPM	T _{IN}	(R) T _{OUT}	(R) P _{TO}	(PSI) P.R.	M($\frac{\text{LBM}}{\text{SEC}}$)	H.P.
1	18310	579.2	550.8	23.56	1.602	5.542	110.1
2	15200	557.4	517.8	20.43	1.390	4.698	63.27
3	21300	578.9	506.8	27.13	1.846	7.033	172.0
4*	30500	640.0	---	41.16	2.8	10.85	485

*Design Point

TABLE III

COMPARISON OF PREDICTED TURBINE PERFORMANCE
VS MEASURED PERFORMANCE

POINT	RUN I			HORSEPOWER		
	<u>FLOWRATE</u> PREDICT.	MEAS.	%DIFF.	PREDICT.	MEAS	%DIFF.
1	5.88	5.542	6.09	99.5	110.1	9.63
2	4.74	4.698	0.89	52.5	63.27	16.17
3	7.04	7.033	0.009	163.64	172.0	4.86
4	N.C.	10.85	---	N.C.	485	---
RUN 2						
1	6.06	5.542	9.35	90.92	110.1	17.4
2	4.90	4.698	4.29	49.76	63.27	21.35
3	7.30	7.033	3.80	130.76	172.0	23.97
4	N.C.	10.85	---	N.C.	485	---
RUN 3						
1	5.82	5.542	5.01	113.12	110.1	2.74
2	4.66	4.698	0.81	61.96	63.27	2.09
3	7.04	7.033	0.10	179.68	172.0	4.47
4	10.40	10.85	4.15	444.18	485	8.42

NC: Computer program would not converge to a solution after a large number of iterations.

TABLE IV

VALUES OF ASSUMED TOTAL INLET TEMPERATURE FOR EACH
PRESSURE RATIO GIVEN IN FIGS. 3, 5, 6, AND 7

<u>PRESSURE RATIO</u>	<u>TOTAL INLET TEMPERATURE (°R)</u>
1.4	545.5
1.6	562.6
1.8	577.3
2.0	591.0
2.2	603.6
2.4	615.3
2.6	626.1
2.8	636.6

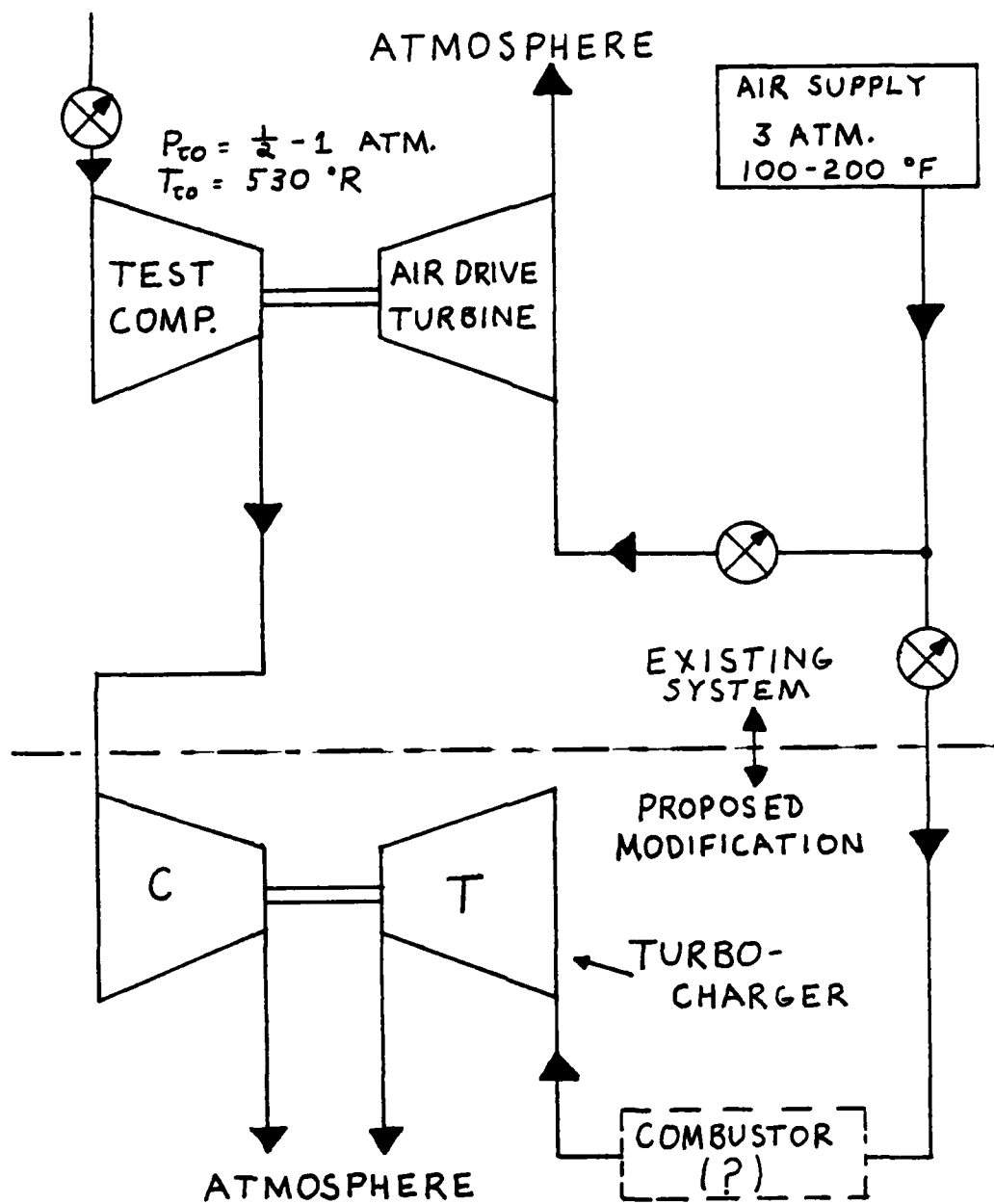


FIGURE 1: SCHEMATIC OF THE COMPRESSOR TEST RIG, WITH PROPOSED MODIFICATIONS

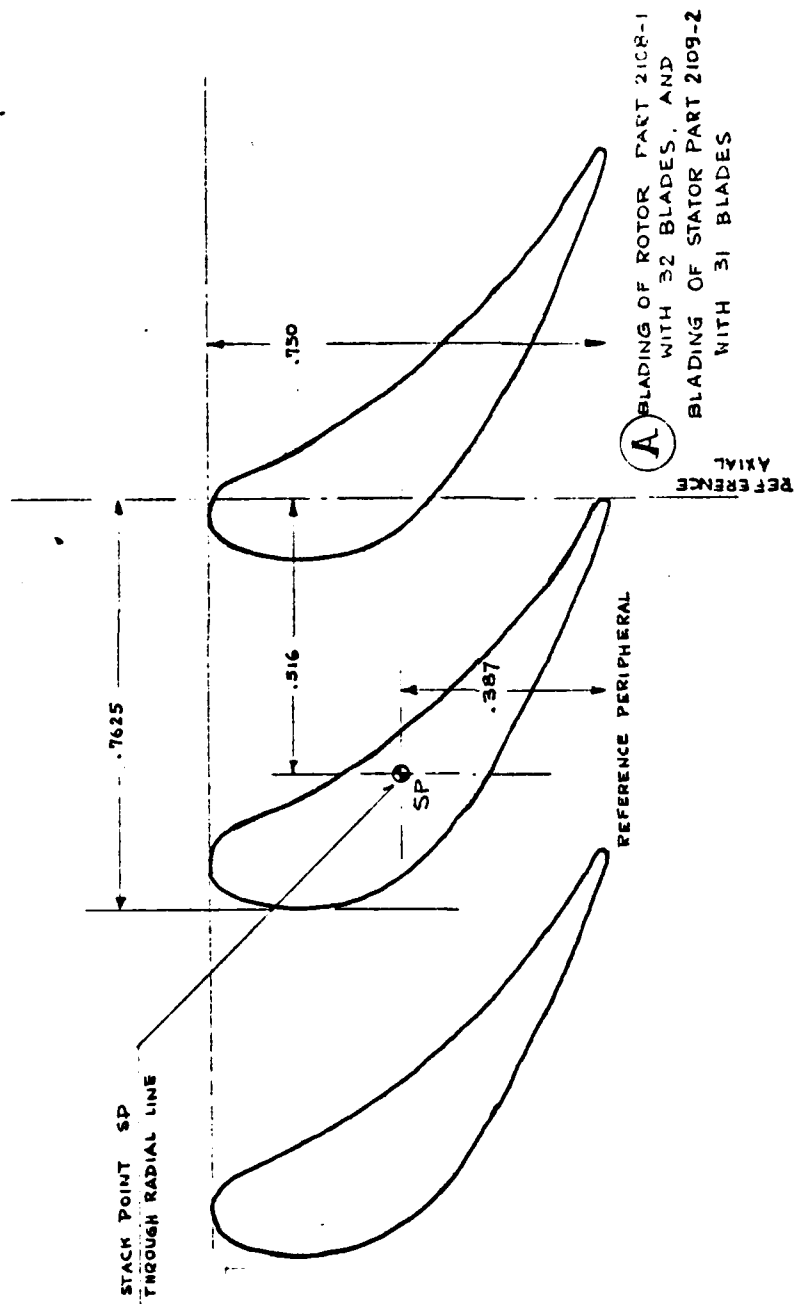


FIGURE 2: TURBINE ROTOR AND STATOR BLADE SHAPES

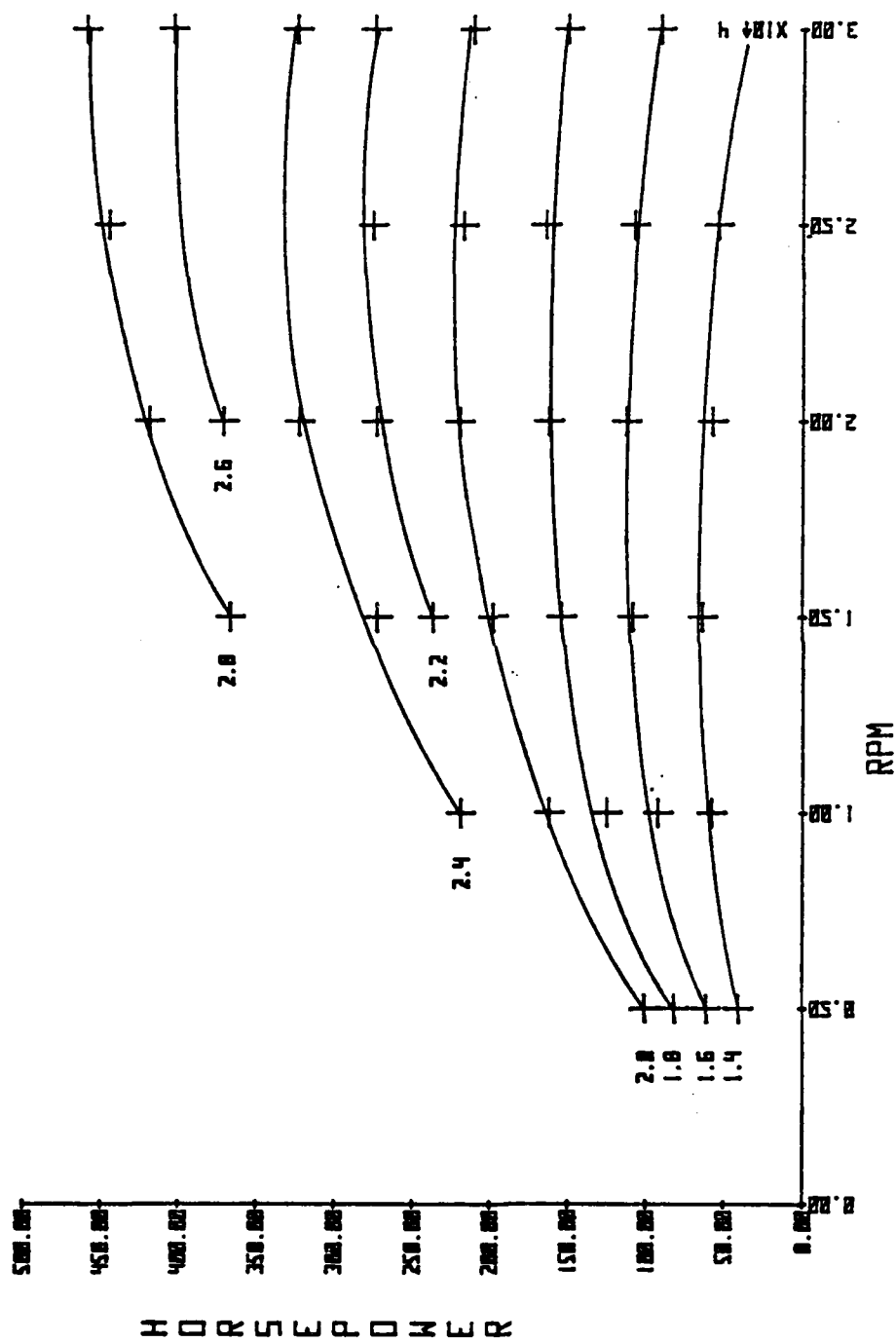


FIGURE 3: PREDICTED HORSEPOWER VS RPM AS A FUNCTION OF PRESSURE RATIO, AT TEMPERATURES TO AVOID CONDENSATION

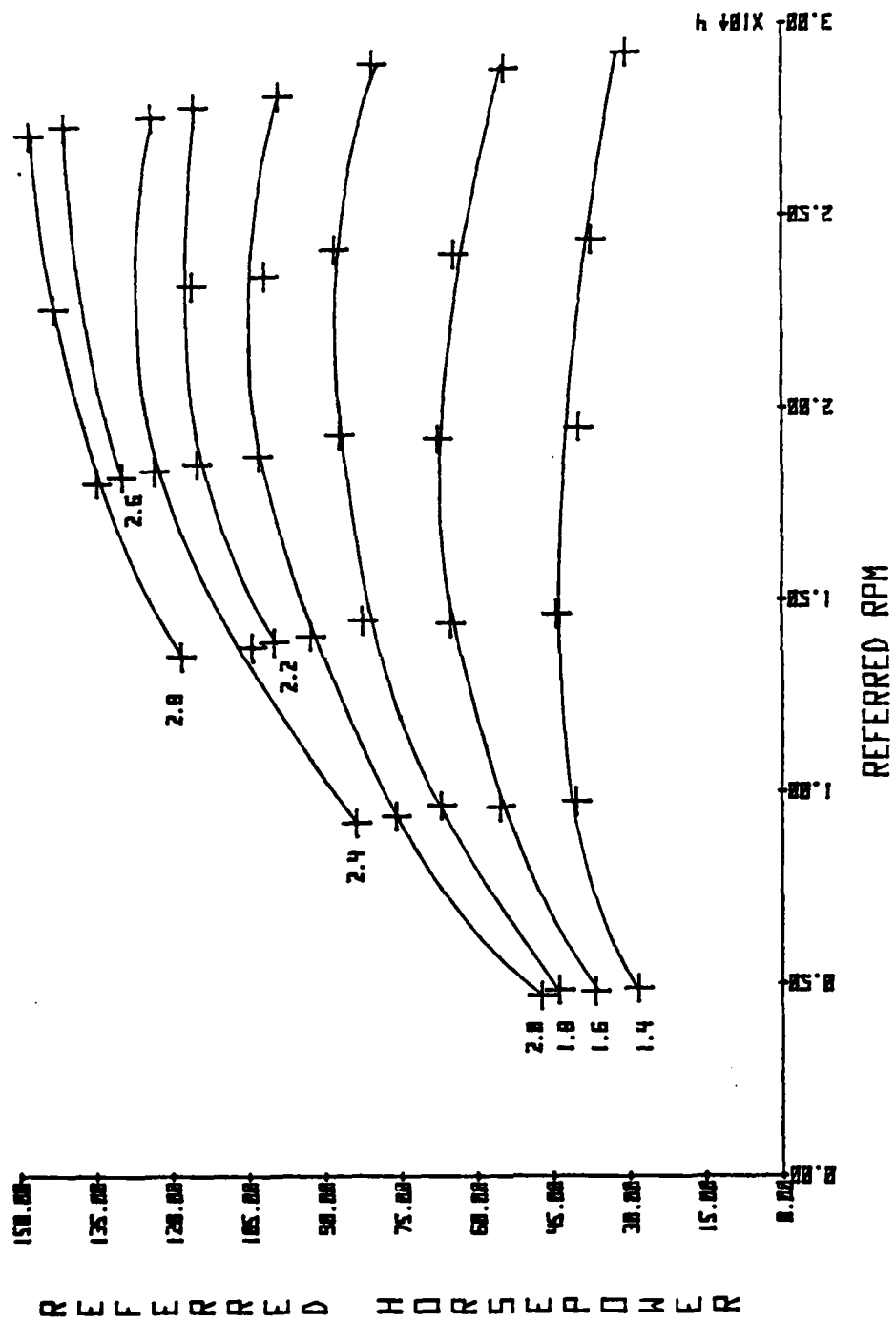


FIGURE 4: PREDICTED REFERRED HORSEPOWER VS REFERRED RPM AS A FUNCTION OF PRESSURE RATIO

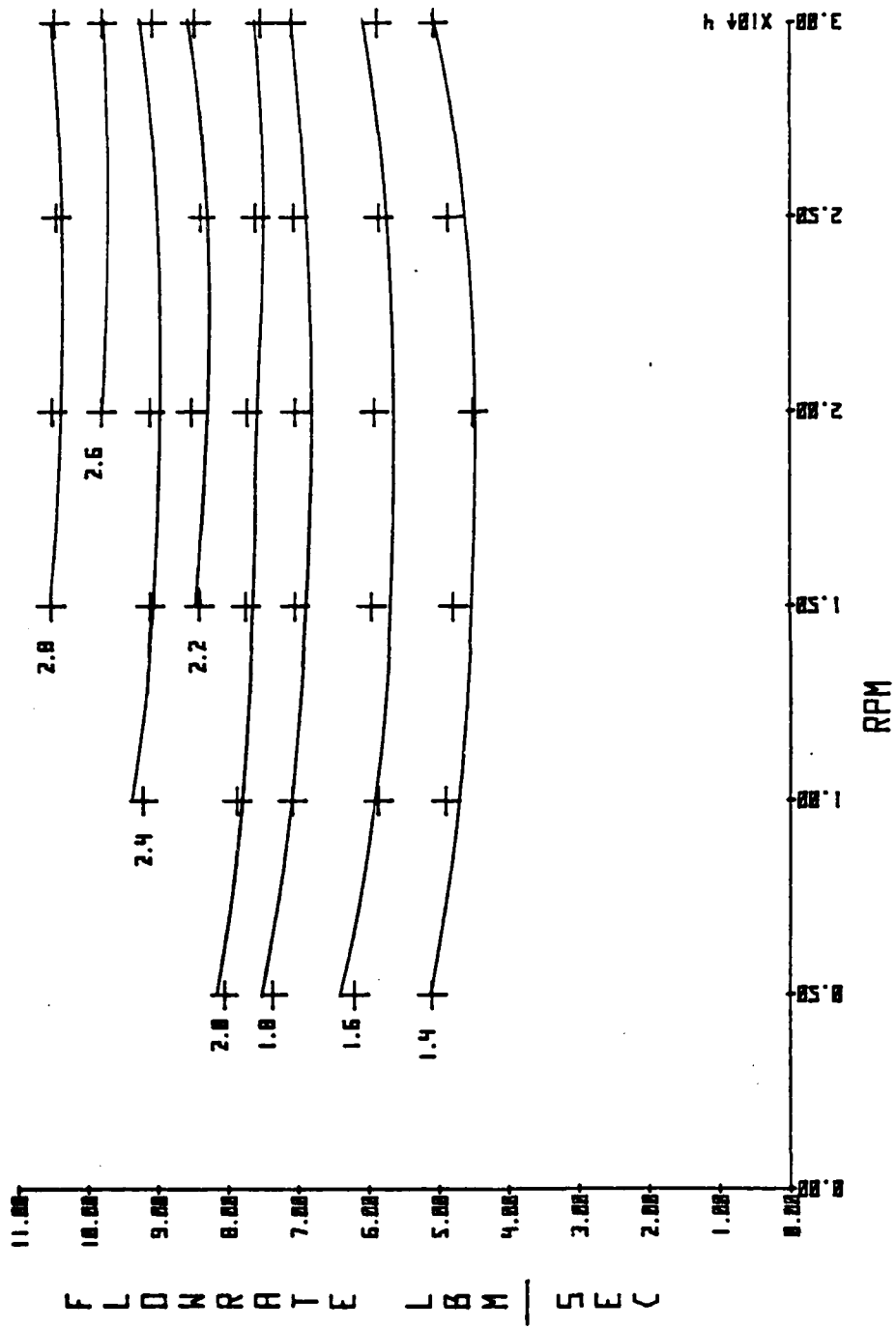


FIGURE 5: PREDICTED FLOWRATE VS RPM AS A FUNCTION OF PRESSURE RATIO AT TEMPERATURES TO AVOID CONDENSATION.

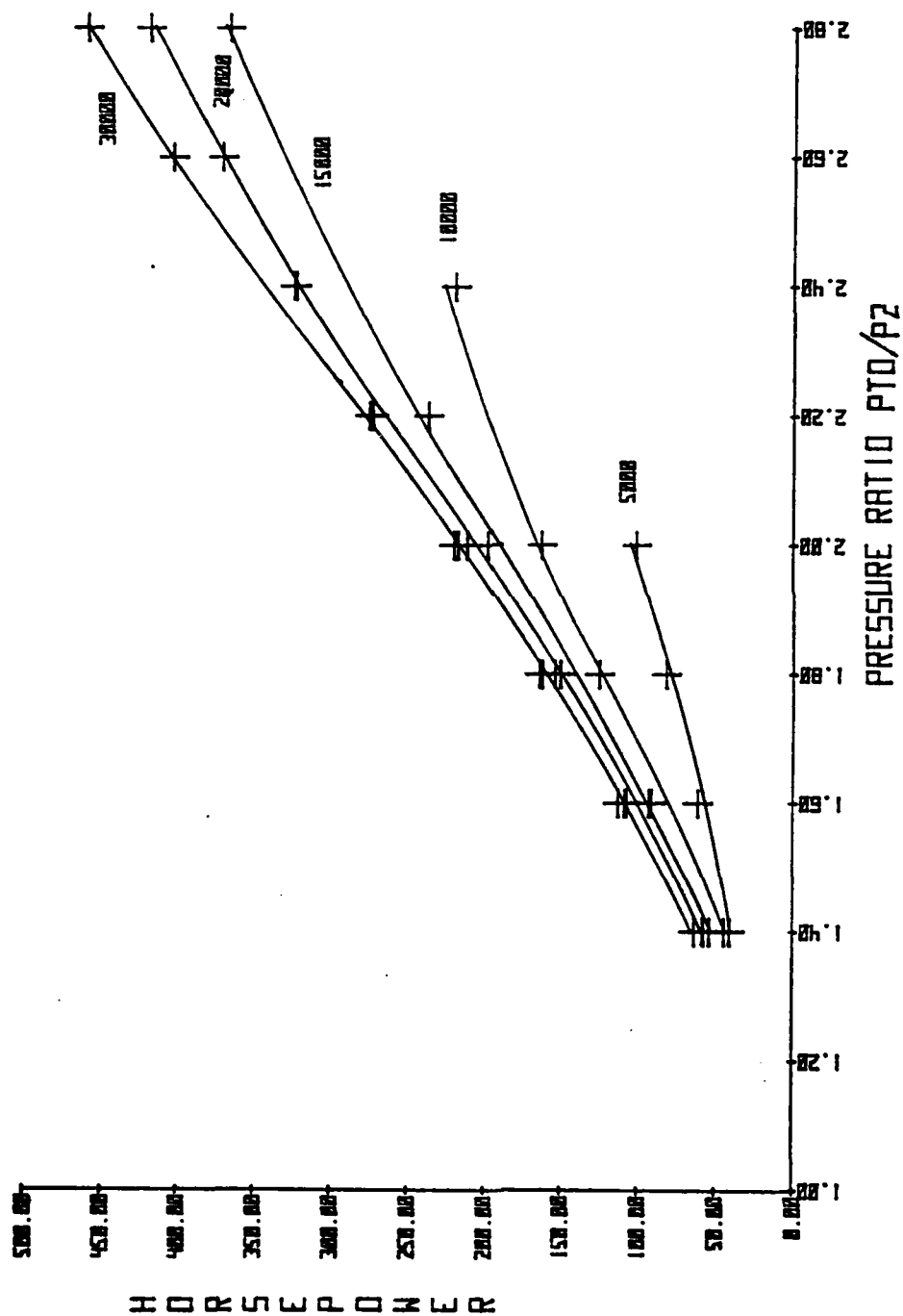


FIGURE 6: PREDICTED HORSEPOWER VS PRESSURE RATIO AS A FUNCTION OF RPM, AT TEMPERATURES TO AVOID CONDENSATION

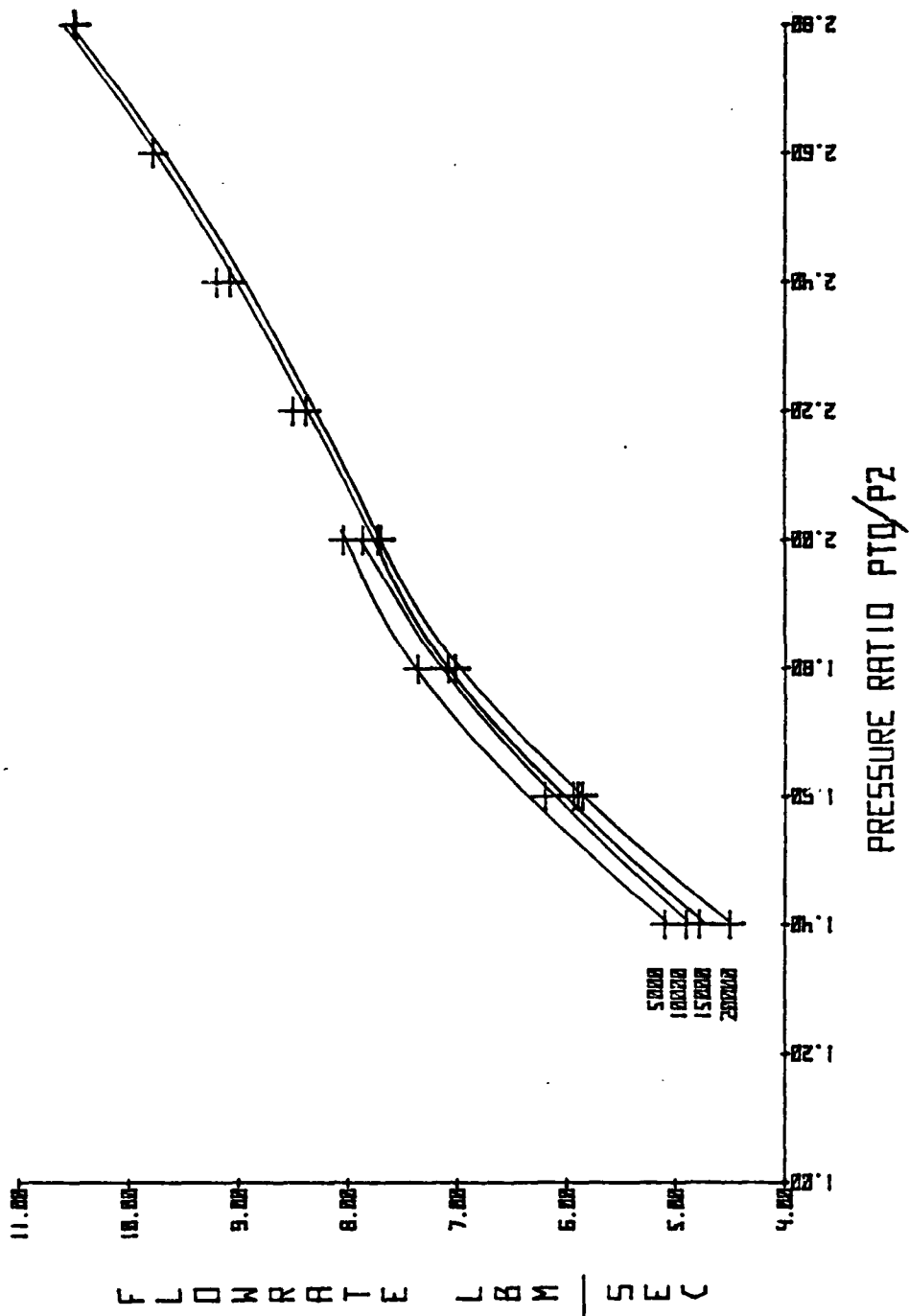


FIGURE 7: PREDICTED FLOW RATE VS PRESSURE RATIO AS A FUNCTION OF RPM AT TEMPERATURES TO AVOID CONDENSATION.

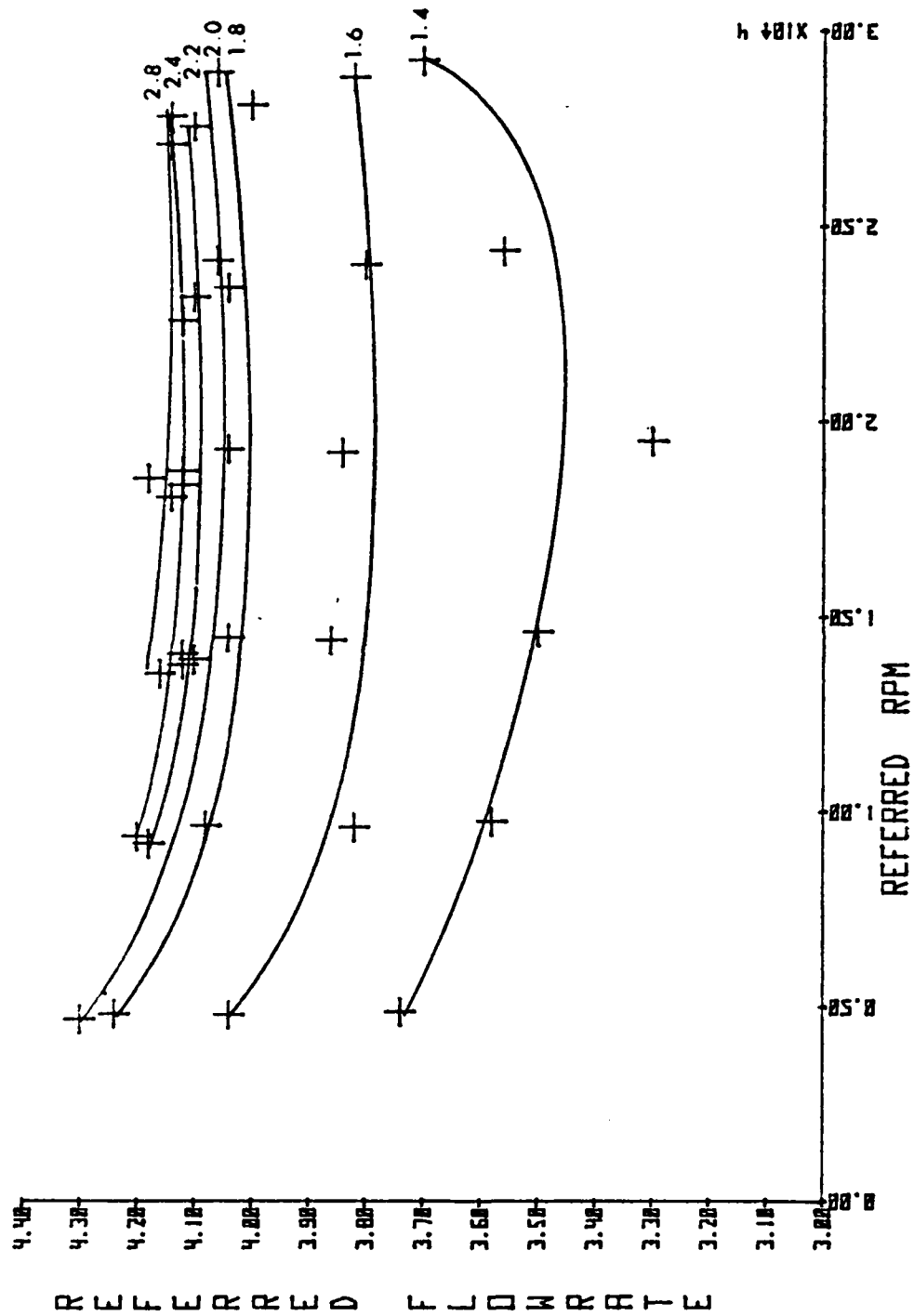


FIGURE 8: PREDICTED REFERRED FLOWRATE VS REFERRED RPM AS A FUNCTION OF PRESSURE RATIO

APPENDIX: A

DESCRIPTION OF THE COMPUTER PROGRAM

A-1. INTRODUCTION

To enable the program to run on the laboratory computer, the program was divided into 4 parts; a main program and 3 segments. A detailed discussion of program segmentation on the HP-1000 computer series is contained in Appendix C. In the description which follows, the program is treated as if it were one large program with many subroutines.

The description follows the individual steps from start to finish in the analysis. A program flowchart is given in Figure A-1 and the FORTRAN symbols used in the program are listed in Tables A-I to A-IX.

A-2. DESCRIPTION

A-2.1 Input Data

There are 4 basic categories of input data; turbine geometry, operating conditions, special data and program control parameters. Since there was no card reader input device on the computer, all data were entered using either data or specification statements. Explanations of the turbine geometry, operating conditions, special data and program control parameters are found in Table A-I through A-V. The nomenclature for the blading is given in Figure A-2.

A-2.2 Initial Geometric Calculations

The first calculation performed is to establish the 5 streamline locations at the stator inlet (station 0). The streamlines are initially positioned such that there are equal areas (25% of the total flow area) between them. Next, blade heights of the stator and rotor are calculated using the hub and tip radii of each blade. Blade spacings for the stator and rotor are computed at 3 streamlines; hub, mean and tip. The blade spacing on the mean streamline for the stator is given by

$$S = \frac{2\pi}{Z_s} R_m \quad (A-1)$$

where

S = Blade spacing

Z_s = Number of stator blades

R_m = Mean stator radius

A-2.3 Calculation of Gas Outlet Angles

Subroutine VAVRA calculates gas outlet angles for both stator and rotor. The method is that of M.H. Vavra [Ref. 1]. The equation programmed in the subroutine is

$$\alpha = \cos^{-1} \left[\frac{a}{S} + 4 \frac{t_e}{S} \left(1 - \frac{\cos^{-1}(\frac{a}{S})}{90} \right) \right] \quad (A-2)$$

where

α = Gas outlet angle

a = Throat opening

S = Blade spacing

t_e = Projected trailing edge thickness

This method is much simpler than that used by Macchi since

there is no variation in outlet angle with Mach number (for sub-sonic conditions). Therefore, once calculated, the stator and rotor exit angles remain unchanged. Subroutine VAVRA computes exit angles for the hub, mean and tip streamlines. The outlet angles at streamlines two and four are computed later in the subroutines STATR and ROTO2.

Before printing the input data, the program calculates the mean throat opening for the stator and for the rotor. The ten equally spaced radii and corresponding throat openings (part of the input geometry) are fitted with a fourth order Chebyshev polynomial. A throat opening corresponding to the mean radius is thus obtained. In the present application of the program to the drive turbine, the mean throat opening was obtained from the design drawing of the blading shown in Figure 2. It was assumed that the throat opening varied linearly with radial position and hence the throat openings at other radii could be calculated. The resulting throat openings are shown in the computer output under the heading of "Input Prints". The design values of the stator and rotor throat areas were obtained from the original design notes of M.H. Vavra.

A-2.4 Calculation of the Flow Rate

Subroutine CHAN is called to calculate the mass flow rate entering the stator. The equations used are as follows:

$$T = \frac{T_{T0}}{1 + \frac{\gamma-1}{2} M_0^2} \quad (A-3)$$

$$V = \sqrt{g_c \gamma R T} \quad (A-4)$$

$$P = \frac{P_{T0}}{1 + \frac{\gamma-1}{2} M_0^2} \quad (A-5)$$

$$\rho = P / R T \quad (A-6)$$

$$A = \pi [R_{TIP}^2 - R_{HUB}^2] \quad (A-7)$$

$$\dot{m} = \rho A V \quad (A-8)$$

$$\dot{m}_{REF} = \frac{\dot{m}}{P_{T0}} \sqrt{\frac{R T_{T0}}{g_c}} \quad (A-9)$$

$\dot{m}_{ref}$ is the reference (dimensionless) flowrate

and is used to check overall continuity later in the program.

A-2.5 Solution of the Equation of Motion for the Stator

Subroutine STATR is called to solve the equation of motion for the stator outlet conditions. The equation of motion which is programmed is as follows:

$$\begin{aligned} \frac{d(\ln Y_1^2)}{dX_1} = & -\cos^2 \alpha_1 \left[-\left(K 2 r_m \frac{\delta R}{L^2} \right) - \left(\frac{4L^2 + (\delta r)^2}{4L^2} \right) \right. \\ & \left. \frac{dS_1^*}{dX_1} \right] - 2 \tan \alpha \frac{d\alpha_1}{dX_1} - \frac{2}{X_1} \sin^2 \alpha_1 + \\ & \frac{C_1 \cos^2 \alpha_1}{Y_1^2 V_{a,im}^2} \frac{dH}{dX_1} - \left[\frac{C_1 H \cos^2 \alpha_1}{Y_1 V_{a,im}^2} - \sin^2 \alpha_1 \right] \frac{dS_1^*}{dX_1} \quad (A-10) \end{aligned}$$

where $C_1 = 2g_c J$ (a constant to convert H, the enthalpy from BTU/LBM TO $\frac{FT^2}{sec}$)

$$Y_1 = \frac{V_a(I)}{V_a(3)} = \frac{\text{Axial velocity at a streamline}}{\text{Axial velocity at mean streamline}}$$

$$X_1 = \frac{R(I)}{R_m} = \frac{\text{Streamline radius}}{\text{Mean streamline radius}}$$

$$\frac{ds^*}{dX_1} = \frac{d}{dX_1} \left[\ln \left[\frac{1 - \frac{Y_1^2 V_{a,m}^2}{C_1 H \cos^2 \alpha_1}}{1 - \frac{Y_1^2 V_{a,m}^2}{C_1 H \cos^2 \alpha (1-\xi)}} \right] \right]$$

ξ = Stator loss coefficient
(which is initially assigned an estimated value)

The derivation of this form of the equation of motion is given in Appendix B. However, at this stage of the analysis, the streamline curvature is assumed to be zero. Therefore, the equation of motion becomes:

$$\begin{aligned} \frac{d(\ln Y_1^2)}{dX_1} &= -2 \tan \alpha_1 \frac{d\alpha_1}{dX_1} - \frac{2}{X_1} \sin^2 \alpha_1 + \frac{C_1 \cos^2 \alpha_1}{Y_1^2 V_{a,m}^2} \\ \frac{dH}{dX_1} &= \left[1 - \frac{C_1 H \cos^2 \alpha_1}{Y_1^2 V_{a,m}^2} \right] \frac{ds^*}{dX_1} \end{aligned} \quad (A-11)$$

The equation of motion is solved when the value of Y_1 at each streamline satisfies the equation. The solution is to first put the equation in the form:

$$\frac{d(\ln Y_1^2)}{dX_1} = I(X) \quad (A-12)$$

where $I(X)$ consists of the right hand side of equation (A-11). Integrating equation (A-12) yields;

$$\ln Y_1^2 = \int_{x_0}^x I(x) dx + \ln c^2 \quad (A-13)$$

where $\ln c^2$ is the constant of integration when $x = 1$ and $Y_1 = 1$.

1. With these boundary conditions Eq. (A-13) gives

$$\ln c^2 = - \int_{x_0}^1 I(x) dx \quad (A-14)$$

using Eq. (A-14) in Eq. (A-13),

$$\ln Y_1^2 = \int_{x_0}^{x_1} I(x) dx - \int_{x_0}^1 I(x) dx \quad (A-15)$$

which becomes

$$\ln Y_1^2 = \int_1^{x_1} I(x) dx \quad (A-16)$$

Taking the inverse natural log and the square root of both sides

$$Y_1 = e^{\frac{1}{2} \int_1^x I(x) dx} \quad (A-17)$$

Equation (A-17) is the form of the equation of motion solved in subroutine STATR. Solution of the equation gives five values of Y_1 and thus the value of the axial velocity at each of the five streamlines. Initially, the value of Y_1 is taken to be 1 and the value of $\frac{ds^*}{dx_1}$ is taken to be zero. In succeeding iterations, the calculated value of Y_1 is used to obtain a new value of $\frac{ds^*}{dx_1}$, and so on.

After calculating five values of Y_1 , the stator exit conditions are calculated at each streamline from the geometry of the velocity diagram. The convention for positive

and negative angles and velocities is defined in Figure A-3.

The required relations are the following:

$$V_{a_1} = V_{a_1}(3) \cdot Y_1 \quad (A-18)$$

$$V_{u_1} = V_{a_1} \cdot \tan \alpha_1 \quad (A-19)$$

$$V_1 = V_{a_1} / \cos \alpha_1 \quad (A-20)$$

$$V_{R_1} = -V_{a_1} \left[\Delta R / 2L \right] \quad (A-21)$$

where L is the axial distance between stations and ΔR is the change in radial position of the streamline. V_{R_1} , the radial component of velocity, is taken to be zero at this stage in the calculation.

$$V_1 = \sqrt{V_1^2 + V_{R_1}^2} \quad (A-22)$$

$$T_1 = T_{T0} - \frac{V_1^2}{2g_c J C_p} \quad (A-23)$$

$$T_{1,3} = T_{T0} - \left[\frac{T_{T0} - T_1}{1 - f_s} \right] \quad (A-24)$$

$$P.R. = P_1 / P_{T0} \quad (A-25)$$

$$P_1 = P_{T0} \left[\frac{T_{1,3}}{T_{T0}} \right]^{\frac{\gamma}{\gamma-1}} \quad (A-26)$$

$$M_1 = V_1 / \sqrt{\gamma g_c R T} \quad (A-27)$$

After the above quantities have been calculated at each streamline, subroutine STATR returns to the main program.

A-2.6 Calculation of the Stator Loss Coefficients

The calculation of the stator loss coefficients at each streamline is accomplished by subroutine ALOS1.

The method of solution to obtain these loss coefficients is that formulated by Traupel [Ref. 7]. In Traupel's method, the value of the total loss coefficient is given by

$$\xi_{\text{total}} = \xi_{\text{profile}} + \xi_{\text{wall}} + \xi_{\text{remaining}} \quad (\text{A-28})$$

The calculation of ξ_{total} requires 9 subroutines. Figure A-4 describes the connection between the subroutines and subroutine ALOS1.

The first step is to obtain the value of the total profile loss coefficient, ξ_p . ξ_p is defined by Traupel to be

$$\xi_p = \xi_{p0} \chi_m \chi_s + \xi_m + \xi_f \quad (\text{A-29})$$

where ξ_{p0} = initial value of the profile loss coefficient

χ_m = mach number correction factor

χ_s = trailing edge thickness correction factor

ξ_m = loss coefficient due to mixing losses and separation losses

ξ_f = loss coefficient due to fan losses

The total profile loss coefficient is calculated in the following manner. First, data for initial profile loss (ξ_{p0}) as a function of gas outlet angle (α_1) for various values of gas inlet angle (α_0) is read from an array (Fig. A-5).

This is done by subroutine TRAU1 and functions XPO and YC. The values of ξ_{po} are contained in two arrays XPO1 (5, 8) and XPO2 (6, 8). This is because the data shown plotted in Fig. A-5 has been divided into two sets. One set is for values of α_1 between 40° and 80° . The other is for values of α_1 between 80° and 170° . The FORTRAN symbols for the two ranges of values of α_1 are ALFO1(I) and ALFO2(I) respectively. The FORTRAN symbol for the gas inlet angle is ALF1 (J) once the data points selected from the plot are entered, fifth and sixth degree polynomials respectively are fitted through the data points. The value of ξ_{po} can then be determined for given values of α_1 and α_0 .

The mach number correction, X_m is obtained from Fig. A-5. Subroutine CSIM calculates the value of X_m using straight line approximations of the plot.

Subroutine CID calculates the remaining terms in the expression for ξ_p . These are X_s , ξ_m , ξ_f . They are obtained from the data in Fig. A-6 using the linear interpolation. The abscissa of the curves for X_s and ξ_m is either f or $1-f$ where f is defined as

$$f = 1 - \frac{\delta}{t \sin \alpha_1} \quad (A-30)$$

where δ = normal trailing edge thickness.

t = blade spacing.

α_1 = gas outlet angle.

The loss coefficient due to wall friction, ξ_w , is calculated using

$$\xi_w \approx \xi_{PO} \cdot \chi_P \frac{t \sin \alpha}{l} \quad (A-31)$$

where t - blade maximum thickness

l = blade height

This equation is programmed in subroutine CSIW.

The value of ξ_R is obtained using subroutine CSIR.

ξ_R is defined by Traupel to be an all-inclusive loss coefficient which accounts for any remaining losses not previously defined. It is written as

$$\xi_R = \chi_L \xi_{RO} \quad (A-32)$$

ξ_{RO} is an initial value of ξ_R which depends on the value of ϕ , where ϕ is given by

$$\phi = \frac{V_1 \sin \alpha_1}{U} \quad (A-33)$$

in which v_1 = true velocity of gas

v = blade speed

A plot of ξ_{RO} vs ϕ is shown in Fig. A-7. The correction χ_L is a function of s/l where

s = chord length

l = blade height

and is obtained using the data in the lower half of Fig. A-7.

The total stator loss coefficient is computed for 3 streamlines; those at the hub, mean and tip.

The loss coefficients at streamlines 2 and 4 are obtained by linear interpolation.

A refinement to the stator loss coefficient may be applied depending on the input value of one program control parameter. The following 3 variations of ξ_s are available:

$$\xi_s = \frac{\left[\frac{1 + \xi_0}{1 + \xi_0 \frac{P}{P_{T0}}} \right]^{\frac{\gamma-1}{\gamma}} - 1}{\left[\frac{1}{\frac{P}{P_{T0}}} \right]^{\frac{\gamma-1}{\gamma}} - 1} \quad (\text{A-34})$$

$$\xi_s = \xi_0 \quad (\text{A-35})$$

and

$$\xi_s = \frac{\left[\frac{1 + \xi_0}{1 + \xi_0 \beta^*} \right]^{\frac{\gamma-1}{\gamma}} - 1}{\left[\frac{1}{\beta^*} \right]^{\frac{\gamma-1}{\gamma}} - 1} \quad (\text{A-36})$$

where ξ_0 = loss coefficient calculated using the method of Traupel

$$\beta^* = \left[1 + \frac{\gamma-1}{2} (.8)^2 \right]^{\frac{\gamma-1}{\gamma}} \quad (\text{A-37})$$

The values of the program control parameter required to select between options are given in Table A-V.

Before returning to the main program, subroutine ALOS1 calculates a value of ξ^* which is a blockage factor to be used in the equation of continuity. There are three ways to define ξ^* ; they are as follows:

$$\xi^* = \xi_0 \quad (A-38)$$

$$\xi^* = \frac{1}{2} \xi_0 \quad (A-39)$$

$$\xi^* = \xi_P \quad (A-40)$$

A-2.7 Solution of the Continuity Equation After Returning to the Main Program

The overall continuity at the stator exit is checked. Subroutine FLOWR performs this task. The flow chart for FLOWR is given in Fig. A-8. In FLOWR the mass flow rate required by continuity is checked against the calculated mass flow rate. If the calculated flow rate does not agree with that required by continuity, adjustments are made to the axial velocity and/or the inlet Mach number, as will be explained.

The mass flow required by continuity is

$$\dot{m}_{REQD} = \frac{\dot{m}_{REF}}{Z_s \cdot A_m R_m} \quad (A-41)$$

where $\dot{m}_{REF}$ = reference mass flowrate as computed in subroutine CHAN

Z_s = # of stator blades

A_m = mean stator throat opening

R_m = mean stator radius

The mass flow rate at each streamline computed in this subroutine is

$$\dot{m}_{ACT} = \left[\frac{P_{TE}}{P_{TO}} \right] \sqrt{\frac{T_{TE}}{T_{TO}}} \left[\frac{A(I)}{A(3)} \right] Z \Phi \quad (A-42)$$

where Z is an area reduction coefficient defined by

$$Z = \frac{H^{***} - 1}{H^{***} - 1 + \xi^*} \quad (A-43)$$

Z gives the percentage of flow area between the blades over which it is permissible to assume a uniform velocity. The boundary layer on both sides of the flow limits the available flow area and the block factor, Z , accounts for this. Equation A-43, Z is seen to be a function of the energy parameter H^{***} and ξ^* . ξ^* is the value of the loss coefficient returned from subroutine ALOS1. The energy parameter is defined as

$$H^{***} = \frac{\delta 3}{\delta 1} = \frac{\text{Energy thickness}}{\text{Displacement thickness}} \quad (\text{A-44})$$

H^{***} can be written as

$$H^{***} = \frac{\left[\frac{1}{X_E^{-1}} + \frac{1}{3m+1} + \frac{X_E}{5m+1} + \frac{X_E^2}{7m+1} + \frac{X_E^3}{9m+1} + \frac{X_E^4}{11m+1} \right]}{\left[\frac{1}{X_E^{-1}} + \frac{1}{m+1} + \frac{X_E}{3m+1} + \frac{X_E^2}{5m+1} + \frac{X_E^3}{7m+1} + \frac{X_E^4}{9m+1} \right]} \quad (\text{A-45})$$

where:

$$m = .15$$

$$X_E = 1 - \left(\frac{P}{P_{TO}} \right)^{\frac{\gamma-1}{\gamma}} \quad \text{for unchoked flow}$$

$$X_E = 1 - [P_{CRIT}]^{\frac{\gamma-1}{\gamma}} \quad \text{for choked flow}$$

and

$$P_{CRIT} = \left[\frac{2}{\gamma+1} \right]^{\frac{\gamma}{\gamma-1}}$$

The derivation of Z and H^{***} as given in Appendix B.

The expression for Φ , the flow function, for unchoked flow is

$$\Phi = \sqrt{\left(\frac{2\gamma}{\gamma-1} \right) \left(\frac{P}{P_{TO}} \right)^{\frac{\gamma}{\gamma-1}} - \left(\frac{P}{P_{TO}} \right)^{\frac{\gamma+1}{\gamma}}} \quad (\text{A-46})$$

and for choked flow is

$$\Phi = \left[\frac{2}{\gamma+1} \right]^{\frac{1}{\gamma-1}} \sqrt{\frac{2\gamma}{\gamma+1}} \quad (\text{A-47})$$

After calculating for each streamline, the flow rate is integrated from hub to tip and the resulting value is compared with $\dot{m}_{reqd}$. If the two values of flow rate agree to within a specified tolerance (see Table A-IV) continuity is considered to be satisfied. Then, after calculating the total percentage of mass flow between adjacent streamlines, subroutine FLOWR returns to the main program.

If the flow rates are not within tolerance the program checks to see if the actual mass flow is too high. If it is too high, the value of the axial velocity is lowered proportionally to the difference between the actual and required flow rates.

If the actual flow rate is too low, the procedure is more complicated. First, the flow is checked to determine whether choking has occurred. Streamlines one and five are checked. If the flow is in fact choked at those streamlines, the inlet Mach number is lowered and the program loops back to recompute the reference mass flow rate and repeat the complete procedure.

If the flow is not choked, the axial velocity is raised proportionally to the difference between actual and required flow rates and subroutine FLOWR returns to the main program.

A-2.8 Calculation of the Rotor Inlet Conditions

Continuity having been satisfied through the stator, the rotor relative inlet conditions are calculated. In subroutine ROT01, the following expressions are used:

$$U = \frac{\omega R}{12} \quad (A-48)$$

$$U_2 = \frac{\omega}{12} \cdot \frac{R_{\text{STATOR}}}{R_{\text{ROTOR}}} \quad (A-49)$$

$$W_{u1} = V_{u1} - U \quad (A-50)$$

$$\beta_1 = \tan^{-1} \left[\frac{W_{u1}}{V_{a1}} \right] \quad (A-51)$$

$$W_1 = \frac{V_{a1}}{\cos \beta_1} \quad (A-52)$$

$$W_1 = \sqrt{V_{R1}^2 + W_1^2} \quad (A-53)$$

$$T_{TE} = \frac{(T_1 + W_1)^2}{2g_c J_{cp} + \left(\frac{U_2^2 - U_1^2}{2g_c J_{cp}} \right)} \quad (A-54)$$

$$P_{TE} = P_1 \left[\frac{T_{TE}}{T_1} \right]^{\frac{\gamma}{\gamma-1}} \quad (A-55)$$

$$H_E = (T_{TE})(.24) \quad (A-56)$$

Where T_{TE} , P_{TE} and H_E are equivalent temperature, pressure and enthalpy respectively.

A-2.9 Calculation of the Rotor Exit Conditions

Calculation of the rotor exit properties follows the same procedure as was used to compute the stator exit properties. The process is outlined here with notable differences explained. Subroutine ROT02 calculates the rotor exit properties. A flowchart of ROT02 is given in Fig. A-9.

The first step in ROT02 is to solve the equation of motion for each streamline. The equation of motion in terms of relative quantities is

$$\begin{aligned} \frac{d(\ln Y_2^2)}{dX_2^2} = & -\cos^2 \beta_2 \left[2K r_m \frac{\delta r}{L^2} - \frac{L^2 + \left(\frac{\Delta R}{2}\right)^2}{L^2} \right. \\ & \left. \frac{ds^*}{dX} \right] - 2 \tan \beta_2 \frac{d\beta_2}{dX_2} - \frac{2}{X_2} \sin^2 \beta_2 - \frac{4U_m \cos \beta_2 \sin \beta_2}{Y_2^2 V_{a_2}^2} \\ & - \frac{2U_m U_2 \cos^2 \beta_2}{Y_2^2 V_{a_2}^2} + \frac{C_1 \cos^2 \beta_2}{Y_2^2 V_{a_2}^2} \cdot \frac{dH_E}{dX_2} + \\ & \left[1 - \frac{C_1 H_E \cos^2 \beta_2}{Y_2^2 V_{a_2}^2} \right] \cdot \frac{ds_2^*}{dX_2} \end{aligned} \quad (A-57)$$

At this point in the calculation, streamline curvature is neglected. Hence, Eq. (A-57) reduces to

$$\begin{aligned} \frac{d(\ln Y_2^2)}{dX_2} = & -2 \tan \beta_2 \frac{d\beta_2}{dX_2} - \frac{2}{X_2} \sin^2 \beta_2 - \\ & \frac{4 U_m \cos \beta_2 \sin \beta_2}{Y_2 V_{a_2}} - \frac{2 U_m U_2 \cos^2 \beta_2}{Y_2^2 V_{a_2}^2} + \\ & \frac{C_1 \cos^2 \beta_2}{Y_2^2 V_{a_2}^2} \frac{dH_E}{dX_2} + \left[1 - \frac{C_1 H_E \cos^2 \beta_2}{Y_2^2 V_{a_2}^2} \right] \frac{dS_2}{dX_2} \end{aligned} \quad (A-58)$$

The derivation of Eq. (A-57) is contained in Appendix B. Equation (A-55) is similar in form to Eq. (A-10). Hence, the method of solution is identical to that employed by subroutine STATR. However, after solving the equation, the value of Y_2 at each streamline is examined to determine whether or not it falls into the range $.2 < Y_2 < 2.0$. Values of Y_2 greater than 2.0 are set equal to 2.0 while those less than .2 are set equal to .2. Successive values of Y_2 at each streamline are compared, and when the values of successive iterations are within a specified tolerance (see Table A-IV), the iteration ends. The values of Y_2 are used to calculate the rotor exit conditions using the following equations:

$$V_{a_2} = V_{a_2} (3) Y_2 \quad (A-59)$$

$$W_2 = \frac{V_{a_2}}{\cos \beta_2} \quad (A-60)$$

$$W_{R_2} = \frac{(-V_{a_2}) \cdot D \cdot CL}{2} \quad (A-61)$$

$$T_2 = T_{TE} - \frac{W_2^2}{2g_c J c_p} \quad (A-62)$$

$$V_{u_2} = V_{a_2} \tan \beta_2 \quad (A-63)$$

$$W_{u_2} = V_{u_2} + U \quad (A-64)$$

$$T_{2s} = T_{TE} - \frac{T_{TE} - T_2}{1 - f_R} \quad (A-65)$$

$$P_2 = P_{TE} \left[\frac{T_{2s}}{T_{TE}} \right]^{\frac{\gamma}{\gamma-1}} \quad (A-66)$$

Subroutine ROT02, then returns to the main program.

After calculating the rotor outlet conditions, the rotor loss coefficients are computed. Subroutine ALOS2

calculates the rotor loss coefficients following the process used in subroutine ALOS1 for the stator losses. The principle exception is that a tip clearance loss is also calculated and added to the total loss coefficient. The tip clearance loss coefficient is obtained from subroutine ALEAK which uses a straight line approximation to the curve shown in Fig. A-10. Subroutine ALOS2 also computes values of ξ^* and one of the three refinements to ξ_R .

Subroutine FLOWR is called to check continuity at the rotor exit. If continuity is satisfied, the program continues. If not, the same procedure is followed as previously explained for the stator outlet (Fig. A-1).

A-2.10 Accounting for Streamline Curvature

All calculations to this point have neglected streamline curvature and assumed that the streamlines remain fixed through the stator and rotor (Fig. A-11). The radial shift in a streamline between stator inlet and rotor outlet can be written as

$$\Delta R = R_{\text{STATOR INLET}} - R_{\text{ROTOR OUTLET}} \quad (\text{A-67})$$

This is the net radial shift in a streamline between stations '0' (stator inlet) and '2' (rotor outlet). It is shown in Section 16.4 of Ref. [5] that the radial shift in a streamline between the stator and the rotor (station 1) can be written as

$$\delta R = R_{\text{STATOR OUTLET}} - \frac{1}{2} \left[R_{\text{STATOR INLET}} - R_{\text{ROTOR OUTLET}} \right] \quad (\text{A-68})$$

The angle between the meridional velocity V_m and the axial velocity V_1 is λ . The radial velocity V_r can be expressed as

$$V_R = V_a \tan \lambda \quad (\text{A-69})$$

and from Fig. 16(1) of Ref.[5], it follows that

$$\tan \lambda = \frac{-\Delta R}{2L} \quad (\text{A-70})$$

Using Eq. (A-68) in Eq. (A-67),

$$V_R = -V_a \frac{\Delta R}{2L} \quad (\text{A-71})$$

where $\frac{\Delta R}{2L}$ = Average streamline slope

Also, from using Eq. (A-68)

$$\cos \lambda = \frac{2L}{\sqrt{\Delta R^2 + (2L)^2}} \quad (\text{A-72})$$

Rearranging;

$$\cos \lambda = \frac{L^2}{L^2 + \left(\frac{\Delta R}{2}\right)^2} \quad (\text{A-73})$$

The remaining term used in the calculation of streamline curvature (Section 16-4 of Ref. [5]) is

$$K \frac{\delta R}{L^2}$$

where K is the so called curvature factor. It usually has a value between 4 and 6 and in the program its value is taken to be 5. Having calculated $\cos\lambda$, ΔR and δR , the program repeats the solution process. However, the only quantity which is unchanged is the reference mass flow rate $\dot{m}_{ref}$. In subroutine STATR the equation of motion is solved, this time accounting for streamline curvature. The same is true in subroutine ROT02.

The flow path of the program is identical to the section which did not account for streamline curvature. Next, the program computes an average pressure ratio at the rotor outlet using the expression

$$\frac{P_2}{P_{T0}} = \left(\frac{P_2}{P_{T0}} \right)_{\text{STREAMLINE}_1} + \frac{1}{4} \left[\left(\frac{P_2}{P_{T0}} \right)_{\text{S.L.}_2} + \left(\frac{P_2}{P_{T0}} \right)_{\text{S.L.}_3} + \left(\frac{P_2}{P_{T0}} \right)_{\text{S.L.}_4} + \left(\frac{P_2}{P_{T0}} \right)_{\text{S.L.}_5} \right] \quad (\text{A-74})$$

If this pressure ratio is within a specified tolerance to the actual pressure ratio (which is input data) the program

proceeds to the final stage of the calculations. If not, the inlet mach number is adjusted by an amount which depends on the difference between the calculated and specified pressure ratios. If the calculated pressure ratio is too high, the Mach number is lowered using

$$M_o = M_o - \frac{\text{Pressure Ratio Difference}}{18} \quad (A-75)$$

If the computed pressure ratio is too low, the Mach number is raised using

$$M_o = M_o + \frac{\text{Pressure Ratio Difference}}{18} \quad (A-76)$$

In both cases, the program loops back to subroutine CHAN and proceeds to compute a new reference mass flow rate based on the new value of the inlet Mach number. The entire process is then repeated until the pressure ratios agree within the specified tolerance.

A-2.11 Final Calculations

Stator and rotor outlet conditions not previously calculated are computed as follows:

$$\alpha_2 = \text{TAN}^{-1} \left[\frac{V_{u2}}{V_{a2}} \right] \quad (A-77)$$

$$V_2 = \frac{V_{a2}}{\cos \alpha_2} \quad (A-78)$$

$$V_2 = \sqrt{V_2^2 + W_{R2}^2} \quad (A-79)$$

$$\Delta h = \frac{U V u_1 - U_2 V u_2}{g_c J} \quad (A-80)$$

$$T_{T2} = T_{T0} - \frac{\Delta h}{C_p} \quad (A-81)$$

$$P_{T2} = P_2 \left[\frac{T_{T2}}{T_2} \right]^{\frac{\gamma}{\gamma-1}} \quad (A-82)$$

$$P_{T1} = P_1 \left[\frac{T_{T0}}{T_1} \right]^{\frac{\gamma}{\gamma-1}} \quad (A-83)$$

$$T_{2,1s} = T_{T0} \left[\frac{P_2}{P_{T0}} \right]^{\frac{\gamma-1}{\gamma}} \quad (A-84)$$

$$\begin{array}{l} \text{ROTOR EXIT} \\ \text{RELATIVE MACH \#} \end{array} = \frac{W_2}{\sqrt{\gamma R g_c T_2}} \quad (A-85)$$

$$T_{T1s} = T_{T0} \left[\frac{P_{T2}}{P_{T0}} \right]^{\frac{\gamma-1}{\gamma}} \quad (A-86)$$

$$\eta_{T-T} = \frac{T_{T0} - T_{T2}}{T_{T0} - T_{T1s}} \quad (A-87)$$

$$\eta_{T-S} = \frac{T_{T0} - T_{T2}}{T_{T0} - T_{21s}} \quad (A-88)$$

$$\text{Stator Blade Efficiency} = \frac{T_{T0} - T_1}{T_{T0} - T_{11s}} \quad (A-89)$$

$$\text{Rotor Blade Efficiency} = \frac{T_{TE} - T_2}{T_{T0} - T_{21s}} \quad (A-90)$$

$$r^* = \frac{T_{11s} - T_{21s}}{T_{T0} - T_{21s}} \quad (A-91)$$

$$\text{Head Coefficient} = \frac{2 g_c J (T_{T0} - T_{21s})}{U^2} \quad (A-92)$$

$$\text{Blade-Jet Ratio} = [\text{Head Coefficient}]^{-1} \quad (A-93)$$

$$\text{Stator Exit Relative Mach \#} = \frac{W_1}{\sqrt{\gamma R g_c T_1}} \quad (A-94)$$

The turbine horsepower is obtained by integration. The Δh term at each streamline is weighted by the percentage of mass flow at that streamline. The product is then integrated from hub to tip and result, $\Delta \bar{h}$, is used in the turbine horsepower equation

$$H.P. = \frac{\Delta \bar{h} \cdot J \cdot \dot{m}}{550} \quad (A-95)$$

The moment is calculated using

$$M = \frac{(H.P.)(550)}{\omega} \quad (A-96)$$

Referred horsepower, moment, mass flow and RPM are calculated using

$$H.P._{REF} = \frac{H.P.}{\theta \delta} \quad (A-97)$$

$$M_{REF} = \frac{M}{\delta} \quad (A-98)$$

$$\dot{m}_{REF} = \frac{\dot{m} \theta}{\delta} \quad (A-99)$$

$$RPM_{REF} = \frac{RPM}{\theta} \quad (A-100)$$

where

$$\Theta = \frac{T_{T0}}{518.4}$$

$$\delta = \frac{P_{T0}}{14.7}$$

The values of the total-static efficiency, total-total efficiency, total-static pressure ratio, total-total pressure ratio, head coefficient, blade/jet ratio, r^* and inlet mach number are then averaged.

With all calculations completed, the results are printed under the heading "STATOR SOLUTION", "ROTOR SOLUTION", and "OVERALL TURBINE CHARACTERISTICS".

TABLE A-I

TURBINE GEOMETRIC INPUT DATA (STATOR)
(see Figure A-2; Dimensions in inches)

<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
ZS	Number of blades
RS(1)	Hub radius at stator outlet
RS(3)	Mean radius at stator outlet
RS(5)	Tip radius at stator outlet
C	Blade chord (mean)
CI	Blade chord (hub)
CO	Blade chord (tip)
E	Blade curvature (mean)
EI	Blade curvature (hub)
EO	Blade curvature (tip)
T	Maximum blade thickness (mean)
TI	Maximum blade thickness (hub)
TO	Maximum blade thickness (tip)
TE	Projected T.E. thickness (mean)
TEI	Projected T.E. thickness (hub)
TEO	Projected T.E. thickness (tip)
TN	Normal T.E. thickness (mean)
TNI	Normal T.E. thickness (hub)
TNO	Normal T.E. thickness (tip)
Al(1-10)	Ten values of throat diameter at 10 equally spaced radii

FORTTRAN SYMBOL	DESCRIPTION
AL	Blade camber line length (mean)
ALI	Blade camber line length (hub)
ALO	Blade camber line length (tip)
RC(1)	Hub radius at stator inlet
RC(3)	Mean radius at stator inlet
RC(5)	Tip radius at stator inlet

TABLE A-II

TURBINE GEOMETRIC INPUT DATA (ROTOR)
(see Figure A-2; Dimensions in inches)

FORTRAN SYMBOL	DESCRIPTION
ZR	Number of blades
RR(1)	Hub radius
RR(3)	Mean radius
RR(5)	Tip radius
CR	Blade chord (mean)
CIR	Blade chord (hub)
COR	Blade chord (tip)
ER	Blade curvature (mean)
EIR	Blade curvature (hub)
EOR	Blade curvature (tip)
TR	Maximum blade thickness (mean)
TIR	Maximum blade thickness (hub)
TOR	Maximum blade thickness (tip)
TER	Projected T.E. thickness (mean)
TEIR	Projected T.E. thickness (hub)
TEOR	Projected T.E. thickness (tip)
TNR	Normal T.E. thickness (mean)
TNIR	Normal T.E. thickness (hub)
TNOR	Normal T.E. thickness (tip)
TIPC	Tip clearance

FORTRAN SYMBOL	DESCRIPTION
A2(1-10)	10 values of throat diameter at 10 equally spaced radii
ALR	Blade camber line length (mean)
ALIR	Blade camber line length (hub)
ALOR	Blade camber line length (tip)
CV	Axial distance between stations
CK	Curvature Factor

TABLE A-III

TURBINE OPERATING CONDITIONS (INPUT DATA)

<u>FORTTRAN SYMBOL</u>	<u>DESCRIPTION</u>
AMC	Assumed inlet Mach number
AMS	Assumed stator exit Mach number (absolute)
AMR	Assumed stator exit Mach number (relative)
PTO	Total inlet pressure (P_{TO})
TTO	Total inlet temperature (T_{TO})
PR	Total-static pressure ratio
RPM	Operating speed (RPM)
VA1(3)	Assumed axial velocity in stator
VA2(3)	Assumed axial velocity in rotor

TABLE A-IV

SPECIAL INPUT DATA

<u>FORTRAN SYMBOL</u>	<u>DESCRIPTION</u>
TOL 1	Tolerance for convergence of equation of continuity
TOL 2	Tolerance for between-S.L. continuity (not used)
TOL 3	Tolerance in pressure ratio convergence
TOL 4	Tolerance in equation of motion convergence

TABLE A-V

PROGRAM CONTROL PARAMETERS

FORTRAN SYMBOL	POSSIBLE VALUE	EFFECT/MEANING
IND	1	Prints results in sub-routines STATR, FLOWR, ROTO2
	1	No printing in the above
ICL	1	Rotor is shrouded
	1	Rotor not shrouded
ICOZ	1	$\xi = \xi_0$
	6	$\xi = \xi$ (Y Pressure Ratio)
	8	$\xi = \xi_{M=.8}$
ICON	1	$\xi = .5 \xi_{TOTAL}$
	2	$\xi = \xi_{PROFILE}$
	3	$\xi = \xi_{TOTAL}$

TABLE A-VI

FORTTRAN SYMBOLS IN THE MAIN PROGRAM

FORTTRAN SYMBOLS	DESCRIPTION
BESP	$\beta^* = [1 + \frac{\gamma-1}{2} \cdot (.8)^2] \frac{\gamma-1}{\gamma}$
OI	Stator throat opening (hub)
OO	Stator throat opening (tip)
OIR	Rotor throat opening (hub)
ORR	Rotor throat opening (tip)
O	Stator throat opening (mean)
OR	Rotor throat opening (mean)
ANG2I	Stator gas outlet angle (hub)
ANG2O	Stator gas outlet angle (tip)
BETAI	Rotor gas outlet angle (hub)
BETAZ	Rotor gas outlet angle (tip)
G	Grav. constant, 32.174 $\frac{\text{FT.LBM}}{\text{LBF.sec}^2}$
CJ	778.16 FT.LBF/BTU
EXP1	$\gamma/\gamma - 1$
EXP2	γ^{-1}/γ
ERRE	Gas constant, 53.3459 $\frac{\text{FT.LBF}}{\text{LBM.OR}}$
EMME	Molecular mass, 28.970 LBM/LB MOLE
GAM	γ , Ratio of specific heats
ETAT	Total-total efficiency
ETAI	Total-static efficiency
ETAS	Stator blade efficiency

FORTTRAN SYMBOL	DESCRIPTION
ETAR	Rotor blade efficiency
RSTAR	Theoretical degree of reaction
ALOS	Head coefficient
BLAJE	Blade/jet ratio
DR1	Radial shift of steamlines
AMW1	Stator exit relative Mach Number
AMS1	Stator exit absolute Mach Number
AMV2	Rotor exit absolute Mach Number
AMR2	Rotor exit relative Mach Number
DELH	Δ
HP	Horsepower
AMOM	Moment
THETA	θ
DELTA	δ
HP1	Referred H.P.
AMOM1	Referred moment
RPM1	Referred RPM
WLBM1	Referred mass flow rate
ETA5	Average total-static efficiency
BETA6	Average total-total pressure ratio
ETA6	Average total-total efficiency
AKIS5	Average head coefficient
RSTAR5	Average theoretical degree of reaction

TABLE A-VII

FORTTRAN SYMBOLS IN SUBROUTINE CHAN

FORTTRAN SYMBOLS	DESCRIPTION
TTO	T_{TO} , total temp. at station $\emptyset$
AMC	Inlet Mach number
PTO	P_{TO} , total pressure at station $\emptyset$
RC (I)	Streamline radii at station $\emptyset$
WLBM	$\dot{M}$, required mass flow, ρAV
TC	Static temperature
VC	Velocity
PC	Static pressure
RHO	ρ , density of air
WCHAN	$\dot{M}_{REF}$, reference mass flow
WPERO	% of $\dot{M}$ at each streamline

TABLE A-VIII

FORTTRAN SYMBOLS IN SUBROUTINE STATR

FORTTRAN SYMBOL	DESCRIPTION
ALFA1	Stator gas outlet angle
X	Ratio of streamline radius/ mean radius
AMS	Mach Number at station 1
T	Static temperature
P	Static pressure
V1	Absolute velocity
VA1	Axial velocity
Y	Ratio of axial velocity to mean axial velocity
S	Entropy
DSDX	Entropy gradient between streamlines
VU1	Tangential velocity
PRAT	(Total-static pressure ratio) ⁻¹
T1IS	T_{1IS}
DALF	$\frac{d\alpha}{dx}$
RSF	Mean stator radius
DELR	$R_{\text{Stator in}} - R_{\text{rotor out}}$
ZETAPS	ξ_p
ZETAS	ξ_s
VR1	Radial velocity

TABLE A-IX

FORTTRAN SYMBOLS IN SUBROUTINE TRAU2

FORTTRAN SYMBOL	DESCRIPTION
CSIP	X_p , correction to
R	ξ_{po} , initial profile loss coefficient
ANG1	Gas outlet angle
ANG2	Gas inlet angle
R1	X_m , Mach No. correction
R3	ξ_R , remaining loss coefficient
R2	ξ_W , loss coefficient due to wall friction
RPRO	ξ_p , total profile loss coefficient
CL	Rotor tip clearance
YCL	Tip clearance loss coefficient
RTOT	Total loss coefficient
T	Blade spacing
DEZ	Normal trailing edge thickness
HM	Blade height
CSID	X_δ , trailing edge thickness correction factor
PSID	ξ_f , loss coefficient due to fan losses
PSIF	ξ_m , loss coefficient due to mixing and separation
UM	Tip speed

TABLE A-X

FORTRAN SYMBOLS IN SUBROUTINE FLOWR

FORTRAN SYMBOL	DESCRIPTION
PRATCR	Critical pressure ratio
PHICR	ϕ_{CRIT} , critical flow function
HSTAR	H***, energy parameter
XI	Z, area reduction coefficient
PHI	ϕ , flow function (unchoked flow)
ARAT	Streamline throat DIA/mean throat DIA
SUM 1,2,3,4	Successive values of the flow integral
AS	Mean stator throat diameter
AR	Mean rotor throat diameter
WREQ	$\dot{M}$ required to satisfy continuity
WSUM	$\dot{M}$ calculated
WPER	% of $\dot{M}$ at each streamline

TABLE A-XI

FORTTRAN SYMBOLS IN SUBROUTINE ROT01

FORTTRAN SYMBOL	DESCRIPTION
OMEG.	ω , wheel speed (RAD/sec)
U	$\omega \cdot R_{\text{stator mean}}$
U2	$\omega \cdot R_{\text{rotor mean}}$
	$R_{\text{stator mean}}$
WU1	W_{u1} see figure A-3
BETA1	β_1 , see figure A-3
W1	W_1 , see figure A-3
TTE	Equivalent temperature
PTE	Equivalent pressure
HE	Equivalent enthalpy
ZETAR	ξ_R rotor loss coefficient
ZETAPR	ξ_p , rotor profile loss coefficient
DHEDX	Enthalpy gradient between streamlines
DSDX	Entropy gradient between streamlines

TABLE A-XII

FORTTRAN SYMBOLS IN SUBROUTINE ROTO2

FORTTRAN SYMBOL	DESCRIPTION
BETA2	β_2 , see figure A-3
DBETDX	$\frac{d\beta}{dx}$ between adjacent streamlines
VA2	V_{a2} , axial velocity
W2	W_2 , see figure A-3
CL	Axial distance between stations
WR2	Radial component of velocity
WU2	Wu_2 , see figure A-3
VU2	Vu_2 , see figure A-3
AMR	Relative Mach No. at rotor exit
T2	T_2
T2S	T_{2s}
P2	P_2
PRAT2	[Total-static pressure ratio] ⁻¹

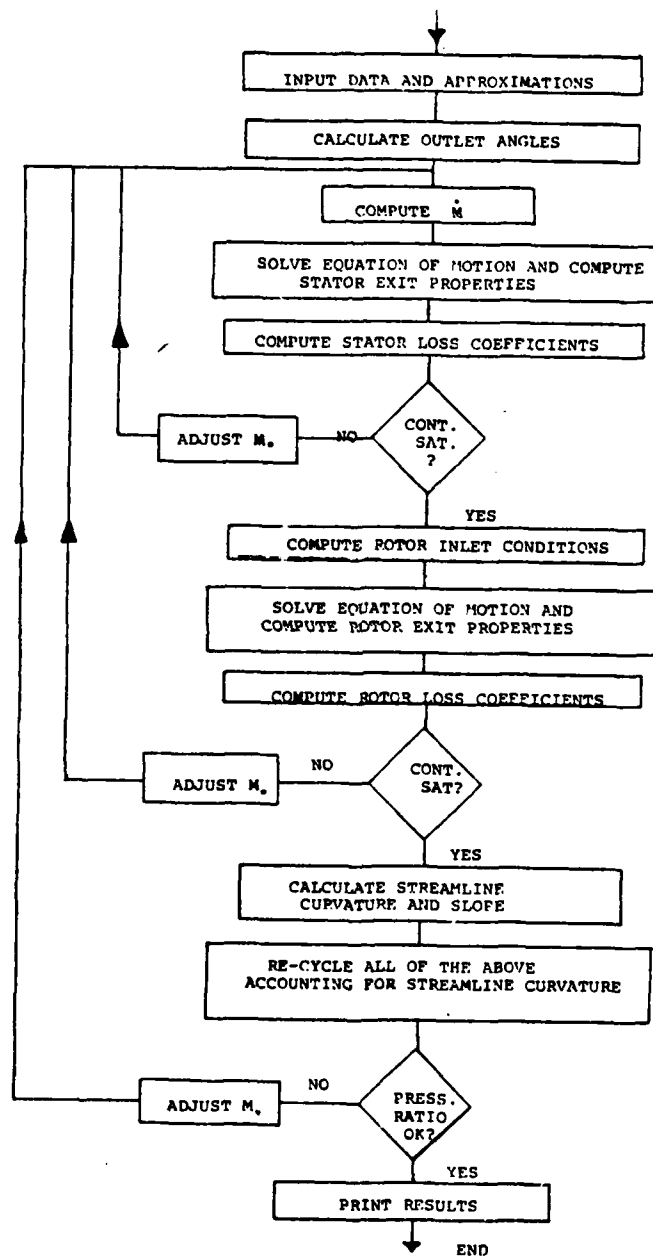


FIGURE A-1: PROGRAM FLOWCHART

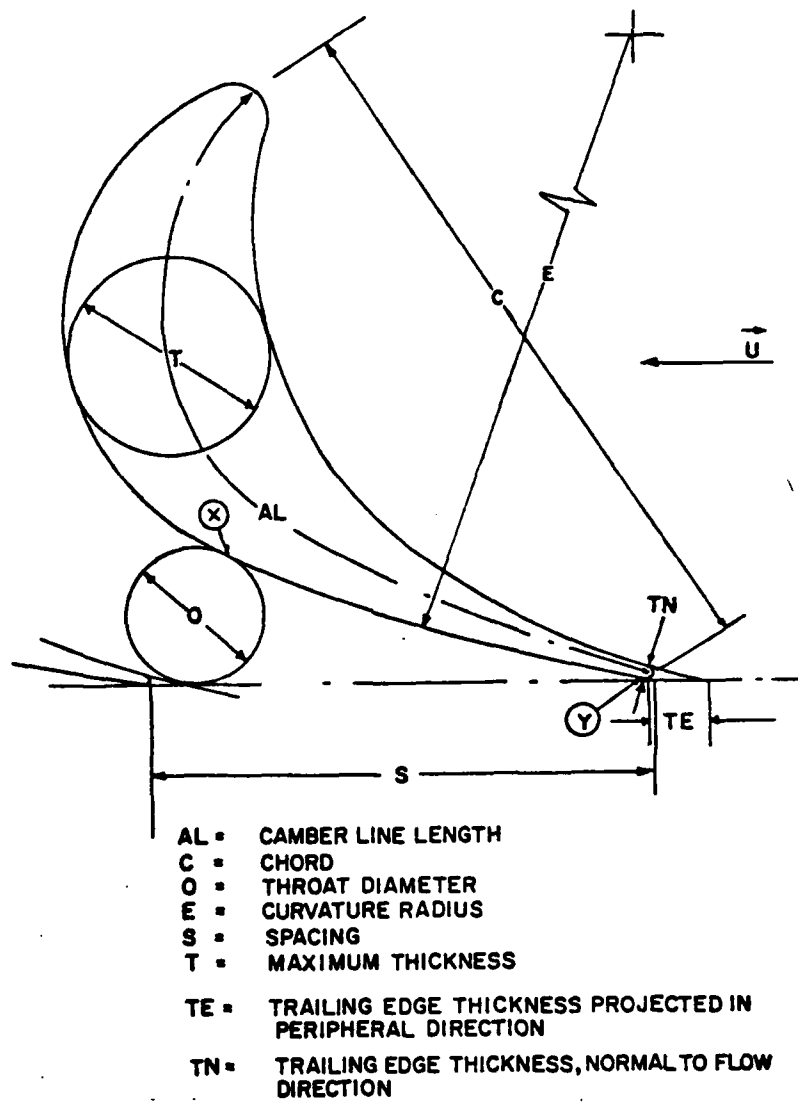


FIGURE A-2: BLADE NOMENCLATURE

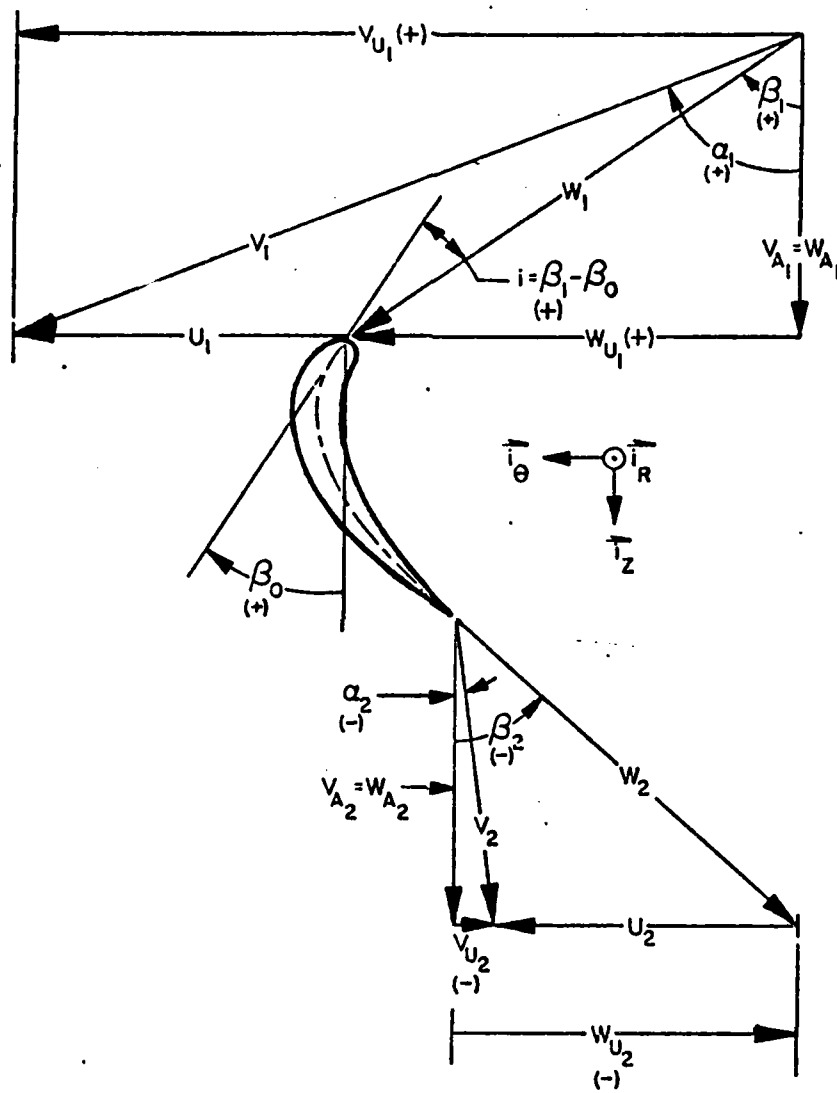


FIGURE A-3: VELOCITY DIAGRAM NOMENCLATURE

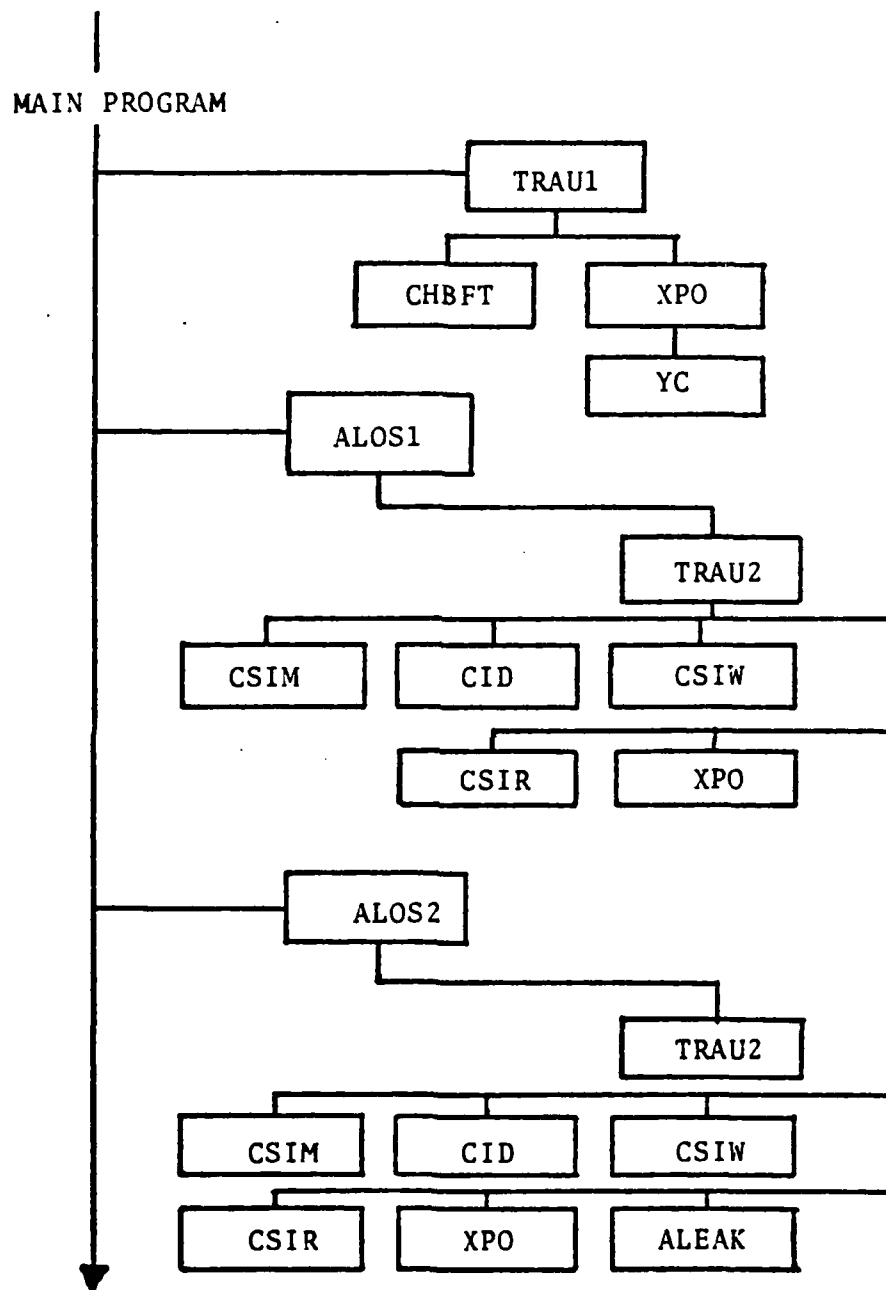


FIGURE A-4: INTERCONNECTION OF THE SUBROUTINES IN THE TRAUPEL METHOD

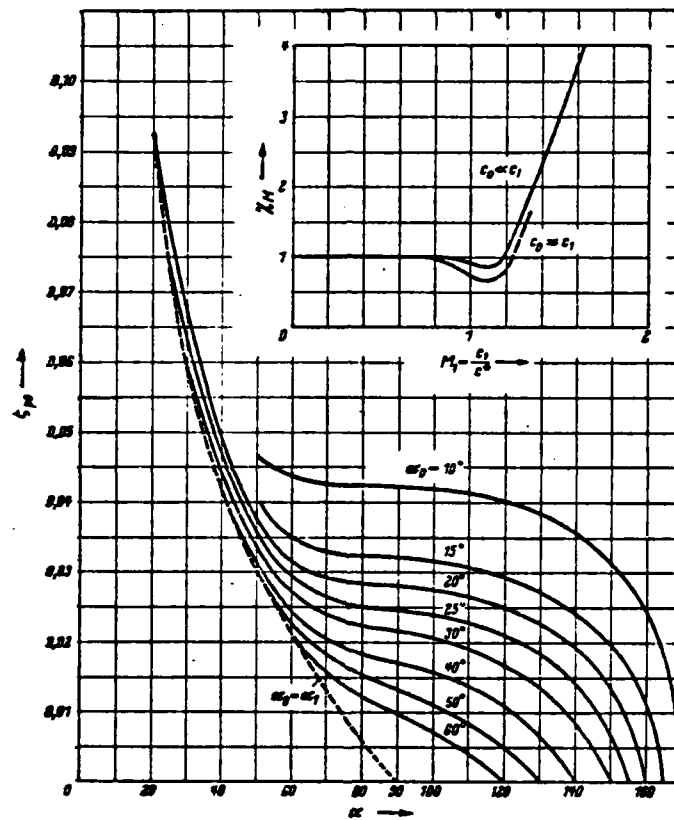


Abb. 8.4.2 Grundwert ζ_{p0} des Profilverlustes für Beschleunigungsgitter und Machzahlkorrektur Z_M

FIGURE A-5: INITIAL PROFILE LOSS COEFFICIENT AND MACH NUMBER CORRECTION FROM TRAUPEL

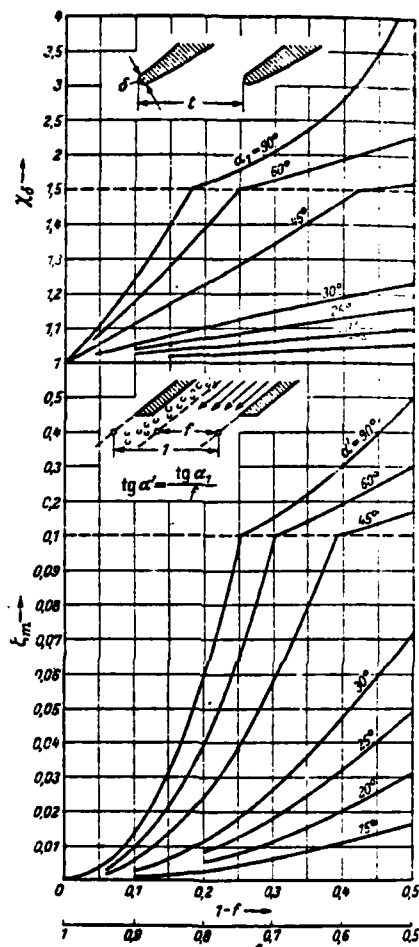


Abb. 8.4.4. Korrekturfaktor χ_s und Mischverlust ζ_m infolge endlicher Austrittskantendicke oder Ablösung

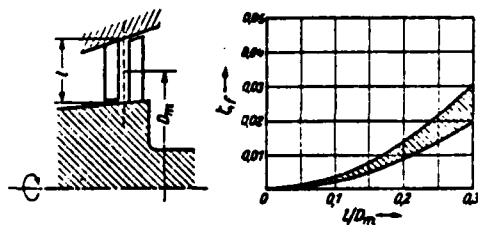


Abb. 8.4.5. Fächerverlust ζ_f

FIGURE A-6: T.E.THICKNESS CORRECTION FACTOR, MIXING LOSS COEFFICIENT AND FAN LOSS COEFFICIENT FROM TRAUPEL

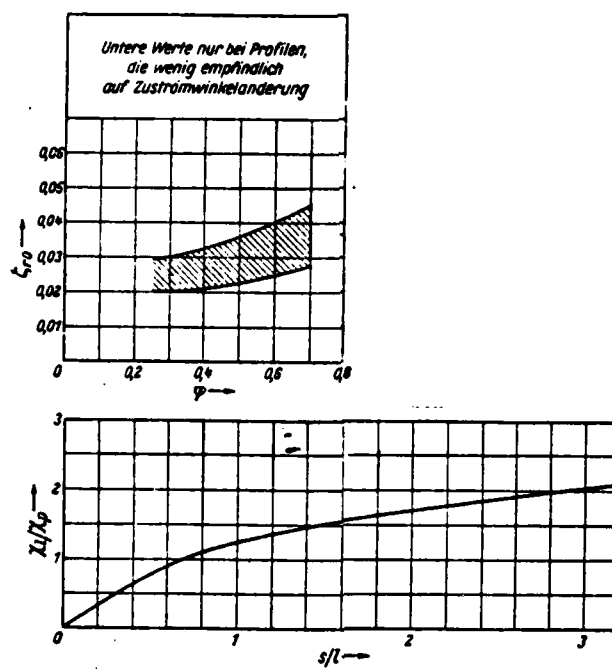


Abb. 8.4.7 Randverlust in Turbinenschaufelungen

FIGURE A-7: "REMAINING" LOSS COEFFICIENT FROM TRAUPEL

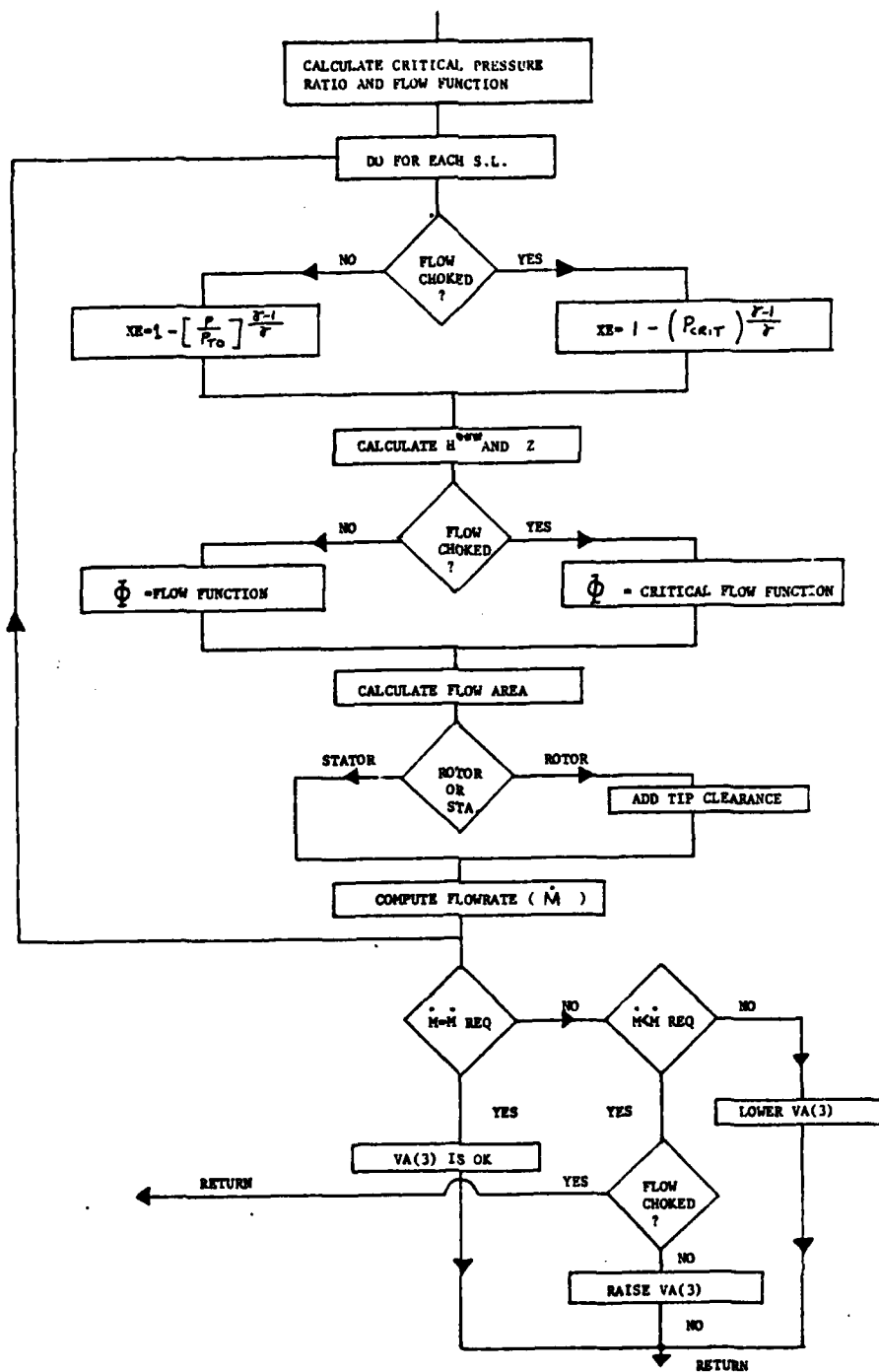


FIGURE A-8: SUBROUTINE FLOWR FLOWCHART

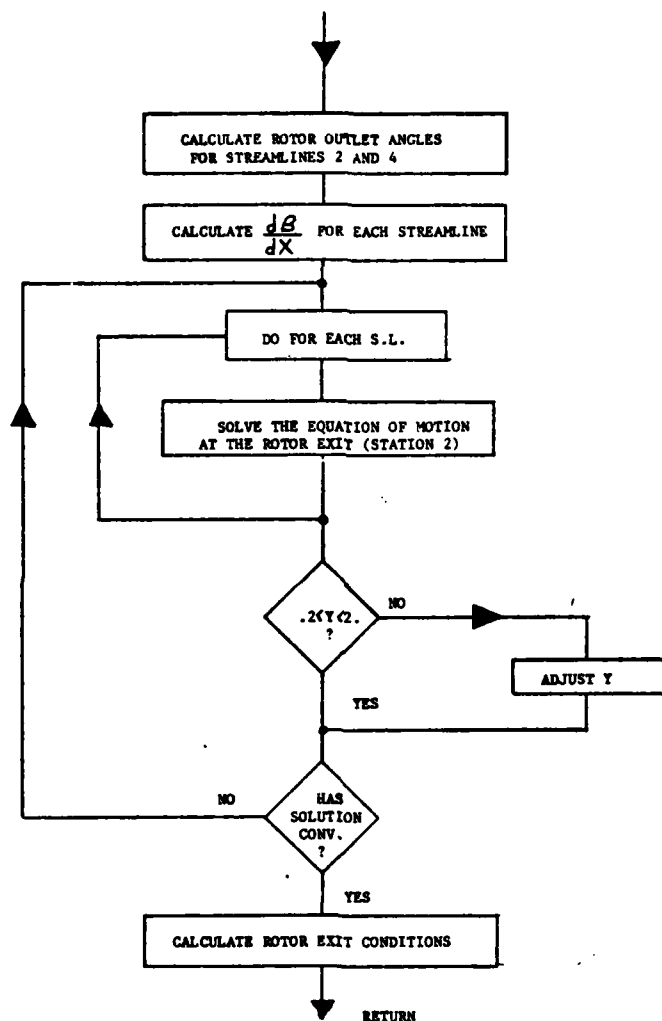


FIGURE A-9: SUBROUTINE ROTO2 FLOWCHART

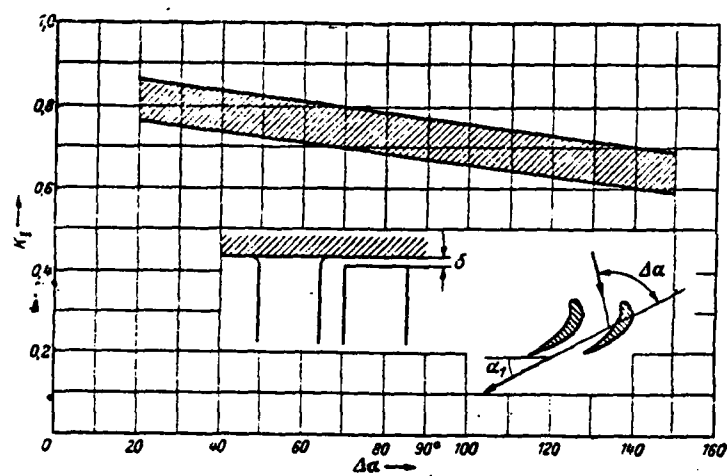


Abb. 8.4.11 Faktor K_I für Spaltverlustberechnung

FIGURE A-10: TIP LEAKAGE LOSS COEFFICIENT PLOT FROM TRAUPEL

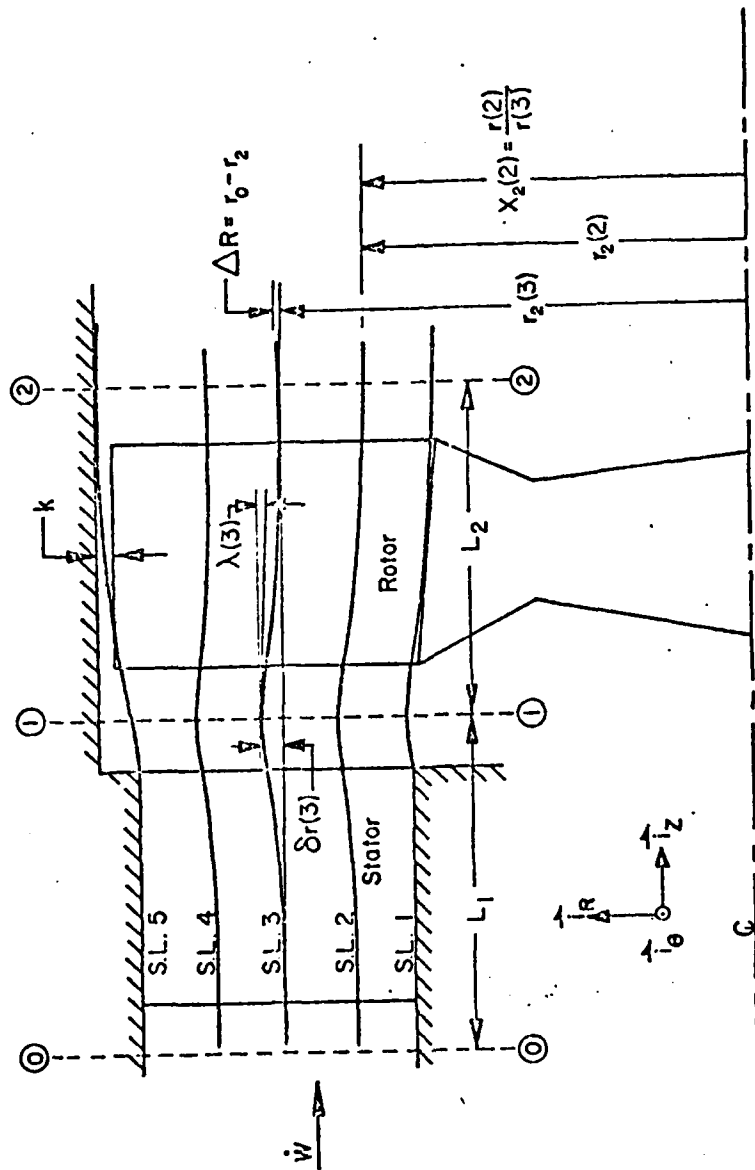


FIGURE A-11: STREAMLINE COORDINATES

APPENDIX: B

DERIVATION OF EQUATIONS USED IN THE PROGRAM

B-1. EQUATION OF MOTION FOR RELATIVE FLOW:

The equation of motion for relative flow Ref. [5] is

$$\nabla H_R = \vec{W} \times (\nabla \times \vec{W} + 2\vec{\omega}) + T \nabla S \quad (B-1)$$

Using cylindrical coordinates, the terms of EQN (B-1) may be expressed as follows:

$$\nabla H_R = \frac{i_\theta}{r} \frac{\partial H_R}{\partial \theta} + i_z \frac{\partial H_R}{\partial z} + i_r \frac{\partial H_R}{\partial r} \quad (B-2)$$

$$\nabla \times \vec{W} = \begin{vmatrix} i_\theta & \frac{i_z}{r} & \frac{i_r}{r} \\ \frac{\partial}{\partial \theta} & \frac{\partial}{\partial z} & \frac{\partial}{\partial r} \\ rW_u & W_a & W_r \end{vmatrix}$$

$$= i_\theta \left[\frac{\partial W_r}{\partial z} - \frac{\partial W_a}{\partial r} \right] + \frac{i_z}{r} \left[\frac{\partial (rW_u)}{\partial r} - \frac{\partial W_r}{\partial \theta} \right] + \frac{i_r}{r} \left[\frac{\partial W_a}{\partial \theta} - \frac{\partial (rW_u)}{\partial z} \right]$$

B-3

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F/G 9/2

COMPUTER EVALUATION OF THE ON-AND-OFF DESIGN PERFORMANCE OF AN --ETC(11)

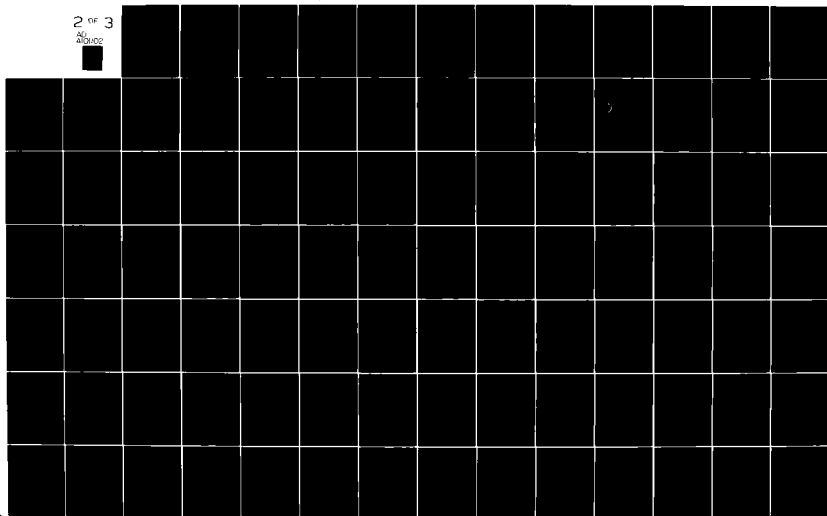
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$$\begin{aligned}
 \vec{W} \times (\nabla \times \vec{W}) &= \\
 & \begin{vmatrix} i_\theta & i_z & i_r \\ W_u & W_a & W_r \\ \left[\frac{\partial W_r}{\partial z} - \frac{\partial W_a}{\partial r} \right] & \frac{1}{r} \left[\frac{\partial(rW_u)}{\partial r} - \frac{\partial W_r}{\partial \theta} \right] & \frac{1}{r} \left[\frac{\partial W_a}{\partial \theta} - \frac{\partial(rW_u)}{\partial z} \right] \end{vmatrix} \\
 &= i_\theta \left[W_a \frac{1}{r} \left(\frac{\partial W_a}{\partial \theta} - \frac{\partial(rW_u)}{\partial z} \right) - W_r \frac{1}{r} \left(\frac{\partial(rW_u)}{\partial r} - \frac{\partial W_r}{\partial \theta} \right) \right] + \\
 & i_z \left[W_r \left(\frac{\partial W_r}{\partial z} - \frac{\partial W_a}{\partial r} \right) - W_u \frac{1}{r} \left(\frac{\partial W_a}{\partial \theta} - \frac{\partial(rW_u)}{\partial z} \right) \right] + \\
 & i_r \left[W_u \frac{1}{r} \left(\frac{\partial(rW_u)}{\partial r} - \frac{\partial W_r}{\partial \theta} \right) - W_a \left(\frac{\partial W_r}{\partial z} - \frac{\partial W_a}{\partial r} \right) \right]
 \end{aligned}$$

(B-4)

$$\vec{W} \times 2\vec{W} = \left[i_\theta W_u + i_z W_a + i_r W_r \right] \times \left[i_z 2\omega \right]$$

$$= i_r (2\omega W_u) - i_\theta (2\omega W_r)$$

(B-5)

$$T \nabla S = T \left[i_0 \frac{1}{r} \frac{\partial S}{\partial \theta} + i_z \frac{\partial S}{\partial z} + i_r \frac{\partial S}{\partial r} \right] \quad (B-6)$$

Combining equations (B-1) through (B-6) the terms in (B-2) can be written as:

$$\begin{aligned} \frac{1}{r} \frac{\partial H_R}{\partial \theta} = & \frac{W_a}{r} \left[\frac{\partial W_a}{\partial \theta} - \frac{\partial(r W_u)}{\partial z} \right] - \\ & \frac{W_r}{r} \cdot \left[\frac{\partial(r W_u)}{\partial r} - \frac{\partial W_r}{\partial \theta} \right] - 2\omega W_r + \frac{T}{r} \frac{\partial S}{\partial \theta} \end{aligned} \quad (B-7)$$

$$\begin{aligned} \frac{\partial H_R}{\partial z} = & W_r \left[\frac{\partial W_r}{\partial z} - \frac{\partial W_a}{\partial r} \right] - \frac{W_u}{r} \left[\frac{\partial W_a}{\partial \theta} - \right. \\ & \left. \frac{\partial(r W_u)}{\partial z} \right] + T \frac{\partial S}{\partial z} \end{aligned} \quad (B-8)$$

$$\begin{aligned} \frac{\partial H_R}{\partial r} = & \frac{W_u}{r} \left[\frac{\partial(r W_u)}{\partial r} - \frac{\partial W_r}{\partial \theta} \right] - \\ & W_a \left[\frac{\partial W_r}{\partial z} - \frac{\partial W_a}{\partial r} \right] + 2\omega W_u + T \frac{\partial S}{\partial r} \end{aligned} \quad (B-9)$$

Since the flow has been assumed to be axisymmetric, all derivatives with respect to θ are zero. Thus, Equations (B-7), (B-8) and (B-9) reduce to, respectively:

$$0 = - \frac{W_a}{r} \frac{\partial(rW_u)}{\partial z} - \frac{W_r}{r} \frac{\partial(rW_u)}{\partial r} - 2\omega W_r \quad (\text{B-10})$$

$$\frac{\partial H_R}{\partial z} = W_r \frac{\partial W_r}{\partial z} - W_r \frac{\partial W_a}{\partial r} + \frac{W_u}{r} \cdot$$

$$\frac{\partial(rW_u)}{\partial z} + T \cdot \frac{\partial S}{\partial z} \quad (\text{B-11})$$

$$\begin{aligned} \frac{\partial H_R}{\partial r} = & \frac{W_u}{r} \frac{\partial(rW_u)}{\partial r} - W_a \frac{\partial W_r}{\partial z} + W_a \frac{\partial W_a}{\partial r} + \\ & 2\omega W_u + T \frac{\partial S}{\partial r} \end{aligned} \quad (\text{B-12})$$

Equation (B-10) may be written as

$$\frac{\partial(rW_u)}{\partial z} = - \frac{W_r}{W_a} \frac{\partial(rW_u)}{\partial r} - 2\omega r \frac{W_r}{W_a} \quad (\text{B-13})$$

Substituting into equation (B-11),

$$\begin{aligned} \frac{\partial H_R}{\partial z} = & - \frac{W_u}{r} \frac{W_r}{W_a} \frac{\partial(rW_u)}{\partial r} + W_r \frac{\partial W_r}{\partial z} - \\ & W_r \frac{\partial W_a}{\partial r} - 2\omega \frac{W_u W_r}{W_a} - T \frac{\partial S}{\partial z} \end{aligned} \quad (\text{B-14})$$

Multiplying equation (B-9) by W_r and Equation (B-14) by W_a results in

$$W_r \frac{\partial H_R}{\partial r} = \frac{W_u W_r}{r} \frac{\partial (r W_u)}{\partial r} - W_a W_r \frac{\partial W_r}{\partial z} +$$

$$W_a W_r \frac{\partial W_a}{\partial r} + 2 \omega W_u W_r + W_r T \frac{\partial S}{\partial r} \quad (B-15)$$

and

$$W_a \frac{\partial H_R}{\partial z} = - \frac{W_u W_r}{r} \frac{\partial (r W_u)}{\partial r} + W_a W_r \frac{\partial W_r}{\partial z} -$$

$$W_a W_r \frac{\partial W_a}{\partial r} - 2 \omega W_u W_r + W_a T \frac{\partial S}{\partial z} \quad (B-16)$$

Adding these two equations yields

$$W_r \frac{\partial H_R}{\partial r} + W_a \frac{\partial H_R}{\partial z} = T \left[W_r \frac{\partial S}{\partial r} + W_a \frac{\partial S}{\partial z} \right] \quad (B-17)$$

Since the flow has been assumed to be adiabatic, the total relative enthalpy, H_R , is constant along a streamline. Thus,

$$\nabla H_R = 0 = W_a \frac{\partial H_R}{\partial z} + W_r \frac{\partial H_R}{\partial r} \quad (B-18)$$

and re-arranging,

$$\frac{\partial H_R}{\partial z} = - \frac{W_r}{W_a} \frac{\partial H_R}{\partial r} \quad (B-19)$$

From equation (B-19), eq. (B-17) can be written as

$$\frac{\partial S}{\partial z} = - \frac{W_r}{W_a} \frac{\partial S}{\partial r} \quad (B-20)$$

Substituting Eq.s (B-19) and (B-20) into equation (B-15) gives

$$-\frac{W_r}{W_a} \frac{\partial H_R}{\partial r} = -\frac{W_u}{r} \frac{W_r}{W_a} \frac{\partial(rW_u)}{\partial r} + W_r \frac{\partial W_r}{\partial z} - W_r \frac{\partial W_a}{\partial r} - 2\omega \frac{W_u W_r}{W_a} - \frac{W_r}{W_a} T \frac{\partial S}{\partial r} \quad (B-21)$$

Multiplying Equation (B-21) by $\frac{-W_a}{W_r}$ yields

$$\frac{\partial H_R}{\partial r} = \frac{W_u}{r} \frac{\partial(rW_u)}{\partial r} - W_a \frac{\partial W_r}{\partial z} + W_a \frac{\partial W_a}{\partial r} + 2\omega W_u + T \frac{\partial S}{\partial r} \quad (B-22)$$

This expression is identical to equation (B-21) and is the equation which must be solved. It must be put into a form which can be solved by the computer. Re-writing equation (B-22) given that

$$W_a \frac{\partial W_a}{\partial r} = \frac{1}{2} \frac{\partial(W_a^2)}{\partial r}$$

yields

$$\frac{\partial(W_a^2)}{\partial r} - 2W_a \frac{\partial W_r}{\partial z} + \frac{2W_u}{r} \frac{\partial(rW_u)}{\partial r} + 4\omega W_u - 2 \frac{\partial H_R}{\partial r} + 2T \frac{\partial S}{\partial r} = 0 \quad (B-23)$$

The relative enthalpy can be written

$$H_R = h_1 + \frac{W_1^2}{2g_c J} - \frac{U_1^2}{2g_c J} = h_2 + \frac{W_2^2}{2g_c J} - \frac{U_2^2}{2g_c J} \quad (B-24)$$

The equivalent enthalpy, defined in ref. [1] is

$$H_E = h_1 + \frac{W_1^2}{2g_c J} + \frac{U_2^2 - U_1^2}{2g_c J} \quad (B-25)$$

Hence, the relative enthalpy can be written as

$$H_R = H_E - \frac{U_2^2}{2} \quad (B-26)$$

Also, the turbine outlet static temperature can be written as

$$T_2 = \frac{H_E}{C_p} - \frac{W_2^2}{2C_p} \quad (B-27)$$

Substituting Eq. (B-26) and Eq. (B-27) into Eq. (B-23) and applying Eq. (B-21) to the rotor exit, gives

$$\begin{aligned} & \frac{\partial(Wa^2)}{\partial r_2} - 2Wa_2 \frac{\partial W r_2}{\partial z} + 2 \frac{W u_2}{r_2} \frac{\partial(r_2 W u_2)}{\partial r_2} + \\ & 4W W u_2 - 2 \frac{\partial}{\partial r_2} \left[H_E - \frac{U_2^2}{2} \right] + 2 \left[\frac{H_E}{C_p} - \right. \\ & \left. \frac{W_2^2}{2C_p} \right] \frac{\partial S_2}{\partial r_2} = 0 \end{aligned} \quad (B-28)$$

Given the relationships:

$$T_{AN}^2 \lambda = \frac{W_r^2}{W_a^2}$$

and $1 + \tan^2 \lambda = \frac{1}{\cos^2 \lambda}$

Equation (B-28) can be written as

$$\begin{aligned} & \frac{\partial (W a_2^2)}{\partial r_2} - 2 W a_2 \frac{\partial W r_2}{\partial z} - \frac{W a_2^2}{c_p \cos^2 \lambda_2} \cdot \frac{\partial S_2}{\partial r_2} + 2 \cdot \\ & \frac{W u_2}{r_2} \cdot \frac{\partial (r_2 W u_2)}{\partial r_2} + 4 \omega W u_2 - 2 \frac{\partial H_E}{\partial r_2} + \\ & \frac{\partial (U_2^2)}{\partial r_2} + \frac{1}{c_p} \left[2 H_E - W u_2^2 \right] \frac{\partial S_2}{\partial r_2} \end{aligned} \quad (B-29)$$

and substituting $\frac{\partial (U_2^2)}{\partial r_2} = 2 \omega^2 r_2$ into equation (B-29) gives

$$\begin{aligned} & \frac{\partial (W a_2^2)}{\partial r_2} - 2 W a_2 \frac{\partial W r_2}{\partial z} - \frac{W a_2^2}{c_p \cos^2 \lambda_2} \frac{\partial S_2}{\partial r_2} - \\ & 2 \frac{W u_2}{r_2} \frac{\partial (r_2 W u_2)}{\partial r_2} + 4 \omega W u_2 - 2 \frac{\partial H_E}{\partial r_2} + \\ & 2 \omega^2 r_2 + \frac{1}{c_p} \left[2 H_E - W u_2^2 \right] \frac{\partial S_2}{\partial r_2} \end{aligned} \quad (B-30)$$

Multiplying Eq. (B-30) by $\left(\frac{r_m}{W a_m^2} \right)$ results in the dimension-

less form of Equation (B-29):

$$\begin{aligned}
& \frac{r_{2m}}{Wa_{2m}^2} \frac{\partial (Wa_2^2)}{\partial r_2} - 2 \frac{Wa_2}{Wa_{2m}^2} \frac{Wa_2}{Wa_2} r_{2m} \frac{\partial (Wr_2)}{\partial z} - \\
& \frac{Wa_2^2 r_{2m}}{Wa_{2m}^2 C_p \cos^2 \lambda_2} \frac{\partial S_2}{\partial r_2} + 2 \frac{Wu_2 Wa_2 r_{2m}}{Wa_{2m} Wa_2 r_2} \cdot \frac{\partial \left[\frac{r_2 Wu_2 Wa_2}{r_{2m} Wa_{2m} Wa_2} \right]}{\partial (r_2/r_{2m})} \\
& + 4 \frac{Wr_{2m} Wu_2 Wa_2}{Wa_{2m}^2 Wa_2} - 2 \frac{r_{2m}}{Wa_{2m}^2} \frac{\partial HE}{\partial r_2} + \frac{2u^2 r_2 r_{2m}}{Wa_{2m}^2} + \\
& \frac{r_{2m}}{C_p} \left[\frac{\partial HE}{Wa_{2m}^2} - \frac{Wu_2^2 Wa_2^2}{Wa_{2m}^2 Wa_2^2} \right] \frac{\partial S_2}{\partial r_2}
\end{aligned}$$

(B-31)

Introducing the non-dimensional quantities

$$Y = \frac{Wa}{Wa_m} \quad (B-32)$$

$$X = \frac{r}{r_m} \quad (B-33)$$

$$S^* = \frac{S}{C_p} \quad (B-34)$$

Equation (B-31) is written as

$$\begin{aligned}
 & \frac{\partial(Y^2)}{\partial X} - 2 \frac{Y^2}{W_a} r_m \frac{\partial W_r}{\partial z} - \frac{Y^2}{\cos^2 \lambda} \frac{\partial S^*}{\partial X} + \\
 & 2Y \frac{\tan \beta}{X} \frac{\partial(XY \tan \beta)}{\partial X} + 4 \frac{U_m Y \tan \beta}{W_{a_m}} - \\
 & \frac{2}{W_{a_m}^2} \frac{\partial H_E}{\partial X} + 2 \frac{U_m U_2}{W_{a_m}^2} + \left[\frac{2 H_E}{W_{a_m}^2} - \right. \\
 & \left. Y^2 \tan^2 \beta \right] \frac{\partial S^*}{\partial X} = 0
 \end{aligned} \tag{B-35}$$

The fourth term of Eq. (B-35) is

$$\begin{aligned}
 & 2Y \frac{\tan \beta}{X} \frac{\partial(XY \tan \beta)}{\partial X} = 2Y \frac{\tan \beta}{X} \left[XY \right. \\
 & \left. \frac{\partial \tan \beta}{\partial X} + X \tan \beta \frac{\partial Y}{\partial X} + Y \tan \beta \frac{\partial X}{\partial X} \right] \\
 & = 2Y^2 \tan \beta \frac{\partial \tan \beta}{\partial X} + 2Y \tan^2 \beta \frac{\partial Y}{\partial X} + \\
 & 2 \frac{Y^2}{X} \tan^2 \beta
 \end{aligned}$$

also,

$$\frac{\partial \tan \beta}{\partial x} = \frac{1}{\cos^2 \beta} \frac{\partial \beta}{\partial x}$$

and $2Y \tan^2 \beta \frac{\partial Y}{\partial x} = \tan^2 \beta \frac{\partial (Y^2)}{\partial x}$

Therefore, equation (B-35) can be written

$$\begin{aligned} & \frac{\partial (Y^2)}{\partial x} (1 + \tan^2 \beta) - 2 \frac{Y^2}{W_a} r_m \frac{\partial W_r}{\partial z} - \frac{Y^2}{\cos^2 \lambda} \frac{\partial s^*}{\partial x} + \\ & 2Y^2 \frac{\tan \beta}{\cos^2 \beta} \frac{\partial \beta}{\partial x} + 2 \frac{Y^2}{x} \tan^2 \beta + \frac{4U_m Y \tan \beta}{W_{a_m}} - \\ & \frac{2}{W_{a_m}^2} \frac{\partial H_E}{\partial x} + 2 \frac{U_m U_z}{W_{a_m}^2} + \left[\frac{2H_E}{W_{a_m}^2} - Y^2 \tan^2 \beta \right] \frac{\partial s^*}{\partial x} \end{aligned}$$

(B-36)

Multiplying Eq. (B-36) by $\left(\frac{\cos^2 \beta}{Y^2} \right)$ and observing that $\left(1 + \tan^2 \beta = \frac{1}{\cos^2 \beta} \right)$,

$$\begin{aligned} & \frac{1}{Y^2} \frac{\partial (Y^2)}{\partial x} + \cos^2 \beta \left[- \frac{2r_m}{W_a} \frac{\partial W_r}{\partial z} - \frac{1}{\cos^2 \lambda} \frac{\partial s^*}{\partial x} \right] + \\ & 2 \tan \beta \frac{\partial \beta}{\partial x} + \frac{2}{x} \sin^2 \beta + \frac{4U_m \sin \beta \cos \beta}{W_{a_m} Y} + \frac{2U_m U_z \cos^2 \beta}{W_{a_m}^2 Y^2} \\ & - \frac{2 \cos^2 \beta}{W_{a_m}^2} \frac{\partial H_E}{\partial x} + \left[\frac{2H_E \cos^2 \beta}{W_{a_m}^2 Y^2} - \sin^2 \beta \right] \frac{\partial s^*}{\partial x} = 0 \end{aligned}$$

(B-37)

To account for streamline curvature the following terms are introduced:

$$\cos^2 \lambda = \frac{L^2}{L^2 + \left(\frac{\Delta R}{2}\right)^2} \quad (\text{B-38})$$

where λ , the angle between the axial and radial components of velocity at a point, is approximated as the average value between two stations.

Also,

$$K \frac{\delta R}{L^2} = - \frac{1}{W_a} \frac{\partial W_r}{\partial z} \quad (\text{B-39})$$

where δr is the streamline shift throught the rotor defined

$$\text{as} \quad \delta r = r_{\text{ROTOR OUTLET}} - r_{\text{ROTOR INLET}} \quad (\text{B-40})$$

Substituting Eqs. (B-38) and (B-39) into (B-37) yields

$$\begin{aligned} \frac{d(\ln Y^2)}{dx} = & -\cos^2 \beta \left[-\left(2K r_m \frac{\delta R}{L^2}\right) - \left(\frac{L^2 + (\Delta R)^2}{L^2}\right) \frac{ds^*}{dx} \right] \\ & - 2 \tan \beta \frac{d\beta}{dx} - \frac{2}{x} \sin^2 \beta - \frac{4 U_m \sin \beta \cos \beta}{W_{a_m} Y} - \\ & \frac{2 U_m U_a \cos^2 \beta}{W_{a_m}^2 Y^2} + \frac{2 \cos^2 \beta}{W_{a_m}^2 Y^2} \frac{dH_E}{dx} - \left[\frac{2 H_E \cos^2 \beta}{W_{a_m}^2 Y^2} - \sin^2 \beta \right] \frac{ds^*}{dx} \end{aligned} \quad (\text{B-41})$$

To obtain a dimensionless equation, the term

$$C_1 = 2g_c J$$

is introduced into Eq. (B-41) giving

$$\begin{aligned} \frac{d(\ln Y^2)}{dx} = & -\cos^2 \beta \left[-\left(K \frac{2(\delta r) r_m}{L^2} \right) - \left(\frac{L^2 + (\Delta R)^2}{L^2} \right) \frac{ds^*}{dx} \right] - \\ & 2 \tan \beta \frac{d\beta}{dx} - \frac{2}{x} \sin^2 \beta - \frac{4U_m \sin \beta \cos \beta}{W a_m Y} - \frac{2U_m U_2 \cos^2 \beta}{W a_m^2 Y^2} + \\ & \frac{C_1 \cos^2 \beta}{W a_m^2 Y^2} \frac{dH_E}{dx} - \left[\frac{C_1 H_E \cos^2 \beta}{W a_m^2 Y^2} - \sin^2 \beta \right] \frac{ds^*}{dx} \end{aligned}$$

(B-42)

Equation (B-42) is the form of equation of motion used in the computer program.

B-2. EQUATION OF MOTION FOR ABSOLUTE FLOW

The equation of motion for absolute flow

$$\nabla H = \vec{V} \times (\nabla \times \vec{V}) + T \nabla S$$

(B-43)

Differs from the equation of motion for relative flow

$$\nabla H_R = \vec{W} \times (\nabla \times \vec{W} + 2\vec{\omega}) + T \nabla S \quad (B-44)$$

only by the term $\vec{W} \times 2\vec{\omega}$ which is the Coriolis acceleration.

To obtain the programmed form of the equation of motion for the stator, the previous derivation is followed, but with $U = 0$, H_E becomes H , W becomes V , and β becomes α .

B-3 THE AREA RESTRICTION FACTOR Z

The condition at the outlet of a blade row with boundary layers on both sides of the flow channel is shown in Fig. B-1. The flow is considered to be turbulent within the boundary layer while, outside the layer, the velocity of the flow is the theoretical velocity. Assuming a power-law velocity profile, the velocity may be written,

$$\frac{u}{V_{TH}} = \left[\frac{y}{\delta} \right]^m \quad (B-45)$$

The mass flow rate exiting the blade row can be expressed as

$$\dot{m} = \rho_{TH} V_{TH} \cos \alpha_d \left[S - \frac{t}{\cos \alpha_d} - \frac{\sum \delta}{\cos \alpha_d} \right] + \sum \int_0^\delta u \rho dy \quad (B-46)$$

where ρ_{th} and V_{th} represent the ideal conditions for an isentropic expansion through the blade row to the discharge

pressure P_d , which is assumed to be constant across the blade spacing. The discharge angle of the flow leaving the blade row is closely approximated by the expression [Ref. 1]

$$\alpha_d = \cos^{-1} \left[\frac{a}{S - \frac{t}{\cos^* \alpha_d}} \right] \quad (B-47)$$

Inserting Eq. (B-47) into (B-46) and reducing yields

$$\dot{m} = \rho_{TH} V_{TH} a \left[1 - \sum \frac{\delta}{a} \left(1 - \int_0^1 \frac{\rho}{\rho_{TH}} \frac{\mu}{\mu_{TH}} d\eta \right) \right] \quad (B-48)$$

Assuming a perfect gas

$$\frac{\rho}{\rho_{TH}} = \frac{T_{TH}}{T} = \frac{T_{T0} - (T_{T0} - T_{TH})}{T_{T0} - (T_{T0} - T_{TH}) \left(\frac{\mu}{V_{TH}} \right)^2} \quad (B-49)$$

Defining

$$X_E = 1 - \left(\frac{P_d}{P_{T0}} \right)^{\frac{\gamma-1}{\gamma}} \quad (B-50)$$

Equation (B-49) can be written

$$\frac{\rho}{\rho_{TH}} = \frac{1 - X_E}{1 - X_E \left(\frac{\mu}{V_{TH}} \right)^2} \quad (B-51)$$

Substituting Eq. (B-51) into (B-45) yields

$$\dot{m} = \rho_{TH} V_{TH} a \left[1 - \sum \frac{\delta}{a} (1 - (1 - X_E)) \int_0^1 \frac{\eta^m}{1 - X_E \eta^{2m}} d\eta \right] \quad (B-52)$$

Using the displacement thickness given by

$$\delta^* = \delta \cdot \left[1 - (1 - X_E) \int_0^1 \frac{\eta^m}{(1 - X_E \eta^{2m})} d\eta \right] \quad (\text{B-53})$$

the mass flow rate can be written as

$$\dot{m} = \rho_{TH} V_{TH} a \left[1 - \frac{\sum \delta^*}{a} \right] \quad (\text{B-54})$$

The loss coefficient, expressed in terms of average kinetic energy lost is

$$\zeta = \frac{\Delta E}{\dot{m} \left(\frac{V_{TH}^2}{2} \right)} = 1 - \frac{E}{\dot{m} \frac{V_{TH}^2}{2}} \quad (\text{B-55})$$

where E is the actual kinetic energy of the flow, given by

$$E = \rho_{TH} V_{TH} (a - \sum \delta) \frac{V_{TH}^2}{2} + \sum \int_0^\delta \rho u \frac{u^2}{2} dy \quad (\text{B-56})$$

Substituting Eq. (B-51) into (B-56) gives

$$E = \rho_{TH} \frac{V_{TH}^2}{2} a \left[1 - \sum \frac{\delta}{a} (1 - (1 - X_E) \int_0^1 \frac{\eta^{3m}}{(1 - X_E \eta^{2m})} d\eta) \right] \quad (\text{B-57})$$

The energy thickness is written as

$$\delta^{***} = \delta \left[1 - (1 - X_E) \int_0^1 \frac{1^{3m}}{(1 - X_E \eta^{2m})} d\eta \right] \quad (B-58)$$

The loss coefficient can therefore be written as

$$\zeta = 1 - \frac{1 - \sum \frac{\delta^{***}}{a}}{1 - \sum \frac{\delta^*}{a}} \quad (B-59)$$

The area restriction factor Z , is the fraction of the flow area through which the uniform theoretical velocity would produce the actual flow rate, thus

$$Z = \frac{\sum \delta^*}{a} \quad (B-60)$$

Defining the energy parameter (a form factor) as

$$H^{***} = \frac{\delta^{***}}{\delta^*} \quad (B-61)$$

using Equations (B-59) and (B-61), Eq. (B-60) becomes

$$Z = \frac{H^{***} - 1}{H^{***} - 1 + \xi_p} \quad (B-62)$$

where ξ_p is the profile loss coefficient.

B-4. THE ENERGY PARAMETER, H^{***}

In Equations (B-53) and (B-58) the denominator of the integrand is expanded using the binomial theorem, so that

$$(1 - X_E \eta^{2m})^{-1} = 1 + X_E \eta^{2m} + X_E^2 \eta^{4m} + X_E^3 \eta^{6m} + \dots \quad (B-63)$$

The integral of Equation (B-58) is now written as

$$\int_0^1 \frac{\eta^{3m}}{1 - X_E \eta^{2m}} d\eta = \int_0^1 \left[\eta^{3m} + X_E \eta^{5m} + X_E^2 \eta^{7m} + X_E^3 \eta^{9m} + X_E^4 \eta^{11m} + \dots \right] d\eta \quad (B-64)$$

which, on integration becomes

$$\int_0^1 \frac{\eta^{3m}}{1 - X_E \eta^{2m}} d\eta = \frac{1}{3m+1} + \frac{X_E}{5m+1} + \frac{X_E^2}{7m+1} + \frac{X_E^3}{9m+1} + \frac{X_E^4}{11m+1} + \dots \quad (B-65)$$

Therefore, Equation (B-58) becomes.

$$\frac{\delta^{***}}{\delta} = 1 - \left[\frac{1}{3m+1} + \frac{X_E}{5m+1} + \frac{X_E^2}{7m+1} + \frac{X_E^3}{9m+1} + \frac{X_E^4}{11m+1} \right] (1 - X_E) \quad (B-66)$$

which can be written as

$$\frac{\delta^{***}}{\delta} = (X_E - 1) \left[\frac{1}{X_E - 1} + \frac{1}{3m+1} + \frac{X_E}{5m+1} + \frac{X_E^2}{7m+1} + \frac{X_E^3}{9m+1} + \frac{X_E^4}{11m+1} \right]$$

(B-67)

In a similar manner,

$$\frac{\delta^*}{\delta} = (X_E - 1) \left[\frac{1}{X_E - 1} + \frac{1}{m+1} + \frac{X_E}{3m+1} + \frac{X_E^2}{5m+1} + \frac{X_E^3}{7m+1} + \frac{X_E^4}{9m+1} \right]$$

(B-68)

Substituting Eq. (B-67) and Eq. (B-68) into Eq. (B-61), the equation for H^{***} used in the computer program is obtained:

$$H^{***} = \frac{\frac{1}{X-1} + \frac{1}{3m+1} + \frac{X_E}{5m+1} + \frac{X_E^2}{7m+1} + \frac{X_E^3}{9m+1} + \frac{X_E^4}{11m+1}}{\frac{1}{X_E - 1} + \frac{1}{m+1} + \frac{X_E}{3m+1} + \frac{X_E^2}{5m+1} + \frac{X_E^3}{7m+1} + \frac{X_E^4}{9m+1}}$$

(B-69)

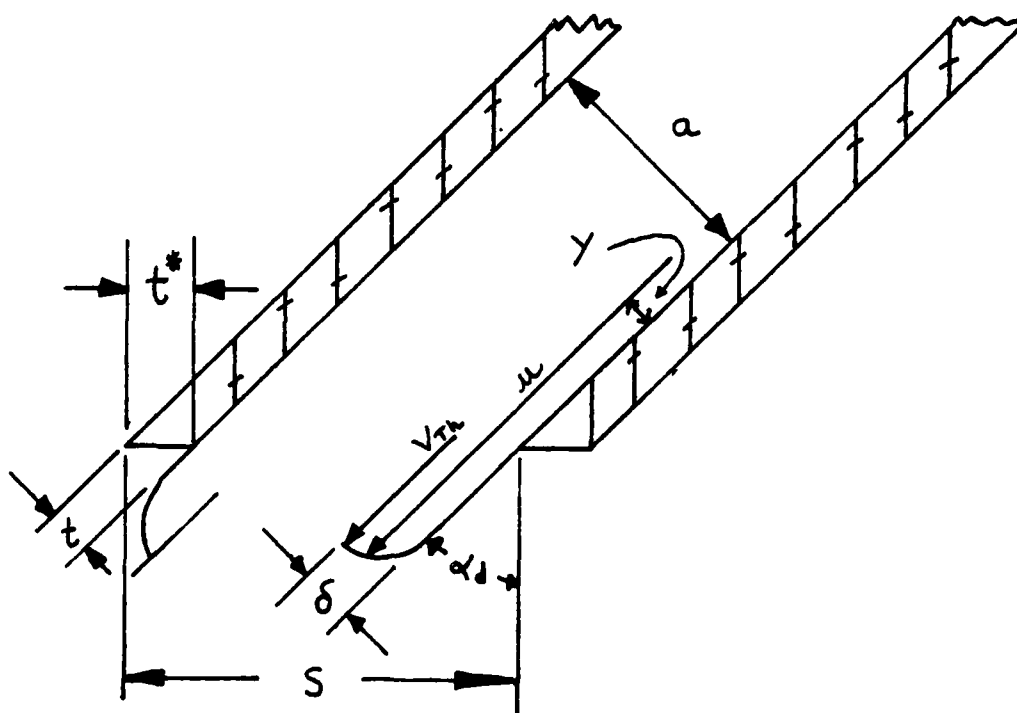


FIGURE B-1: BOUNDARY LAYER EFFECTS AT THE EXIT OF A BLADE ROW

APPENDIX: C

PROGRAM SEGMENTATION ON THE HP-1000

Segmentation allows large programs to be run on the HP-1000. The program is divided by the programmer into a main program and several segments, which are stored on the disc. Each segment and the main program are then compiled and loaded. When the program is executed, the main program and its segments are called into memory individually, and only as they are needed for execution. In this manner, a program can run in a partition which is smaller than that program's total size.

When the main program has performed all executable statements, the first segment is called into memory by an EXEC call. The system then loads that segment from the disc into a memory block following the end of the main program. The process is illustrated in Figure C-1. Note; the main program plus the largest segment may not together exceed 29 k. Once a segment is in memory it can call another segment.

When executing, any segment can call any subroutine which is attached to the main program. It was this feature which allowed the present program to be run. All subroutines were placed within the main program. In fact, the main program consisted of nineteen subroutines and functions. A segment may not return to the main program. Communication of data

between the main program and the segments is accomplished through a common block.

The four segments of the present program are "MAIN", "SHORT", "PART 2" and "PART 3". The manner in which control is passed from the main program to the first segment and from the first segment to the second is as follows:

BLOCK DATA

.
.
.

END

PROGRAM THESS

DIMENSION INAM (3)

DATA INAM /2HSH, 2HOR, 2HT /

.
.
.

CALL EXEC (8, INAM)

END

PROGRAM SHORT (5)

DIMENSION INAM (3)

DIMENSION NAME (3)

DATA INAM /2HSH, 2HOR, 2HT /

DATA NAME /2HPA, 2HRT, 2H2 /

.
.
.

CALL EXEC (8, NAME)

END

PROGRAM PART 2 (5)

DIMENSION NAME (3)

DIMENSION NAMR (3)

DATA NAME /2HPA, 2HRT, 2H2 /

DATA NAMR /2HPA, 2HRT, 2H3 /

.
.
.

CALL EXEC (8, NAMR)

END

PROGRAM PART 3 (5)

DIMENSION NAME (3)

DIMENSION NAMR (3)

DATA NAME /2HPA, 2HRT, 2H2 /

DATA NAMR /2HPA, 2HRT, 2H3 /

.
.
.

END

The "(5)" after the program name indicates that it is a program segment. Note the manner in which the program name is put into a data statement using the Hollerith notation.

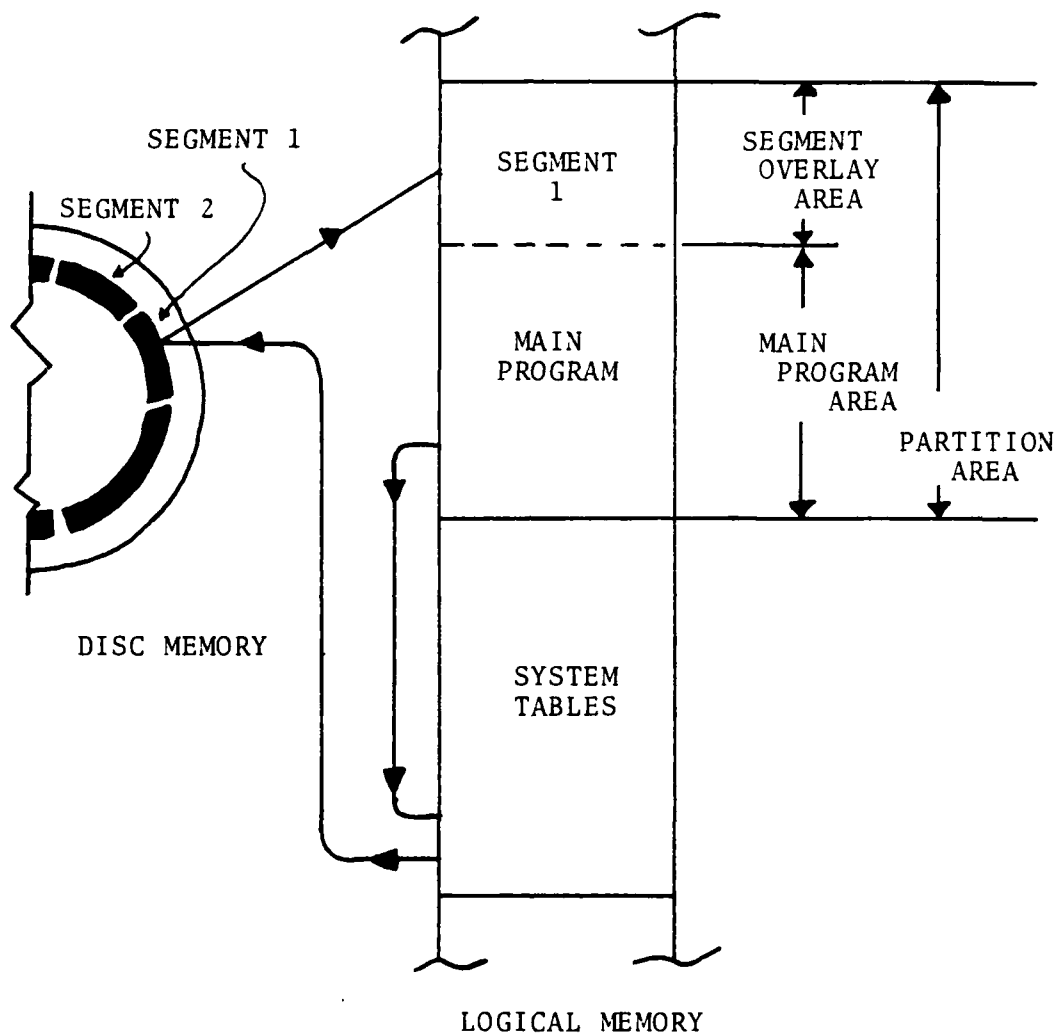


FIGURE C-1: PROGRAM SEGMENTATION-ILLUSTRATION OF THE MAIN PROGRAM CALLING A SEGMENT INTO LOGICAL MEMORY

APPENDIX: D

RUNNING THE COMPUTER PROGRAM

If the reader is unfamiliar with the HP-1000 Computer System, references [11] and [12] should be consulted before attempting to run the program.

D-1. DATA INPUT

Using the editor, input the following data into segment "SHORT".

1. Turbine operating conditions: referring to Table A-III, type in appropriate data in lines 66 through 69 and 74 through 78.

2. Special input data/program control parameters: referring to Tables A-IV and A-V, type in appropriate data in lines 83 through 98.

3. Turbine geometry: referring to Tables A-1 and A-II, type in data for stator and rotor in lines 103 through 186.

D-2 COMPILING THE PROGRAM

1. To compile the main program type:

:RU,FTN4,MAIN::25,-,-

2. Compile the first segment:

:RU,FTN4,SHORT::25,-,-

3. Compile the second segment:

:RU,FTN4,PART2::25,-,-

4. Compile the final segment:

:RU,FTN4PART3::25,-,-

D-3. LOADING THE PROGRAM

Type

: RU, LOADR

Tap return key

Will display

LOADR:

Type

OP,LB

Will display

LOADR:

Type

:RE,%MAIN::25

Will display

LOADR:

Type

:RE,%SHORT::25

Will display

LOADR:

Type

:RE,%PART2::25

Will display

LOADR:

Type

:RE,%PART3::25 .

Will display

LOADR:

Type

:END

After the end statement, the loader will display that the program is ready for execution.

D-4 RUNNING THE PROGRAM

Type

: RUN, THESS

The program will be executed and no further action by the operator is required. The computed pressure ratio of each iteration of the outer loop of the program is displayed on the screen as it is calculated. The operator therefore has some idea where in the iteration process the computer program is executing.

APPENDIX: E

DISCREPANCIES IN MACCHI'S PROGRAM

1. Main program, lines 21 and 22; the value of ICL has not yet been read.

2. Main program, lines 163-166; the Traupel method of calculating gas outlet angles does not take the Mach number into consideration. However, in lines 163-164, the program is attempting to draw a parabola through points which represent outlet angle as a function of Mach number.

3. Main program line 281; the calling of subroutine SLINE is questionable. Parameters are transferred to that subroutine, but many of them have not yet been defined (HE, DHEDX, WPER2, DSDX1). These undefined variables will be set equal to zero by the IBM 360 and 370 computers. Thus, in line 10 of subroutine SLINE, the value of DWDX will be zero and in line 17, division by zero will occur and the execution of the program should cease.

4. Subroutine ROTOR1 lines 22 and 26; the stator radii are used in the calculation whereas the rotor radii should be used.

5. Subroutine ASOSI, line 107; the correct Fortran code is

$$\text{ZETAPS(I)} = .5 * \text{ZETAS(I)}$$

6. Subroutine ALOS2, line 121; the correct Fortran code is

$$\text{ZETAPR}(I) = .5 * \text{ZETAPR}(I)$$

7. Subroutine ALOS2, lines 123-126; the stator radii are used in the calculation whereas the rotor radii should be used.

8. Subroutine ANGAIN, line 14; the correct Fortran code is

$$\begin{aligned} \text{AO} = & \text{ATAN}(1. - \text{XCL}/\text{H} * \text{CH} * \text{COS}(\text{ANG1}) / \text{COS}(\text{ANG2}) * \\ & \text{TAN}(\text{ANG2}) + \text{XCL}/\text{H} * \text{CL} * \text{COS}(\text{ANG1}) / \text{COS}(\text{ANG2}) * \\ & \text{TAN}(\text{ANG1}) \end{aligned}$$

Note: Since reference [2] was published, Professor Macchi's program has been further developed by Professor Macchi under private sponsorship [Ref. 13]. The new code however, is not generally available.

APPENDIX F
COMPUTER OUTPUT

INPUT PRINTS

R1	A1	K2	AP
2.764	.2126	2.693	.1912
2.860	.2115	2.820	.2030
2.958	.2103	2.947	.2149
3.056	.2091	3.074	.2269
3.154	.2079	3.201	.2388
3.252	.2067	3.328	.2506
3.350	.2055	3.455	.2625
3.448	.2043	3.582	.2743
3.546	.2031	3.709	.2862
3.644	.2019	3.836	.2981
3.742	.2007	3.963	.3100
3.840	.1995	4.090	.3219
3.938	.1983	4.217	.3338
4.036	.1971	4.344	.3457
4.134	.1959	4.471	.3576
4.232	.1947	4.598	.3695
4.330	.1935	4.725	.3814
4.428	.1923	4.852	.3933
4.526	.1911	4.979	.4052
4.624	.1899	5.106	.4171
4.722	.1887	5.233	.4290
4.820	.1875	5.360	.4409
4.918	.1863	5.487	.4528
5.016	.1851	5.614	.4647
5.114	.1839	5.741	.4766
5.212	.1827	5.868	.4885
5.310	.1815	5.995	.5004
5.408	.1803	6.122	.5123
5.506	.1791	6.249	.5242
5.604	.1779	6.376	.5361
5.702	.1767	6.503	.5480
5.800	.1755	6.630	.5599
5.898	.1743	6.757	.5718
5.996	.1731	6.884	.5837
6.094	.1719	7.011	.5956
6.192	.1707	7.138	.6075
6.290	.1695	7.265	.6194
6.388	.1683	7.392	.6313
6.486	.1671	7.519	.6432
6.584	.1659	7.646	.6551
6.682	.1647	7.773	.6670
6.780	.1635	7.900	.6789
6.878	.1623	8.027	.6908
6.976	.1611	8.154	.7027
7.074	.1599	8.281	.7146
7.172	.1587	8.408	.7265
7.270	.1575	8.535	.7384
7.368	.1563	8.662	.7503
7.466	.1551	8.789	.7622
7.564	.1539	8.916	.7741
7.662	.1527	9.043	.7860
7.760	.1515	9.170	.7979
7.858	.1503	9.297	.8098
7.956	.1491	9.424	.8217
8.054	.1479	9.551	.8336
8.152	.1467	9.678	.8455
8.250	.1455	9.805	.8574
8.348	.1443	9.932	.8693
8.446	.1431	10.059	.8812
8.544	.1419	10.186	.8931
8.642	.1407	10.313	.9050
8.740	.1395	10.440	.9169
8.838	.1383	10.567	.9288
8.936	.1371	10.694	.9407
9.034	.1359	10.821	.9526
9.132	.1347	10.948	.9645
9.230	.1335	11.075	.9764
9.328	.1323	11.202	.9883
9.426	.1311	11.329	.1002
9.524	.1299	11.456	.1121
9.622	.1287	11.583	.1240
9.720	.1275	11.710	.1359
9.818	.1263	11.837	.1478
9.916	.1251	11.964	.1597
10.014	.1239	12.091	.1716
10.112	.1227	12.218	.1835
10.210	.1215	12.345	.1954
10.308	.1203	12.472	.2073
10.406	.1191	12.599	.2192
10.504	.1179	12.726	.2311
10.602	.1167	12.853	.2430
10.700	.1155	12.980	.2549
10.798	.1143	13.107	.2668
10.896	.1131	13.234	.2787
10.994	.1119	13.361	.2906
11.092	.1107	13.488	.3025
11.190	.1095	13.615	.3144
11.288	.1083	13.742	.3263
11.386	.1071	13.869	.3382
11.484	.1059	13.996	.3501
11.582	.1047	14.123	.3620
11.680	.1035	14.250	.3739
11.778	.1023	14.377	.3858
11.876	.1011	14.504	.3977
11.974	.0999	14.631	.4096
12.072	.0987	14.758	.4215
12.170	.0975	14.885	.4334
12.268	.0963	15.012	.4453
12.366	.0951	15.139	.4572
12.464	.0939	15.266	.4691
12.562	.0927	15.393	.4810
12.660	.0915	15.520	.4929
12.758	.0903	15.647	.5048
12.856	.0891	15.774	.5167
12.954	.0879	15.901	.5286
13.052	.0867	16.028	.5405
13.150	.0855	16.155	.5524
13.248	.0843	16.282	.5643
13.346	.0831	16.409	.5762
13.444	.0819	16.536	.5881
13.542	.0807	16.663	.6000
13.640	.0795	16.790	.6119
13.738	.0783	16.917	.6238
13.836	.0771	17.044	.6357
13.934	.0759	17.171	.6476
14.032	.0747	17.298	.6595
14.130	.0735	17.425	.6714
14.228	.0723	17.552	.6833
14.326	.0711	17.679	.6952
14.424	.0699	17.806	.7071
14.522	.0687	17.933	.7190
14.620	.0675	18.060	.7309
14.718	.0663	18.187	.7428
14.816	.0651	18.314	.7547
14.914	.0639	18.441	.7666
15.012	.0627	18.568	.7785
15.110	.0615	18.695	.7904
15.208	.0603	18.822	.8023
15.306	.0591	18.949	.8142
15.404	.0579	19.076	.8261
15.502	.0567	19.203	.8380
15.600	.0555	19.330	.8499
15.698	.0543	19.457	.8618
15.796	.0531	19.584	.8737
15.894	.0519	19.711	.8856
15.992	.0507	19.838	.8975
16.090	.0495	19.965	.9094
16.188	.0483	20.092	.9213
16.286	.0471	20.219	.9332
16.384	.0459	20.346	.9451
16.482	.0447	20.473	.9570
16.580	.0435	20.600	.9689
16.678	.0423	20.727	.9808
16.776	.0411	20.854	.9927
16.874	.0399	20.981	.1006
16.972	.0387	21.108	.1085
17.070	.0375	21.235	.1164
17.168	.0363	21.362	.1243
17.266	.0351	21.489	.1322
17.364	.0339	21.616	.1401
17.462	.0327	21.743	.1480
17.560	.0315	21.870	.1559
17.658	.0303	21.997	.1638
17.756	.0291	22.124	.1717
17.854	.0279	22.251	.1796
17.952	.0267	22.378	.1875
18.050	.0255	22.505	.1954
18.148	.0243	22.632	.2033
18.246	.0231	22.759	.2112
18.344	.0219	22.886	.2191
18.442	.0207	23.013	.2270
18.540	.0195	23.140	.2349
18.638	.0183	23.267	.2428
18.736	.0171	23.394	.2507
18.834	.0159	23.521	.2586
18.932	.0147	23.648	.2665
19.030	.0135	23.775	.2744
19.128	.0123	23.902	.2823
19.226	.0111	24.029	.2902
19.324	.0099	24.156	.2981
19.422	.0087	24.283	.3060
19.520	.0075	24.410	.3139
19.618	.0063	24.537	.3218
19.716	.0051	24.664	.3297
19.814	.0039	24.791	.3376
19.912	.0027	24.918	.3455
20.010	.0015	25.045	.3534
20.108	.0003	25.172	.3613
20.206	.0000	25.299	.3692
20.304	.0000	25.426	.3771
20.402	.0000	25.553	.3850
20.500	.0000	25.680	.3929
20.598	.0000	25.807	.4008
20.696	.0000	25.934	.4087
20.794	.0000	26.061	.4166
20.892	.0000	26.188	.4245
20.990	.0000	26.315	.4324
21.088	.0000	26.442	.4403
21.186	.0000	26.569	.4482
21.284	.0000	26.696	.4561
21.382	.0000	26.823	.4640
21.480	.0000	26.950	.4719
21.578	.0000	27.077	.4798
21.676	.0000	27.204	.4877
21.774	.0000	27.331	.4956
21.872	.0000	27.458	.5035
21.970	.0000	27.585	.5114
22.068	.0000	27.712	.5193
22.166	.0000	27.839	.5272
22.264	.0000	27.966	.5351
22.362	.0000	28.093	.5430
22.460	.0000	28.220	.5509
22.558	.0000	28.347	.5588
22.656	.0000	28.474	.5667
22.754	.0000	28.601	.5746
22.852	.0000	28.728	.5825
22.950	.0000	28.855	.5904
23.048	.0000	28.982	.5983
23.146	.0000	29.109	.6062
23.244	.0000	29.236	.6141
23.342	.0000	29.363	.6220
23.440	.0000	29.490	.6299
23.538	.0000	29.617	.6378
23.636	.0000	29.744	.6457
23.734	.0000	29.871	.6536
23.832	.0000	30.000	.6615
23.930	.0000	30.127	.6694
24.028	.0000	30.254	.6773
24.126	.0000	30.381	.6852
24.224	.0000	30.508	.6931
24.322	.0000	30.635	.7010
24.420	.0000	30.762	.7089
24.518	.0000	30.889	.7168
24.616	.0000	31.016	.7247
24.714	.0000	31.143	.7326
24.812	.0000	31.270	.7405
24.910	.0000	31.397	.7484
25.008	.0000	31.524	.7563
25.106	.0000	31.651	.7642
25.204	.0000	31.778	.7721
25.302	.0000	31.905	.7800
25.400	.0000	32.032	.7879
25.498	.0000	32.159	.7958
25.596	.0000	32.286	.8037
25.694	.0000	32.413	.8116
25.792	.0000	32.540	.8195
25.890	.0000	32.667	.8274
25.988	.0000	32.794	.8353
26.086	.0000	32.921	.8432
26.184	.0000	33.048	.8511
26.282	.0000	33.175	.8590
26.380	.0000	33.302	.8669
26.478	.0000	33.429	.8748

SET NUMBER 1 PAGE 1 RPM 5000.0 TOTAL/STATIC PRESSURE RATIO 1.400 INLET TOTAL PRESSURE 20.580 INLET TOTAL TEMPERATURE 545.50

STATOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION (IN)	X-R/RM	RADIAL SHIFT (IN)	BLADE OPENING (IN)	BLADE Y-VA /VAM	EFFICIENCY	LOSS COEFFICIENT	CONTINUITY	7/100	FLOW RATE FRACTION
1	3.764	.865	0.0000	.2126	1.1015	.8980	.1020	.1020		0.0000
2	3.683	.940	0.0000	.2147	1.1468	.8935	.1065	.1065		.2581
3	3.175	1.000	0.0290	.2026	1.0000	.8899	.1101	.1101		.4790
4	3.227	1.074	0.0000	.2245	.9407	.8871	.1129	.1129		.7609
5		1.135	0.0000	.2926	.8916	.8847	.1153	.1153		1.0000

ABSOLUTE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	332.98	-13.35	735.38	807.33	332.90	-13.35	614.78	699.25	120.60
2	316.31	7.91	651.17	760.06	316.36	3.01	560.05	643.23	131.03
3	295.48	24.68	658.59	723.98	295.48	6.18	514.91	593.71	139.41
4	284.29	31.97	591.92	633.75	284.27	31.97	460.86	522.05	149.73
5	266.47						416.87	497.24	158.26

MACH NUMBER

STREAM LINE	ABSOLUTE	RELATIVE	ABSOLUTE	RELATIVE	FLOW ANGLE (DEG)	TEMPERATURE (DEG. R)	PRESSURE (PSI)	STATIC	TOTAL	101/TOT	101/STA
1	.74	.64	65.65	61.57		545.50	19.591	13.648	19.591	1.0452	1.5079
2	.78	.59	63.21	60.74		545.50	18.623	14.309	18.623	1.0914	1.4382
3	.68	.54	63.21	60.74		545.50	18.623	14.309	18.623	1.0914	1.4382
4	.61	.49	65.64	59.17		545.50	19.591	13.648	19.591	1.0452	1.5079
5	.57	.45	64.89	57.11		545.50	19.591	13.648	19.591	1.0452	1.5079

SET PAGE KPM TOTAL/STATIC PRESSURE TOTAL TEMPERATURE
NUMBER NUMBER (DEG. R)

545.50

20.580

1.400

5000.0

1 2

ROTOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION	X=R/RM	RADIAL SHIFT	MADE OPENING	Y=VA /VAM	EFFICIENCY	MADE	LOSS	COEFFICIENT	CONTINUITY	RELATIVE VELOCITY (FPS)	FLOW RATE FRACTION
1	2.693	.825	.0710	.1912	.9734	.7689	.2311	.2311	.2311	.2311	0.0000	.2418
2	3.020	.925	-.0168	.2218	1.0000	.7689	.2311	.2311	.2311	.2311	.4446	.7358
3	3.365	1.000	-.0405	.2447	1.0000	.7689	.2311	.2311	.2311	.2311	.7358	1.0000
4	3.585	1.098	-.1537	.2983	1.0000	.7689	.2311	.2311	.2311	.2311	.7358	1.0000
5	3.837	1.175	-.2100	.2983	1.0000	.7689	.2311	.2311	.2311	.2311	.7358	1.0000

RELATIVE VELOCITY (FPS)

ABSOLUTE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	RELATIVE VELOCITY (FPS)
1	214.82	-8.62	-399.46	453.64	214.82	-8.62	-399.46	559.89	137.58
2	219.89	-5.89	-371.35	433.29	219.89	-5.89	-371.35	550.90	131.77
3	220.62	-5.05	-342.58	411.76	220.62	-5.05	-342.58	537.47	125.44
4	220.15	-5.92	-333.13	396.43	220.15	-5.92	-333.13	531.96	122.42
5	240.79	-8.57	-313.63	396.43	240.79	-8.57	-313.63	530.71	122.42

PRESSURE RATIO

TEMPERATURE (DEG. R)

FLOW ANGLE (DEG)

MACH NUMBER

STREAM LINE	ABSOLUTE	RELATIVE	ABSOLUTE	RELATIVE	TOTAL	STATIC	TOTAL	STATIC	TOTAL	STATIC	TOTAL	STATIC
1	41	51	-61.73	-67.44	522.93	505.60	16.080	14.312	16.080	14.312	16.080	14.312
2	37	50	-59.51	-66.48	522.94	506.62	16.080	14.312	16.080	14.312	16.080	14.312
3	36	49	-57.59	-65.76	521.08	508.77	16.080	14.312	16.080	14.312	16.080	14.312
4	36	48	-54.64	-64.45	521.07	508.77	16.080	14.312	16.080	14.312	16.080	14.312
5	36	49	-52.49	-63.41	521.02	508.77	16.080	14.312	16.080	14.312	16.080	14.312

EQUIVALENT PRESSURE RATIO

TEMPERATURE (DEG. R)

STREAM LINE

STREAM LINE	EQUIVALENT PRESSURE RATIO	TEMPERATURE (DEG. R)
1	18.024	1.3
2	18.008	1.3
3	18.119	1.2
4	18.172	1.2
5	18.376	1.2

SEL NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	3	5000.0	1.400	20.580	545.50

OVERALL TURBINE CHARACTERISTICS

STREAM LINE	TOT/STA PRESSURE RATIO	TOT/STA EFFICIENCY	OT	HEAD COEFFICIENT	BLADE/JET SPEED RATIO	THEORETICAL DEGREE OF REACTION
1	1.4381	.4197	.6079	44.4345	.1500	-.1231
2	1.4285	.4279	.6279	36.5720	.1654	-.10296
3	1.4015	.4470	.6435	31.5843	.1790	-.0376
4	1.3858	.4675	.6724	23.1752	.1952	.1209
5	1.3833	.4944			.2077	.2130

MASS AVERAGED QUANTITIES

HORSE POWER = 20.27 (HP)
 MOMENTUM = 21.29 (FT-LB)
 FLOW RATE = 2.55 (LB/SEC)

REFERRED RPM = 4874.22
 REFERRED HORSE POWER = 15.22 (HP)
 REFERRED MOMENTUM = 15.22 (FT-LB)
 REFERRED FLOW RATE = 1.87 (LB/SEC)

TOTAL/STATIC EFFICIENCY = .4634
 TOTAL/STATIC EFFICIENCY = .4435
 TOTAL/STATIC PRESSURE RATIO = 1.4058
 TOTAL/STATIC PRESSURE RATIO = 1.2731

HEAD COEFFICIENT = 31.8004
 BLADE/JET SPEED RATIO = .1771
 THEORETICAL DEGREE OF REACTION = .0825
 MACH NUMBER AT STATION 6 = .1858

SET PAGE RPM TOTAL/STATIC INLET TOTAL INLET TOTAL
NUMBER NUMBER 18000.0 PRESSURE RATIO PRESSURE TEMPERATURE
1 1 1.408 20.580 545.50

STATOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION (IN)	X=R/RH	RADIAL SHIFT (IN)	BLADE OPENING (IN)	Y=VA /VAM	EFFICIENCY	LOSS COEFFICIENT	CONTINUITY	Z/TAS	FLOW RATE FRACTION
1	2.764	.865	0.0000	.2126	1.0991	.8809	.1111	.1111	.1111	0.0000
2	3.003	.948	0.0000	.2147	1.0456	.8827	.1114	.1114	.1114	.2602
3	3.195	1.000	0.0000	.2526	1.0000	.8829	.1121	.1121	.1121	.4812
4	3.432	1.074	0.0000	.2745	.8938	.8825	.1148	.1148	.1148	.7613
5	3.627	1.135	0.0000	.2926	.8960	.8872	.1128	.1128	.1128	1.0000

ABSOLUTE VELOCITY (FPS)

RELATIVE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	291.65	-11.78	644.27	707.30	291.65	-11.78	403.06	497.65	241.21
2	277.43	-12.64	686.06	666.55	277.43	-2.64	343.99	441.93	242.07
3	265.36	6.97	574.53	632.89	265.36	6.97	295.67	397.34	278.86
4	250.25	21.73	537.47	593.27	250.25	21.73	238.00	346.03	299.47
5	237.78	28.21	507.31	560.98	237.78	28.21	190.79	306.16	316.52

MACH NUMBER

FLOW ANGLE (DEG)

TEMPERATURE (DEG. R)

PRESSURE (PSI)

PRESSURE RATIO

STREAM LINE	ABSOLUTE	RELATIVE	ABSOLUTE	RELATIVE	TOTAL	STATIC	TOTAL	STATIC	101/101	101/514
1	.64	.45	65.65	54.12	545.50	503.87	19.846	15.032	1.0470	1.3691
2	.60	.40	65.41	51.12	545.50	508.53	19.911	15.975	1.0336	1.3214
3	.57	.36	65.21	48.10	545.50	512.17	19.965	16.012	1.0308	1.2853
4	.53	.31	65.04	43.57	545.50	516.21	20.055	16.933	1.0262	1.2448
5	.50	.27	64.89	38.75	545.50	519.31	20.122	16.939	1.0228	1.2149

SET NUMBER 1 2 10000.0 RPM 1.400 20.580 545.50
 PRESSURE RATIO TOTAL INLET TOTAL
 (PSI) (DEG. R)

KOTOR EXIT SOLUTION

STREAM LINE	POSITION	X=R/RM	RADIAL OPENING	FLARE	Y=VA /VAM EFFICIENCY	COEFFICIENT	CONTINUITY	FLOW RATE
1	3.523	.825	.0718	.1912	.9832	.1755	.1715	0.0000
2	3.265	.825	.0718	.2218	.9556	.1755	.1678	.2340
3	3.265	.825	.0718	.2447	1.0800	.1755	.1678	.4108
4	3.265	.825	.0718	.2747	1.0916	.1755	.1678	.7242
5	3.265	.825	.0718	.2983	1.1871	.1755	.1678	1.0000

ABSOLUTE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHITEL VELOCITY
1	201.32	-8.08	-249.46	328.46	201.32	-8.08	-404.47	524.70	245.04
2	195.57	1.86	-185.71	263.78	195.57	1.86	-449.35	489.97	245.04
3	195.57	1.86	-185.71	263.78	195.57	1.86	-449.35	489.97	245.04
4	201.32	19.48	-154.28	287.25	201.32	19.48	-457.17	518.20	312.88
5	201.32	28.82	-150.52	287.25	201.32	28.82	-485.36	543.54	334.84

MACH NUMBER

STREAM LINE	ABSOLUTE RELATIVE	RELATIVE	FLOW ANGLE (DEG)
1	.29	.48	-31.19
2	.24	.45	-31.19
3	.24	.45	-31.19
4	.26	.49	-31.19
5	.26	.49	-31.19

TEMPERATURE (DEG. R)

STREAM LINE	TOTAL	STATIC	TEMPERATURE (DEG. R)	TEMPERATURE RATIO
1	509.88	501.32	15.156	101/101
2	510.92	504.37	15.156	101/101
3	510.92	504.37	15.156	101/101
4	510.92	504.37	15.156	101/101
5	510.92	504.37	15.156	101/101

EQUIV/STATIC PRESSURE RATIO

STREAM LINE	EQUIV/STATIC PRESSURE RATIO
1	1.2
2	1.2
3	1.2
4	1.2
5	1.2

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	3	10000.0	1.400	20.580	545.50

OVERALL TURBINE CHARACTERISTICS

STREAM LINE	PRESSURE RATIO TOT/STA	EFFICIENCY TOT/10T	HEAD COEFFICIENT	BLADE/JET SPEED RATIO	THEORETICAL DEGREE OF REACTION
1	1.4407	.7802	11.1627	.3993	.1314
2	1.3923	.7891	9.1222	.3408	.1518
3	1.3876	.8080	7.5111	.3024	.2253
4	1.3859	.8195	6.5076	.2920	.3187
5	1.3927	.8263	5.7890	.4114	.4000

MASS AVERAGED QUANTITIES

HORSE POWER = 28.96 (HP)
 MOMENT = 15.24 (FT-LB)
 FLOW RATE = 2.45 (LB/SEC)

REFERRED RPM = 9748.44
 REFERRED HORSE POWER = 20.17 (HP)
 REFERRED MOMENT = 10.86 (FT-LB)
 REFERRED FLOW RATE = 1.79 (LB/SEC)

TOTAL/STATIC EFFICIENCY = .7044
 TOTAL/STATIC EFFICIENCY = .6075
 TOTAL/STATIC PRESSURE RATIO = 1.3348

HEAD COEFFICIENT = 7.7267
 BLADE/JET SPEED RATIO = .3581
 THEORETICAL DEGREE OF REACTION = .2407
 MACH NUMBER AT STATION 6 = .1777

SET PAGE RPM TOTAL/STATIC INLET TOTAL INLET TOTAL
NUMBER 1 15000.0 PRESSURE RATIO 1.400 PRESSURE 20.580 TEMPERATURE 545.50

STATOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION (IN)	X-R/RM SHIFT (IN)	RADIAL OPENING (IN)	BLADE ANGLE (IN)	Y=VA /VAM	EFFICIENCY	LOSS COEFFICIENT	CONTINITY	7ETAP	FLOW RATE FRACTION
1	2.764	.865	0.0000	.2126	1.0972	.8953	.1045	.1045	.1045	0.0000
2	3.183	.900	0.0000	.2127	1.0453	.8953	.1047	.1047	.1047	.2610
3	3.195	1.000	0.0290	.2227	1.0400	.8952	.1048	.1048	.1048	.4826
4	3.432	1.074	0.0000	.2246	.8928	.8945	.1052	.1052	.1052	.7635
5	3.627	1.135	0.0000	.2926	.8928	.8945	.1055	.1055	.1055	1.0000

ABSOLUTE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	279.79	-11.22	618.88	678.55	279.79	-11.22	256.27	379.59	361.81
2	264.45	-12.53	582.07	640.16	264.45	-12.53	188.97	326.67	393.10
3	294.98	-5.83	551.88	607.93	255.90	-5.83	133.59	287.84	418.29
4	227.58	20.84	515.46	568.98	248.00	20.84	10.79	229.43	449.20
5	227.58	27.00	485.56	536.93	227.58	27.00			474.77

MACH NUMBER

FLOW ANGLE (DEG)

TEMPERATURE (DEG. R)

PRESSURE RATIO

STREAM LINE	ABSOLUTE RELATIVE	ABSOLUTE RELATIVE	TOTAL	STATIC	TOTAL	STATIC	101/101	101/STA
1	.61	.34	65.65	42.49	507.19	15.463	1.0415	1.3409
2	.59	.29	65.41	35.35	545.50	15.463	1.0278	1.3803
3	.51	.22	65.21	27.66	514.75	15.463	1.0247	1.2557
4	.48	.20	65.04	19.40	518.90	15.463	1.0247	1.2198
5	.48	.20	64.89	21.71	545.50	15.463	1.0192	1.1930

SET NUMBER PAGE RPM TORQUE/STATIC PRESSURE TOTAL INLET TOTAL INLET TOTAL
 NUMBER NUMBER (DEG. R) PRESSURE (PBI) TEMPERATURE (DEG. R) TEMPERATURE (DEG. R)
 1 2 15000.0 1.400 20.500 545.50

ROTOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION	X=R/RM	RADIAL SHIFT	BLADE OPENING	Y=VA/VAM	EFFICIENCY	LOSS COEFFICIENT	CONTINUITY	FLUX RATE
1	3.693	.835	-.0710	.1912	.9944	.8722	.1279	.1279	0.0000
2	3.620	.935	-.0710	.2219	.9132	.8785	.1216	.1216	.2253
3	3.265	1.000	-.0405	.2747	1.0000	.8832	.1169	.1169	.2152
4	3.585	1.098	-.1517	.2983	1.1517	.8737	.1263	.1263	.2112
5	3.837	1.175	-.2100		1.3031	.8663	.1337	.1337	1.0000

ABSOLUTE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WIRL VELOCITY
1	192.13	-7.71	-109.84	221.44	192.13	-7.71	-462.35	500.74	353.51
2	173.34	1.68	-10.00	176.23	173.34	1.68	-405.30	432.05	305.11
3	193.21	4.32	-1.64	193.27	193.21	4.32	-429.03	470.55	427.33
4	223.93	19.26	-3.20	223.78	223.93	19.26	-466.13	517.05	466.13
5	251.77	29.87	-7.72	253.54	251.77	29.87	-502.98	563.27	502.98

MACH NUMBER

STREAM LINE	ABSOLUTE	RELATIVE	FLOW ANGLE (DEG)	TEMPERATURE (DEG. R)	PRESSURE (PSI)	PRESSURE RATIO
1	28	.46	-29.74	TOTAL	TOTAL	101/101
2	16	.43	-3.74	501.84	14.582	1.4113
3	18	.47	-66.48	504.16	14.961	1.4524
4	20	.51	-65.76	506.97	15.253	1.3510
5	23	.51	-64.45	507.21	15.270	1.3471
			-63.41	507.87	15.199	1.3764
						1.3479
						1.3543
						1.4054

EQUIVALENT PRESSURE RATIO

STREAM LINE	EQUIVALENT PRESSURE RATIO	EQUIVALENT PRESSURE RATIO
1	518.62	1.2
2	520.42	1.2
3	522.28	1.2
4	525.29	1.2
5	528.13	1.2

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	3	15000.0	1.400	20.580	545.50

OVERALL TURBINE CHARACTERISTICS

STREAM LINE	PRESSURE RATIO TOT/STA	EFFICIENCY TOT/101	HEAD COEFFICIENT	BLADE/JET SPEED RATIO	THEORETICAL DEGREE OF REACTION
1	1.4113	.8539	5.0637	.4443	.2043
2	1.3271	.8657	3.2684	.5531	.2781
3	1.3479	.8584	2.9014	.5821	.3821
4	1.3542	.8488	2.6948	.6092	.4694

MASS AVERAGED QUANTITIES

HORSE POWER = 31.71 (HP)
 TORQUE = 1.10 (FT-LB)
 FLOW RATE = 2.39 (LB/SEC)

REFERRED RPM POWER = 14622.66 (HP)
 REFERRED TORQUE = 22.09 (FT-LB)
 REFERRED FLOW RATE = 7.93 (LB/SEC)

TOTAL/STATIC EFFICIENCY = .7968
 TOTAL/TOTAL EFFICIENCY = .8594
 TOTAL/STATIC PRESSURE RATIO = 1.3521

HEAD COEFFICIENT = 3.4357
 BLADE/JET SPEED RATIO = .5395
 THEORETICAL DEGREE OF REACTION = .3013
 MACH NUMBER AT STATION 0 = .1735

SET PAGE TOTAL/STATIC INFI TOTAL INFI TOTAL
NUMBER NUMBER 1 PRESSURE RATIO 1.400 PRESSURE 20.580 TEMPERATURE 545.50

RPM 20000.0

STATOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION (IN)	X=R/RM	RADIAL SHIFT (IN)	BLADE OPENING (IN)	Y=VA /VAM	EFFICIENCY	LOSS COEFFICIENT	ZETA	CONTINUITY	FLOW RATE FRACTION
1	2.764	.865	0.0000	.2126	1.4027	.9133	.0877	.0877		0.0000
2	3.083	.740	0.0000	.2126	1.4027	.9061	.0909	.0909		.2613
3	3.433	1.070	0.0000	.2326	1.0000	.9065	.0935	.0935		.4839
4	3.627	1.070	0.0000	.2326	.8903	.9061	.0949	.0949		.7637
5		1.135	0.0000	.2926		.9040	.0960	.0960		1.0000

ABSOLUTE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY
1	291.10	-11.68	643.06	705.98
2	276.49	-2.63	604.00	664.29
3	241.95	6.04	571.59	629.64
4	245.16	21.55	532.98	588.31
5	235.05	27.89	501.49	554.54

RELATIVE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY
1	291.10	-11.68	160.65	332.69
2	276.49	-2.63	79.86	297.81
3	241.95	6.04	-13.87	243.48
4	245.16	21.55	-13.76	267.68
5	235.05	27.89	-13.54	270.79

MACH NUMBER FLOW ANGLE (DEG)

STREAM LINE	ABSOLUTE	RELATIVE
1	.64	.30
2	.60	.26
3	.57	.23
4	.53	.23
5	.50	.24

TEMPERATURE (DEG. R)

STREAM LINE	TOTAL	STATIC
1	545.50	504.03
2	545.50	508.20
3	545.50	510.70
4	545.50	510.70
5	545.50	510.70

PRESSURE RATIO

STREAM LINE	TOT/101	TOT/STA
1	1.0282	1.0282
2	1.0257	1.0257
3	1.0232	1.0232
4	1.0207	1.0207
5	1.0185	1.0185

SET NUMBER RACE RPM TOTAL/STATIC PRESSURE INLET TOTAL TEMPERATURE (DEG. R)

545.50

20.580

1.400

ROTOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION	X=R/RM	RADIAL SHIFT	BLADE OPENING	Y=VA /VAM	EFFICIENCY	COEFFICIENT	CONTINUITY	FRACTION RATE
1	3.693	.825	.0710	.1912	1.0076	.8915	.1095	.1095	0.0000
2	3.020	.925	-.0168	.2218	1.0000	.8753	.1244	.1244	.02140
3	3.265	1.000	-.0412	.2447	1.0000	.8637	.1364	.1364	.3939
4	3.585	1.058	-.0712	.2647	1.0000	.8696	.1304	.1304	.6617
5	3.837	1.175	-.2100	.2983	1.4565	.8743	.1258	.1258	1.0000

RELATIVE VELOCITY (FPS)

ABSOLUTE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	DIFFERENTIAL VELOCITY	WHEEL VELOCITY
1	178.28	-7.15	40.98	183.02	178.28	-7.15	-429.04	464.66	470.02
2	154.63	1.45	173.25	231.82	154.63	1.45	-353.00	383.90	372.07
3	176.94	4.05	176.82	250.27	176.94	4.05	-497.28	430.82	589.85
4	218.53	18.98	168.82	276.99	218.53	18.98	-494.95	406.82	619.78
5	257.72	30.58	154.81	302.20	257.72	30.58	-514.88	576.59	689.68

STREAM LINE	MACH NUMBER	FLOW ANGLE (DEG)	TEMPERATURE (DEG. R)	PRESSURE (PSI)	PRESSURE RATIO
1	.17	12.95	497.08	14.214	13.927
2	.21	48.36	508.01	14.970	14.453
3	.23	45.00	509.23	15.516	14.970
4	.25	37.69	509.96	15.871	15.324
5	.28	30.99	509.92	15.819	15.324

STREAM LINE	EQUIVALENT TEMPERATURE (DEG. R)	EQUIVALENT INLET PRESSURE (PSI)	EQUIV/STATIC PRESSURE RATIO
1	512.26	16.062	1.2
2	515.93	16.509	1.1
3	518.54	16.837	1.1
4	520.99	16.855	1.2

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	3	2000.0	1.400	20.580	545.50

OVERALL TURBINE CHARACTERISTICS

STREAM LINE	PRESSURE RATIO TOT/STA	EFFICIENCY TOT/TOT	COEFFICIENT TOT/TOT	SPEED/1610	THEORETICAL DEGREE OF REACTION
1	1.4745	.8453	.8880	.5814	.2065
2	1.3741	.7919	.8735	.5919	.2468
3	1.3322	.7529	.8615	.7110	.2468
4	1.3247	.7398	.8514	.7882	.3178
5	1.3214	.7150	.8419	.8186	.4311

MASS AVERAGED QUANTITIES

HORSE POWER = 29.63 (HP)
MOMENT = 2.25 (FT-LB)
FLOW RATE = 2.25 (LB/SEC)

REFERRED RPM = 19496.88 (RPM)
REFERRED HORSE POWER = 19.94 (HP)
REFERRED MOMENT = 5.37 (FT-LB)
REFERRED FLOW RATE = 1.65 (LB/SEC)

TOTAL/STATIC EFFICIENCY = .7662
TOTAL/STATIC EFFICIENCY = .8629
TOTAL/STATIC PRESSURE RATIO = 1.3411

HEAD COEFFICIENT = 1.9418
BLADE/TFT SPEED RATIO = .9176
THEORETICAL DEGREE OF REACTION = .2620
MACH NUMBER AT STATION 0 = .1629

SET NUMBER 1 PAGE 1 RPM 25000.0 TOTAL/STATIC PRESSURE RATIO 1.400 INLET TOTAL PRESSURE 20.500 INLET TOTAL TEMPERATURE 545.50

STATOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION (IN)	X=R/RM	RADIAL SHIFT (IN)	BLADE OPENING (IN)	Y=UA /VAM	EFFICIENCY	LOSS COEFFICIENT	CONTINUITY	ZEIGER	FLOW RATE FRACTION
1	2.764	.865	0.0000	.2126	1.1005	.9045	.0955	.0955	.0955	0.0000
2	3.003	.940	0.0000	.2337	1.0465	.9026	.0974	.0974	.0974	.2612
3	3.195	1.000	0.0000	.2526	1.0000	.9011	.0989	.0989	.0989	.4829
4	3.432	1.074	0.0000	.2745	.9405	.8997	.1003	.1003	.1003	.7837
5	3.627	1.135	0.0000	.2926	.8912	.8986	.1014	.1014	.1014	1.0000

ABSOLUTE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WAKE VELOCITY
1	295.88	-11.47	631.53	673.32	295.88	-11.47	28.52	287.53	603.01
2	271.05	2.50	573.87	653.14	271.05	2.50	-61.31	278.49	655.17
3	244.34	27.23	522.75	617.58	244.34	27.23	-134.70	395.56	697.15
5	231.51	27.47	493.94	546.20	231.51	27.47	-297.35	377.85	791.29

MACH NUMBER

FLOW ANGLE (DEG)

TEMPERATURE (DEG. R)

PRESSURE (PSI)

PRESSURE RATIO

STREAM LINE	ABSOLUTE	RELATIVE	ABSOLUTE	RELATIVE	TOTAL	STATIC	TOTAL	STATIC	TOT/TOT	TOT/STA
1	.63	.26	65.45	5.70	545.50	505.50	19.985	15.109	1.0298	1.5443
2	.62	.27	65.21	-35.13	242.20	210.89	20.042	15.838	1.0243	1.5924
3	.59	.30	65.04	-22.50	242.20	210.89	20.042	16.267	1.0243	1.5924
4	.58	.34	64.89	-22.50	242.20	210.89	20.042	16.766	1.0243	1.5924
5	.57	.34	64.89	-22.50	242.20	210.89	20.042	17.157	1.0243	1.5924

SET NUMBER 1 2 25000.0 RPM PRESSURE RATIO 1.400 PRELIMINARY TOTAL PRESSURE (PSI) 20.580 PRELIMINARY TOTAL TEMPERATURE (DEG. R) 545.50

MOTOR EXIT SOLUTION

STREAM LINE	POSITION	X=R/RM	RADIAL OPENING	BLADE	Y=VA /VAM	EFFICIENCY	COEFFICIENT	LOSS	CONTINUITY	FRACTION RATE
1	2.423	.825	.0710	.1912	1.0181	.8812	.1189	.1189	.1189	0.0000
2	3.020	.925	.0168	.2218	1.0317	.8756	.1245	.1245	.1245	.2453
3	3.265	1.000	.0405	.2447	1.0000	.8714	.1287	.1287	.1287	.3887
4	3.585	1.098	.1537	.2747	1.2682	.8796	.1205	.1205	.1205	.6822
5	3.817	1.175	.2100	.2983	1.5106	.8861	.1140	.1140	.1140	1.0000

ABSOLUTE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	RELATIVE VELOCITY (FPS)	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	193.78	-7.77	121.38	228.72		193.78	-7.77	-466.14	504.85	587.52
2	158.25	1.50	295.33	335.24		158.25	1.50	-363.52	396.47	664.64
3	190.26	4.35	299.84	368.74		190.26	4.35	-432.42	483.26	783.21
4	241.26	28.96	277.69	388.48		241.26	28.96	-504.93	559.64	837.11
5	287.48	34.10	262.93	391.02		287.48	34.10	-574.17	642.99	

STREAM LINE	MACH NUMBER	FLOW ANGLE (DEG)	TEMPERATURE (DEG. R)	PRESSURE (PSI)	PRESSURE RATIO
1	.21	32.87	493.99	13.836	101/101
2	.36	61.02	513.13	15.973	101/514
3	.42	56.72	534.79	16.086	1.4874
4	.51	49.02	544.97	16.209	1.2885
5	.58	42.44	544.36	16.238	1.2794
					1.2696
					1.3719
					1.3829

STREAM LINE	EQUIVALENT TEMPERATURE (DEG. R)	EQUIVALENT INLET PRESSURE (PSI)	EQUIVALENT PRESSURE RATIO
1	510.05	15.883	1.2
2	516.07	16.597	1.1
3	522.08	17.272	1.1
4	528.09	17.946	1.2
5	534.10	18.620	1.3

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSIA)	INLET TOTAL TEMPERATURE (DEG. R)
1	3	25000.0	1.400	20.580	545.50

OVERALL TURBINE CHARACTERISTICS

STREAM LINE	PRESSURE RATIO TOT/STA	EFFICIENCY TOT/TOT	HEAD COEFFICIENT	BLADE/JET SPEED RATIO	THEORETICAL DEGREE OF REACTION
1	1.5342	.8806	2.0754	.6942	.2952
2	1.3746	.8204	1.1724	.8686	.1693
3	1.3491	.6888	1.1528	.9294	.2430
4	1.3719	.6598	1.0102	.9950	.3414
5	1.3829	.6205	.9261	1.0391	.4275

MASS AVERAGED QUANTITIES

HORSE POWER =	26.70 (HP)
MOMENT =	5.63 (FT-LB)
FLOW RATE =	2.43 (LB/SEC)
REFERRED RPM =	24371.10 (RPM)
REFERRED HORSE POWER =	18.63 (HP)
REFERRED MOMENT =	4.12 (FT-LB)
REFERRED FLOW RATE =	1.78 (LB/SEC)

TOTAL/STATIC EFFICIENCY =	.6072
TOTAL/DYNAMIC EFFICIENCY =	.8335
TOTAL/STATIC PRESSURE RATIO =	1.3934
TOTAL/TOTAL PRESSURE RATIO =	1.3037

HEAD COEFFICIENT =	1.2485
BLADE/JET SPEED RATIO =	.8950
THEORETICAL DEGREE OF REACTION =	.2988
MACH NUMBER AT STATION 0	.1768

SET PAGE
NUMBER 1
RPM 3000.0
TOTAL/STATIC
PRESSURE RATIO 1.400
INLET TOTAL
PRESSURE 20.580
INLET TOTAL
TEMPERATURE 545.50

STATOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION (IN)	X=R/RM	RADIAL SHIFT (IN)	BLADE OPENING (IN)	Y=VA./VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	CONTINUITY	7.10%	FLOW RATE FRACTION
1	2.764	.845	0.0000	.2129	1.0012	.9028	.0922	.0945	.0922	0.0000
2	3.192	.940	0.0000	.2347	1.0468	.9055	.0945	.0964	.0945	.2601
3	3.432	1.000	0.0000	.2526	1.0000	.9036	.0964	.0981	.0964	.4815
4	3.627	1.074	0.0000	.2745	.9403	.9006	.0994	.0994	.0994	.7628
5		1.135	0.0000	.2926	.8907					1.0000

STREAM LINE	ABSOLUTE VELOCITY (FPS)			RELATIVE VELOCITY (FPS)			WHF FL VELOCITY
	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	
1	305.04	-12.24	739.78	-12.24	-49.77	309.32	723.62
2	289.96	6.34	676.62	6.34	-152.78	327.76	700.54
3	280.02	22.62	649.48	22.62	-236.83	366.80	698.41
4	275.46	29.27	582.11	29.27	-339.00	438.11	698.41
5	246.73				-423.13	470.68	949.55

STREAM LINE	MACH NUMBER		FLOW ANGLE (DEG)		TEMPERATURE (DEG. R)		PRESSURE (PSI)		PRESSURE RATIO	
	ABSOLUTE	RELATIVE	ABSOLUTE	RELATIVE	TOTAL	STATIC	TOTAL	STATIC	TOT/TOT	TOT/STN
1	.67	.28	65.65	-9.27	545.50	499.96	19.921	14.683	1.0331	1.4006
2	.63	.30	65.21	-27.29	545.50	505.12	19.895	12.528	1.0298	1.3472
3	.60	.30	65.21	-40.83	545.50	513.77	20.000	10.298	1.0271	1.2672
4	.56	.30	65.04	-52.47	545.50	517.30	20.150	16.734	1.0239	1.2638
5	.52	.44	64.89	-59.76					1.0213	1.2298

NET NUMBER 1 2 30000.0 1.400 20.580 545.50
 RPM PRESSURE RATIO INLET TOTAL INLET TOTAL
 (DEG. R)

ROTOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION	X=R/RM	RADIAL OPENING	BLADE	Y=V-A	EFFICIENCY	LOSS	COEFFICIENT	CONTINITY	FLOW RATE
1	2.693	.825	.0718	.1912	1.0274	.8817	.1181	.1181	.1181	0.0000
2	3.265	1.000	-.0405	.2216	1.0000	.8772	.1208	.1208	.1208	.1951
3	3.585	1.098	-.1537	.2747	1.0000	.8772	.1208	.1208	.1208	.3644
4	3.837	1.175	-.2100	.2983	1.0000	.8772	.1208	.1208	.1208	.6688
5					1.0000	.8772	.1208	.1208	.1208	1.0000

ABSOLUTE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	200.40	-8.04	222.75	299.74	200.40	-8.04	-482.24	522.32	705.03
2	155.94	1.48	432.40	452.64	155.94	1.48	-752.21	805.48	790.61
3	195.05	4.46	421.66	464.61	195.05	4.46	-538.60	562.34	878.78
4	257.10	22.33	379.05	493.03	257.10	22.33	-625.47	700.44	1004.53
5	313.08	37.15			313.08	37.15			

RELATIVE VELOCITY (FPS)

STREAM LINE	ABSOLUTE RELATIVE	TEMPERATURE (DEG. R)	TEMPERATURE (DEG. R)	TEMPERATURE (DEG. R)	TEMPERATURE (DEG. R)	TEMPERATURE (DEG. R)	TEMPERATURE (DEG. R)	TEMPERATURE (DEG. R)	TEMPERATURE (DEG. R)	TEMPERATURE (DEG. R)
1	.28	48	48.03	-67.44	480.47	483.01	13.432	12.729	1.5322	1.4168
2	.42	36	70.17	-66.48	519.51	501.93	16.642	14.753	1.5322	1.5920
3	.42	43	65.18	-65.76	521.98	504.16	16.642	14.753	1.5322	1.5920
4	.54	54	57.34	-64.45	524.51	505.58	17.868	15.008	1.5322	1.5920
5	.43	54	50.45	-63.41	525.68	505.45	17.120	14.923	1.5322	1.5920

STREAM LINE	EQUIVALENT TEMPERATURE (DEG. R)	EQUIVALENT INLET PRESSURE (PSI)	EQUIVALENT PRESSURE RATIO	EQUIVALENT PRESSURE RATIO	EQUIVALENT PRESSURE RATIO	EQUIVALENT PRESSURE RATIO	EQUIVALENT PRESSURE RATIO	EQUIVALENT PRESSURE RATIO	EQUIVALENT PRESSURE RATIO	EQUIVALENT PRESSURE RATIO
1	515.71	15.283	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
2	515.71	16.297	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
3	515.71	16.297	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
4	515.71	16.297	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
5	515.71	16.297	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	5	30000.0	1.400	20.580	545.50

OVERALL TURBINE CHARACTERISTICS

STREAM LINE	PRESSURE RATIO TOT/STA	EFFICIENCY TOT/101	HEAD COEFFICIENT TOT/101	SPEED/RATIO DEGREE OF REACTION	THEORETICAL
1	1.5148	1.5322	.8787	1.6058	.7891
2	1.5958	1.5366	.8092	1.0195	.0787
3	1.5783	1.2205	.7798	.8205	1.1040
4	1.5713	1.2058	.7392	.7806	1.1747
5	1.5791	1.2021	.7092	.6379	1.2523

MASS AVERAGED QUANTITIES

HORSE POWER	=	22.02	(HP)
MOMENT	=	3.86	(FT-LB)
FLOW RATE	=	2.53	(LB/SEC)

REFERRED RPM	=	29245.42	(RPM)
REFERRED HORSE POWER	=	15.33	(HP)
REFERRED MOMENT	=	2.75	(FT-LB)
REFERRED FLOW RATE	=	1.85	(LB/SEC)

TOTAL/STATIC EFFICIENCY	=	.5159
TOTAL/TOTAL EFFICIENCY	=	.7803
TOTAL/STATIC PRESSURE RATIO	=	1.4106
TOTAL/TOTAL PRESSURE RATIO	=	1.2575

HEAD COEFFICIENT	=	.9013
MASS FLOW RATIO	=	1.0534
THEORETICAL DEGREE OF REACTION	=	.2061
MACH NUMBER AT STATION 0	=	.1841

SET		PAGE		RPM	TOTAL/STATIC		INLET TOTAL		INLET TOTAL	
NUMBER	NUMBER	NUMBER	NUMBER		PRESSURE RATIO	EFFICIENCY	LOSS COEFFICIENT	CONTINUITY	TEMPERATURE	TEMPERATURE
1	1	1	1	5000.0	1.600	1.1046	.0894	.0894	23.1720	562.23
STATOR EXIT SOLUTION										
STREAM LINE	RADIAL POSITION (IN)	X=R/RM	RADIAL SHIFT (IN)	BLADE OPENING (IN)	Y=VA	EFFICIENCY	LOSS COEFFICIENT	CONTINUITY	TEMPERATURE	TEMPERATURE
1	2.764	.865	0.0000	.2126	1.1046	.9406	.0894	.0894	0.0000	0.0000
2	3.003	.940	0.0000	.2126	1.0480	.9049	.0959	.0959	.2295	.2295
3	3.195	1.000	0.0000	.2526	1.0000	.8908	.1012	.1012	.4270	.4270
4	3.432	1.074	0.0000	.2726	.9395	.8946	.1054	.1054	.7678	.7678
5	3.627	1.135	0.0000	.2726	.8698	.8912	.1098	.1098	1.0000	1.0000
RELATIVE VELOCITY (FPS)										
STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY	WHEEL VELOCITY
1	402.80	-16.16	889.81	976.87	402.80	-16.16	769.21	868.43	120.40	120.40
2	382.17	3.63	814.81	918.39	382.17	3.63	753.83	800.90	131.03	131.03
3	346.39	8.34	709.52	802.20	358.89	8.34	680.60	742.82	149.82	149.82
4	325.01	20.76	715.84	802.20	342.61	20.76	680.60	742.82	155.23	155.23
5	329.43	38.49	692.24	763.49	324.46	38.49	543.98	676.81	158.26	158.26
TEMPERATURE (DEG. R)										
STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY	WHEEL VELOCITY
1	402.80	-16.16	889.81	976.87	402.80	-16.16	769.21	868.43	120.40	120.40
2	382.17	3.63	814.81	918.39	382.17	3.63	753.83	800.90	131.03	131.03
3	346.39	8.34	709.52	802.20	358.89	8.34	680.60	742.82	149.82	149.82
4	325.01	20.76	715.84	802.20	342.61	20.76	680.60	742.82	155.23	155.23
5	329.43	38.49	692.24	763.49	324.46	38.49	543.98	676.81	158.26	158.26
PRESSURE RATIO										
STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY	WHEEL VELOCITY
1	402.80	-16.16	889.81	976.87	402.80	-16.16	769.21	868.43	120.40	120.40
2	382.17	3.63	814.81	918.39	382.17	3.63	753.83	800.90	131.03	131.03
3	346.39	8.34	709.52	802.20	358.89	8.34	680.60	742.82	149.82	149.82
4	325.01	20.76	715.84	802.20	342.61	20.76	680.60	742.82	155.23	155.23
5	329.43	38.49	692.24	763.49	324.46	38.49	543.98	676.81	158.26	158.26

SHI RAGE RPM TOTAL/STATIC INLET TOTAL INLET TOTAL
NUMBER NUMBER PRESSURE RATIO PRESSURE TEMPERATURE
(PSI) (DEG. R)

1 2 5000.0 1.600 23.520 562.23

ROTOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION	X-R/RM	RADIAL SHIFT	BLADE OPERATING	Y=VA /VAM	EFFICIENCY	LOSS COEFFICIENT	70% CONTINUITY	FLOW RATE FRACTION
1	2.693	.825	.0710	.1912	.9722	.7663	.2337	.2337	0.0000
2	3.020	.825	.0618	.1818	1.0012	.7635	.2337	.2337	.2445
3	3.265	1.000	-.0405	.2447	1.0000	.7635	.2337	.2337	.4445
4	3.585	1.098	-.1537	.2747	1.0302	.7654	.2337	.2337	.7362
5	3.837	1.175	-.2100	.2903	1.0743	.7669	.2331	.2331	1.0000

ABSOLUTE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	268.85	-10.46	-510.24	573.15	268.85	-10.46	-627.75	679.87	117.50
2	268.76	-2.55	-489.60	555.02	268.76	-2.55	-617.37	673.34	117.77
3	268.76	26.14	-431.30	506.79	268.76	26.14	-595.76	653.42	117.46
4	268.76	34.20	-400.42	504.88	268.76	34.20	-578.80	641.10	117.44
5	268.76	34.20	-400.42	504.88	268.76	34.20	-578.80	644.86	117.42

RELATIVE VELOCITY (FPS)

STREAM LINE	ABSOLUTE	RELATIVE	FLOW ANGLE (DEG)	TEMPERATURE (DEG. R)	STATIC	TOTAL	101/101	101/514
1	52	62	-67.44	534.39	507.06	17.137	14.260	1.1725
2	50	59	-66.48	533.37	507.74	17.101	14.393	1.1731
3	48	58	-65.76	533.36	507.73	17.012	14.706	1.1733
4	46	58	-65.45	533.36	511.73	17.042	15.045	1.1733
5	45	58	-65.41	533.36	511.73	17.042	15.104	1.1733

MACH NUMBER

STREAM LINE	EQUIVALENT INLET TEMPERATURE (DEG. R)	EQUIVALENT INLET PRESSURE (PSI/100)	EQUIVALENT PRESSURE RATIO
1	546.52	19.1904	1.4
2	546.47	20.095	1.4
3	546.53	20.262	1.4
4	546.53	20.423	1.4

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	3	5000.0	1.600	24.520	562.23

OVERALL TURBINE CHARACTERISTICS

STREAM LINE	PRESSURE RATIO TOT/STA	EFFICIENCY TOT/STA	HEAD COEFFICIENT TOT/TOT	SPEED/INLET RATIO	THEORETICAL DEGREE OF REACTION
1	1.6494	.3717	.5225	.1271	.1643
2	1.3754	.3921	.61.8818	.1363	.16543
3	1.5973	.4118	.51.5135	.1514	.0077
4	1.3663	.4351	.43.6353	.1664	.0072
5	1.5572	.4431	.36.1130	.1766	.1813

MASS AVERAGED QUANTITIES

HORSE POWER = 30.55 (HP)
 MOMENT = 32.09 (FT-LB)
 FLOW RATE = 3.10 (LB/SEC)

REFERRED RPM = 4801.15 (HP)
 REFERRED HORSE POWER = 18.33 (FT-LB)
 REFERRED MOMENT = 20.06 (LB/SEC)
 REFERRED FLOW RATE = 2.02

TOTAL/STATIC EFFICIENCY = .4116
 TOTAL/STATIC EFFICIENCY = .4062
 TOTAL/STATIC PRESSURE RATIO = 1.6000
 TOTAL/STATIC PRESSURE RATIO = 1.5653

HEAD COEFFICIENT = 44.5568
 THEORETICAL DEGREE OF REACTION = .1498
 MACH NUMBER AT STATION 0 = .0128
 MACH NUMBER AT STATION 0 = .2011

SET NUMBER 1 PAGE 1
 TOTAL/STATIC PRESSURE RATIO 1.600
 INLET TOTAL TEMPERATURE 562.13
 INLET TOTAL PRESSURE 23.520
 KPM 10000.0

STATOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION (IN)	X=R/RM	RADIAL SHIF (IN)	BLADE OPENING (IN)	Y=VA /VAM	EFFICIENCY	LOSS COEFFICIENT	CONTINITY	ZETA*	FLUX RATE FRACTION
1	2.764	.865	0.0000	.2126	1.1044	.9084	.0916	.0916	.0916	0.0000
2	3.003	.940	0.0000	.2347	1.0479	.9019	.0981	.0981	.0981	.2562
3	3.195	1.000	0.0000	.2536	1.0000	.8948	.1052	.1052	.1052	.4765
4	3.432	1.074	0.0000	.2745	.9397	.8931	.1069	.1069	.1069	.7591
5	3.627	1.135	0.0000	.2926	.8901	.8901	.1099	.1099	.1099	1.0000

ABSOLUTE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	471.28	-14.89	848.18	900.42	371.28	-14.89	578.97	682.95	241.21
2	363.48	3.35	769.58	846.39	362.29	3.35	507.51	647.07	267.07
3	340.89	27.54	727.85	801.77	320.89	7.69	448.99	541.45	273.85
4	315.91	27.44	658.50	708.94	315.91	27.44	379.03	434.29	274.22
5	294.23	35.50	638.43	705.97	299.23	35.50	321.91	440.94	316.22

MACH NUMBER

STREAM LINE	ABSOLUTE	RELATIVE	ABSOLUTE	RELATIVE	TEMPERATURE (DEG. R)	PRESSURE (PSI)	TEMPERATURE (DEG. R)	PRESSURE (PSI)	TOI/TOI	TOI/STA
1	.83	.63	65.65	57.33	TOTAL 562.23	22.407	STATIC 494.77	14.425	1.0487	1.619
2	.77	.56	65.41	55.24	562.23	22.475	502.62	15.125	1.0487	1.619
3	.73	.50	65.21	54.52	562.23	22.538	508.74	15.684	1.0487	1.619
4	.67	.44	63.18	50.19	562.23	22.640	515.55	16.216	1.0487	1.619
5	.63	.39	64.89	47.09	562.23	22.720	520.76	17.376	1.0487	1.619

SET NUMBER PAGE NUMBER RPM
 1 2 10000.0
 TOTAL/STATIC PRESSURE RATIO 1.600
 INLET TOTAL PRESSURE (PSI) 23.520
 INLET TOTAL TEMPERATURE (DEG. R) 562.23

ROTOR EXIT SOLUTION

STREAM LINE	AXIAL POSITION	X=R/RM	SHOULDER	BLADE	Y=VA/VUM	EFFICIENCY	COEFFICIENT	CONTINUITY	FRACTION RATE
1	2.693	8.25	0.210	1912	0.799	0.816	1834	1814	0.0000
2	3.020	9.25	0.168	2218	0.715	0.816	1802	1802	0.2360
3	3.265	1.000	0.045	2447	1.0000	0.823	1777	1777	0.4144
4	3.485	1.098	0.137	2747	1.0795	0.838	1673	1673	0.7270
5	3.637	1.175	0.210	2983	1.1644	0.849	1591	1571	1.0000

ABSOLUTE VELOCITY (FPS)

RELATIVE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	242.82	-9.71	-347.41	423.51	242.82	-9.71	-347.41	640.78	242.82
2	247.93	2.28	-287.63	374.58	247.93	2.28	-287.63	601.14	247.93
3	262.38	21.65	-263.49	361.19	262.38	21.65	-263.49	601.14	262.38
4	267.60	34.12	-248.13	362.07	267.60	34.12	-248.13	643.44	267.60
5	267.60	34.12	-239.71	375.95	267.60	34.12	-239.71	643.44	267.60

FLUX NUMBER

FLOW ANGLE (DEG)

TEMPERATURE (DEG. R)

PRESSURE RATIO

STREAM LINE	ABSOLUTE	RELATIVE	ABSOLUTE	RELATIVE	TOTAL	STATIC	TOTAL	STATIC	TOTAL/01	TOTAL/STA
1	1.29	1.29	-55.14	-62.44	515.72	509.79	15.718	14.192	1.4904	1.4584
2	1.33	1.33	-50.17	-66.48	516.05	504.37	15.649	14.073	1.4794	1.4507
3	1.33	1.33	-46.86	-65.76	515.96	504.20	15.645	14.073	1.4751	1.4497
4	1.34	1.34	-39.51	-64.45	515.70	504.79	15.604	14.050	1.4720	1.4455
5	1.34	1.34	-39.81	-63.41	515.24	503.48	15.594	14.052	1.4706	1.4441

EQUIVALENT INLET PRESSURE RATIO

EQUIVALENT INLET PRESSURE (DEG. R)

TEMPERATURE (DEG. R)

STREAM LINE	EQUIVALENT INLET PRESSURE (DEG. R)	EQUIVALENT INLET PRESSURE RATIO
1	533.50	1.3
2	534.44	1.3
3	534.33	1.3
4	534.56	1.3
5	537.93	1.3

STATION LINE	TEST NUMBER	PSI/STA TOT/STN	EFFICIENCY TOT/TOT	KPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	5	1.4964	1.4964	10000.0	1.400	23.520	562.23
2		1.4964	1.4964				
3		1.4964	1.4964				
4		1.4964	1.4964				
5		1.4964	1.4964				

OVERALL TURBINE CHARACTERISTICS

PASS AVERAGED QUANTITIES

HORSE POWER = 46.12 (HP)
MOMENT = 34.25 (FT-LB)
FLOW RATE = 2.93 (LB/SEC)

REVERSED RISE POWER = 9602.10 (HP)
REVERSED MOMENT = 22.21 (FT-LB)
REVERSED FLOW RATE = 1.91 (LB/SEC)

TOTAL/STATIC EFFICIENCY = .6355
TOTAL/STATIC PRESSURE RATIO = 1.6029
TOTAL/STATIC PRESSURE RATIO = 1.4964

HEAD COEFFICIENT = 11.1498
HEAD/FT SPEED RATIO = 1.2995
TEMPERATURE DEGREE OF REACTION = 1.000
WATER NUMBER AT STATION 0 = 1.000

SET NUMBER PAGE RPM INLET/STATIC PRESSURE INLET TOTAL TEMPERATURE INLET TOTAL TEMPERATURE
(PSI) (DEG. R)

1 2 15000.0 1.600 23.520 562.23

ROTOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION	X=R/RM	RADIAL SHIFT	BLADE OPENING	BLADE	Y=VA /VAM	EFFICIENCY	LOSS COEFFICIENT	RELATIVE CONTINUITY	FLOW RATE FRACTION
1	2.493	.025	-.0710	.3412	.8631	.9084	.1370	.1370	.1370	0.0009
2	3.000	.050	-.0405	.2647	.8702	.9247	.1298	.1298	.1298	.0009
3	3.265	.100	-.0405	.2647	.8702	.9247	.1298	.1298	.1298	.0009
4	3.585	.100	-.0405	.2647	.8702	.9247	.1298	.1298	.1298	.0009
5	3.817	.1175	-.0400	.2683	.8862	.9392	.1139	.1139	.1139	.0009

ABSOLUTE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY
1	230.29	-220.95	325.11	230.29	-9.56	-573.46	621.03
2	245.32	-214.38	335.45	245.32	-9.56	-573.46	621.03
3	241.10	-182.98	269.24	241.10	-9.56	-573.46	621.03
4	249.98	-195.22	287.24	249.98	-9.56	-573.46	621.03
5	248.76	-94.60	315.30	248.76	-9.56	-573.46	621.03

MACH NUMBER FLOW ANGLE (DEG)

STREAM LINE	ABSOLUTE	RELATIVE	ABSOLUTE	RELATIVE	TEMPERATURE (DEG. R)	PRESSURE (PSI)	TEMPERATURE (DEG. R)	PRESSURE (PSI)	TEMPERATURE (DEG. R)	PRESSURE (PSI)
1	.30	.57	-42.84	-62.44	505.89	494.30	14.240	14.240	14.240	14.240
2	.23	.51	-28.50	-66.48	508.97	501.36	15.247	15.247	15.247	15.247
3	.24	.53	-24.13	-65.76	508.97	501.36	15.247	15.247	15.247	15.247
4	.26	.57	-19.43	-64.45	509.02	502.16	15.630	15.630	15.630	15.630
5	.29	.61	-17.57	-63.41	508.75	500.47	15.616	15.616	15.616	15.616

EQUIVALENT INLET PRESSURE EQUIVALENT INLET PRESSURE

STREAM LINE	EQUIVALENT INLET PRESSURE (DEG. R)	EQUIVALENT INLET PRESSURE (DEG. R)	EQUIVALENT INLET PRESSURE (DEG. R)	EQUIVALENT INLET PRESSURE (DEG. R)
1	18.126	18.126	18.126	18.126
2	18.418	18.418	18.418	18.418
3	18.742	18.742	18.742	18.742
4	19.158	19.158	19.158	19.158
5	19.595	19.595	19.595	19.595

SURNAME	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	15000.0	1.600	23.520	562.23
2	1.6253	1.5754		
3	1.5212	1.5129		
4	1.5276	1.5084		
5	1.5273	1.5041		
	1.5951	1.5061		

OVERALL TURBINE CHARACTERISTICS

STATION	EFFICIENCY	HEAD COEFFICIENT	HEAD	HEAD/FT	THEORETICAL
1	.8145	2.0247	3260	3260	3260
2	.8492	2.2651	4636	4636	4636
3	.8556	4.6545	4946	4946	4946
4	.8598	4.0026	5168	5168	5168
5	.8615	3.7435			

MASS AVERAGED QUANTITIES

HORSE POWER = 54.17 (HP)
 MOMENT = 18.97 (FT-LB)
 FLOW RATE = 2.97 (LB/SEC)

REFERRED RPM = 1403.46 (RPM)
 REFERRED HORSE POWER = 32.51 (HP)
 REFERRED MOMENT = 11.86 (FT-LB)
 REFERRED FLOW RATE = 1.93 (LB/SEC)

TOTAL/TOTAL EFFICIENCY = .7739
 TOTAL/TOTAL EFFICIENCY = .8532
 TOTAL/TOTAL PRESSURE RATIO = 1.5073
 TOTAL/TOTAL PRESSURE RATIO = 1.5165

HEAD COEFFICIENT = 4.8616
 HEAD/FT SPEED RATIO = 4.8616
 THEORETICAL DEGREE OF REACTION = 1.0000
 RECH NUMBER AT STATION 0 = 1.0000

SET NUMBER 1 PAGE NUMBER 1 RPM 2000.0 TOTAL/STATIC PRESSURE RATIO 1.600 INLET TOTAL PRESSURE 23.520 INLET TOTAL TEMPERATURE 562.23

STATOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION (IN)	X-R/RM	RADIAL SHIFT (IN)	BLADE ANGLE (DEG)	Y=VA /VAM	EFFICIENCY	LOSS COEFFICIENT	ZEIAX	CONTINUITY	FLOW RATE FRACTION
1	2.764	.845	.2126	1.0995	.9033	.0967	.0967	.0967	.0967	0.0000
2	3.093	.940	.2347	1.0441	.9819	.0981	.0981	.0981	.0981	.2585
3	3.135	1.000	.2525	1.0000	.9999	.0002	.0002	.0002	.0002	.2772
4	3.432	1.074	.2926	.8917	.8989	.1011	.1011	.1011	.1011	.2772
5	3.827	1.135	.0000	.0000	.0000	.0000	.0000	.0000	.0000	1.0000

RELATIVE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	326.89	-13.11	722.13	793.78	482.41
2	313.61	-13.11	643.70	705.28	552.14
3	279.77	-13.11	643.70	705.28	552.14
4	279.77	-13.11	643.70	705.28	552.14
5	265.11	-13.11	643.70	705.28	552.14

ABSOLUTE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY
1	326.89	-13.11	722.13	793.78
2	313.61	-13.11	643.70	705.28
3	279.77	-13.11	643.70	705.28
4	279.77	-13.11	643.70	705.28
5	265.11	-13.11	643.70	705.28

TEMPERATURE (DEG. R)

STREAM LINE	ABSOLUTE	RELATIVE	TEMPERATURE (DEG. R)	STATIC	TOTAL	101/101	101/51A
1	72	37	562.23	509.93	23.628	1.0194	1.4678
2	72	37	562.23	509.93	23.628	1.0194	1.4678
3	72	37	562.23	509.93	23.628	1.0194	1.4678
4	72	37	562.23	509.93	23.628	1.0194	1.4678
5	72	37	562.23	509.93	23.628	1.0194	1.4678

PRESSURE (PSI)

STREAM LINE	ABSOLUTE	RELATIVE	TEMPERATURE (DEG. R)	STATIC	TOTAL	101/101	101/51A
1	72	37	562.23	509.93	23.628	1.0194	1.4678
2	72	37	562.23	509.93	23.628	1.0194	1.4678
3	72	37	562.23	509.93	23.628	1.0194	1.4678
4	72	37	562.23	509.93	23.628	1.0194	1.4678
5	72	37	562.23	509.93	23.628	1.0194	1.4678

SET NUMBER PAGE RPM INLET/STATIC PRESSURE INLET TOTAL PRESSURE INLET TOTAL TEMPERATURE (DEG. R)

1 2 20000.0 1.600 23.520 562.23

ROTOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION	X=R/RM	RADIAL SHIFT	BLADE OPENING	Y=VA/VAM	EFFICIENCY	LOSS COEFFICIENT	CONTINUITY	FLOW RATE
1	2.673	.825	-.0710	.1912	.9981	.8887	.1111	.1111	0.0000
2	3.020	.925	-.0160	.2218	.8994	.8926	.1074	.1074	.2215
3	3.265	1.000	-.0405	.2447	1.0000	.8954	.1046	.1046	.4105
4	3.505	1.070	-.1337	.2747	1.1677	.8843	.1157	.1157	.7083
5	3.837	1.175	-.2100	.2983	1.3318	.8756	.1245	.1245	1.0000

ABSOLUTE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	RELATIVE VELOCITY (FPS)	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	234.59	-9.41	-74.53	253.10	253.10	234.59	-9.41	-544.55	611.42	478.02
2	215.61	-2.10	-41.67	218.94	218.94	215.61	-2.10	-485.61	529.63	527.07
3	204.92	23.88	-56.90	200.14	200.14	204.92	23.88	-521.87	573.48	587.83
4	274.84	37.12	-44.70	318.19	318.19	274.84	37.12	-624.98	699.89	667.68

MACH NUMBER

STREAM LINE	ABSOLUTE	RELATIVE	FLOW ANGLE (DEG)	TEMPERATURE (DEG. R)	PRESSURE (PSI)	PRESSURE RATIO
1	.23	.56	-21.95	496.86	14.279	1.6272
2	.22	.52	-11.10	502.74	15.477	1.7196
3	.24	.58	11.53	502.50	15.531	1.7634
4	.26	.64	18.49	501.09	15.519	1.8157
5	.29	.64	18.13	499.20	15.411	1.8182

STREAM LINE	EQUIVALENT TEMPERATURE (DEG. R)	EQUIVALENT PRESSURE (PSI)	EQUIV/STATIC PRESSURE RATIO
1	522.64	17.525	1.3
2	524.88	18.808	1.3
3	529.77	18.515	1.3
4	534.93	19.229	1.4
5	539.96	19.928	1.4

STREAM LINE	SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
	1	3	20000.0	1.600	23.520	562.23
OVERALL TURBINE CHARACTERISTICS						
	PRESSURE RATIO TOT/STA	EFFICIENCY TOT/STA	HEAD COEFFICIENT TOT/TOT	BLADE/JET SPEED RATIO	THEORETICAL DEGREE OF REACTION	
1	1.7186	.8177	.8750	.4252	.2757	
2	1.5412	.8279	.8776	.4833	.2334	
3	1.5627	.8199	.8780	.6250	.3102	
4	1.5860	.7864	.8244	.6250	.4141	
5	1.6182	.7560	.8537	.6794	.4987	
MASS AVERAGED QUANTITIES						
			HORSE POWER =	56.33 (HP)		
			MOMENT =	14.79 (FT-LB)		
			FLOW RATE =	2.95 (LB/SEC)		
			REFLECTED RPM =	19204.61 (RPM)		
			REFLECTED HORSE POWER =	33.81 (HP)		
			REFLECTED MOMENT =	9.25 (FT-LB)		
			REFLECTED FLOW RATE =	1.92 (LB/SEC)		
			TOTAL/STATIC EFFICIENCY =	.8052		
			TOTAL/TOTAL EFFICIENCY =	.8717		
			TOTAL/STATIC PRESSURE RATIO =	1.5445		
			HEAD COEFFICIENT	2.7512		
			BLADE/JET SPEED RATIO	.6027		
			THEORETICAL DEGREE OF REACTION =	.3362		
			MACH NUMBER AT STATION 0	.1912		

SET NUMBER 1 PAGE 1 RPM 25000.0 TOTAL/STATIC PRESSURE RATIO 1.880 INLET TOTAL PRESSURE 562.23 INLET TOTAL TEMPERATURE 562.23

STATOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION (IN)	X=R/RM	RADIAL SHIFT (IN)	BLADE OPENING (IN)	Y=VA /VAM	EFFICIENCY	LOSS COEFFICIENT	CONFIDENCY	FLOW RATE FRACTION
1	2.764	.865	0.000	.5129	1.1009	.9884	.0916	.0916	0.0000
2	3.192	1.000	0.000	.5129	1.0027	.9843	.0937	.0937	.2584
3	3.432	1.074	0.000	.5129	1.0000	.9847	.0953	.0953	.4794
4	3.627	1.135	0.000	.5129	1.0000	.9831	.0969	.0969	.7613
5				.2926	.8988	.9818	.0982	.0982	1.0000

RELATIVE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	332.96	-13.36	735.53	807.49	603.01
2	316.55	3.01	691.51	740.53	655.17
3	302.44	6.92	654.81	721.32	697.15
4	284.39	24.70	610.80	674.22	746.67
5	269.41	31.96	574.81	635.61	791.29

ABSOLUTE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	RELATIVE VELOCITY (FPS)
1	332.96	-13.36	735.53	807.49	603.01
2	316.55	3.01	691.51	740.53	655.17
3	302.44	6.92	654.81	721.32	697.15
4	284.39	24.70	610.80	674.22	746.67
5	269.41	31.96	574.81	635.61	791.29

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TEMPERATURE (DEG. R)

STREAM LINE	ABSOLUTE	RELATIVE	TEMPERATURE (DEG. R)	PRESSURE (PSI)	PRESSURE RATIO
1	73	.32	562.23	22.646	1.0384
2	.68	.29	562.23	22.646	1.0384
3	.65	.27	562.23	22.646	1.0384
4	.60	.20	562.23	22.646	1.0384
5	.56	.31	562.23	22.646	1.0384

SET NUMBER 1 2 25000.0 1.600 23.520 562.23

ROTUN EX11 SOLUTION

STREAM LINE	RADIAL POSITION	X=RM	Y=VA	EFFICIENCY	COEFFICIENT	CONTINITY	FLOW RATE
1	2.693	.825	1.0074	.9844	.0968	.0968	0.0000
2	3.020	.825	1.0074	.8666	.1156	.1156	.2132
3	3.265	1.000	1.0000	.8704	.1297	.1297	.3545
4	3.485	1.098	1.2198	.8796	.1204	.1204	.4949
5	3.637	1.175	1.4240	.8869	.1132	.1132	1.0000

ABSOLUTE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WAKE VELOCITY
1	203.41	-9.36	25.81	235.02	243.41	-9.36	-541.71	600.45	507.57
2	214.79	-5.91	197.80	281.80	200.70	1.91	-441.04	502.83	558.84
3	285.60	24.20	198.07	304.78	231.59	5.30	-544.95	545.95	765.81
4	329.78	39.13	178.27	382.17	282.58	24.54	-590.93	637.11	837.11
5				376.92	329.78	39.13	-656.83	737.80	

MACH NUMBER

STREAM LINE	ABSOLUTE	RELATIVE	ABSOLUTE	RELATIVE
1	.56	.56	6.31	-67.44
2	.56	.56	41.67	-66.48
3	.56	.56	41.67	-65.76
4	.56	.56	34.43	-64.41
5	.56	.56	26.40	-63.41

TEMPERATURE (DEG. R)

STREAM LINE	TOTAL	STATIC	TOTAL	STATIC	TOI/TOT	TOI/STA
1	490.94	485.34	13.757	13.312	1.2076	1.7659
2	508.52	511.91	15.691	14.996	1.4943	1.5763
3	509.74	502.01	15.791	14.901	1.4943	1.5763
4	511.05	501.31	15.816	14.801	1.4943	1.5763
5	511.37	499.55	15.815	14.572	1.4943	1.6111

PRESSURE RATIO

STREAM LINE	EQUIVALENT INLET TEMPERATURE (DEG. R)	EQUIVALENT INLET PRESSURE (PSI)	EQUIVALENT PRESSURE RATIO
1	512.14	16.901	1.3
2	522.95	17.643	1.3
3	528.48	18.341	1.3
4	537.04	19.496	1.4
5	544.84	20.565	1.4

SFT NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	3	25000.0	1.600	23.520	162.23

OVERALL TURBINE CHARACTERISTICS

SIRFAM LINE	PRESSURE RATIO TOT/STA	EFFICIENCY TOT/TOT	HEAD COEFFICIENT	BLADE/JET SPEED RATIO	THEORETICAL DEGREE OF REACTION
1	1.7669	.8448	2.7088	.5988	.5922
2	1.5790	.7911	1.9008	.7253	.5179
3	1.5782	.7438	1.6948	.7681	.4018
4	1.5882	.7449	1.4913	.8181	.3986
5	1.6141	.7076	1.3776	.8514	.4814

MASS AVERAGED QUANTITIES

HORSE POWER = 53.63 (HP)
MOMENT = 13.27 (FT-LB)
FLOW RATE = 2.92 (LB/SEC)

REFURVED RPM = 24005.76 (RPM)
REFURVED MOMENT = 32.19 (FT-LB)
REFURVED FLOW RATE = 7.04 (LB/SEC)

TOTAL/STATIC EFFICIENCY = .7670
TOTAL/STATIC PRESSURE RATIO = 1.6041
TOTAL/STATIC PRESSURE RATIO = 1.5192

HEAD COEFFICIENT = 1.7933
BLADE/JET SPEED RATIO = .7248
THEORETICAL DEGREE OF REACTION = .3463
MACH NUMBER AT STATION 0 = 1.809

SET NUMBER 1 PAGE 1 RPM 30000.0 TOTAL/STATIC PRESSURE RATIO 1.600 INLET TOTAL PRESSURE 23.520 INLET TOTAL TEMPERATURE 562.23

STATOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION (IN)	X=R/RM	RADIAL SHIFT (IN)	BLADE OPENING (IN)	Y=V/A	EFFICIENCY	MADE	LOSS COEFFICIENT	CONTINUITY	Z/LAS	FLOW RATE FRACTION
1	2.764	.865	0.0000	.2126	1.1019	.9121		.0879	.0879		0.0000
2	3.083	.940	0.0000	.2147	1.0471	.9094		.0906	.0906		.2580
3	3.175	1.000	0.0200	.2526	1.0000	.9075		.0908	.0908		.4789
4	3.512	1.070	0.0000	.2525	.8980	.9023		.0947	.0947		.7689
5	3.627	1.135	0.0000	.2926	.8902	.9038		.0962	.0962		1.0000

ABSOLUTE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY
1	341.40	-13.69	754.17	827.96
2	324.41	7.08	728.17	779.40
3	305.59	7.09	620.80	738.93
4	291.23	25.29	625.48	690.42
5	275.81	32.72	588.46	650.71

RELATIVE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY
1	341.40	-13.69	30.56	343.84
2	324.41	7.08	-72.23	333.26
3	305.59	7.09	-162.73	327.23
4	291.23	25.29	-272.93	339.93
5	275.81	32.72	-361.09	455.55

MACH NUMBER FLOW ANGLE (DEG)

STREAM LINE	ABSOLUTE RELATIVE	ABSOLUTE	RELATIVE
1	.75	65.65	5.12
2	.70	65.41	-13.44
3	.66	65.21	-28.48
4	.62	65.04	-43.15
5	.58	64.89	-52.63

TEMPERATURE (DEG. R) PRESSURE (PSI)

STREAM LINE	TOTAL	STATIC	TOTAL	STATIC
1	542.23	505.19	22.636	15.566
2	542.23	516.68	22.719	16.338
3	542.23	522.56	22.788	16.968
4	542.23	522.00	22.873	17.206
5	542.23	522.00	22.939	18.290

PRESSURE RATIO

STREAM LINE	TOT/TOI	TOT/STA
1	1.0391	1.1110
2	1.0352	1.1195
3	1.0331	1.1262
4	1.0283	1.1284
5	1.0253	1.1260

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	3	30000.0	1.600	23.520	562.23

OVERALL TURBINE CHARACTERISTICS

STREAM LINE	PRESSURE RATIO TOT/STA	EFFICIENCY TOT/TOT	HEAD COEFFICIENT	BLADE/JET SPEED RATIO	THEORETICAL DEGREE OF REACTION
1	1.8221	.8263	2.0322	.7014	.2938
2	1.4114	.8265	1.2972	.8780	.1669
3	1.3845	.8270	1.3668	.7377	.2435
4	1.3845	.8270	1.3668	1.0074	.3380
5	1.5700	.8275	.9860	1.8506	.4285

MASS AVERAGED QUANTITIES

HORSE POWER	=	45.44	(HP)
MOMENT	=	7.96	(FT-LB)
FLOW RATE	=	2.93	(LB/SEC)

REFERRED RPM	=	28806.91	(RPM)
REFERRED HORSE POWER	=	27.27	(HP)
REFERRED MOMENT	=	4.97	(FT-LB)
REFERRED FLOW RATE	=	1.91	(LB/SEC)

TOTAL/STATIC EFFICIENCY	=	.6674
TOTAL/TOTAL EFFICIENCY	=	.8406
TOTAL/STATIC PRESSURE RATIO	=	1.5082
TOTAL/TOTAL PRESSURE RATIO	=	1.4421

HEAD COEFFICIENT RATIO	=	1.3322
BLADE/JET SPEED RATIO	=	.8045
THEORETICAL DEGREE OF REACTION	=	.2771
MACH NUMBER AT STATION 0	=	.1898

SET NUMBER PAGE RPM TOTAL/STATIC INLET TOTAL INLET TOTAL
 1 1 5000.0 PRESSURE RATIO PRESSURE TEMPERATURE
 1.800 26.460 557.30

STATOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION (IN)	X=R/RM	RADIAL SHIFT (IN)	BLADE OPENING (IN)	BLADE EFFICIENCY	Y=U/V	LOSS COEFFICIENT	CONTINUITY	ZETA*	FLUX RATE FRACTION
1	2.764	.865	0.0000	.2126	.9152	1.1053	.0843	.0843	.0843	0.0000
2	3.003	.940	0.0000	.2447	.9088	1.0484	.0912	.0912	.0912	.2504
3	3.195	1.000	0.0290	.2526	.9033	1.0000	.0967	.0967	.0967	.4689
4	3.432	1.074	0.0000	.2745	.8983	.9390	.1017	.1017	.1017	.7530
5	3.627	1.135	0.0000	.2926	.8941	.8888	.1059	.1059	.1059	1.0000

ABSOLUTE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY
1	439.17	-17.62	970.14	1065.86
2	416.53	-7.68	987.27	1007.74
3	416.53	9.49	880.27	984.54
4	373.11	32.41	800.34	883.17
5	353.15	41.90	753.16	833.17

RELATIVE VELOCITY (FPS)

STREAM LINE	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	-17.62	970.14	956.50	120.60
2	-8.06	978.53	893.23	130.03
3	32.41	728.68	763.63	149.73
4	41.90	651.60	693.35	158.26

STREAM LINE	MACH NUMBER	FLOW ANGLE (DEG)	TEMPERATURE (DEG. R)	PRESSURE (PSI)	PRESSURE RATIO
1	1.01	65.45	557.30	24.762	1.0486
2	.94	62.67	557.30	24.762	1.0486
3	.88	60.21	557.30	24.762	1.0486
4	.81	59.32	557.30	24.762	1.0486
5	.76	59.32	557.30	24.762	1.0486

MODEL PAGE RPM TOTAL/STATIC INLET TOTAL
NUMBER NUMBER PRESSURE RATIO PRESSURE TEMPERATURE
(DEG. R)

557.30

26.460

1.800

5000.0

1

2

ROTOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION	X=R/RM	RADIAL SHIFT	BLADE OPENING	BLADE ANGLE	Y=UA /VAM EFFICIENCY	LOSS COEFFICIENT	CONTINUITY	71108	FLOW RATE FRACTION
1	2.693	.825	.0710	.1912	.1912	.9717	.2278	.2328	.2328	0.0000
2	3.620	.925	.0148	.2218	.2218	1.0028	.2208	.2348	.2348	.2445
3	3.265	1.000	-.0405	.2447	.2447	1.0000	.2313	.2313	.2313	.4415
4	3.585	1.098	-.1537	.2747	.2747	1.0235	.2335	.2335	.2335	.7363
5	3.837	1.175	-.2100	.2983	.2983	1.0613	.2352	.2352	.2352	1.0000

ABSOLUTE VELOCITY (FPS)

STREAM LINE	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	298.74	-11.98	671.68	298.74	-11.98	-718.97	778.66	117.50
2	308.34	-2.93	653.81	308.34	2.93	-708.29	773.50	131.27
3	307.47	7.04	621.98	307.47	7.04	-682.74	748.81	142.46
4	314.69	27.33	592.77	314.69	27.33	-658.03	729.92	156.44
5	326.33	38.72	585.44	326.33	38.72	-651.94	730.08	167.42

RELATIVE VELOCITY (FPS)

STREAM LINE	ABSOLUTE RELATIVE	ABSOLUTE RELATIVE	RELATIVE RELATIVE	TEMPERATURE (DEG. R)	PRESSURE (PSI)	STATIC	TOTAL	101/101	101/STA
1	.62	.72	-63.59	488.52	18.159	14.014	18.159	1.4571	1.4571
2	.67	.71	-61.87	489.24	18.093	14.152	18.093	1.4625	1.4625
3	.67	.69	-60.36	492.72	18.244	14.657	18.244	1.4503	1.4503
4	.67	.67	-57.70	495.03	18.397	15.049	18.397	1.4383	1.4383
5	.64	.67	-56.04	495.44	18.425	15.147	18.425	1.4361	1.4361

TEMPERATURE (DEG. R)

STREAM LINE	EQUIVALENT INLET PRESSURE (PSI)	EQUIVALENT INLET PRESSURE (PSI)	EQUIVALENT INLET PRESSURE (PSI)	EQUIVALENT INLET PRESSURE (PSI)	EQUIVALENT INLET PRESSURE (PSI)	EQUIVALENT INLET PRESSURE (PSI)	EQUIVALENT INLET PRESSURE (PSI)	EQUIVALENT INLET PRESSURE (PSI)	EQUIVALENT INLET PRESSURE (PSI)
1	22.027	22.027	22.027	22.027	22.027	22.027	22.027	22.027	22.027
2	22.106	22.106	22.106	22.106	22.106	22.106	22.106	22.106	22.106
3	22.259	22.259	22.259	22.259	22.259	22.259	22.259	22.259	22.259
4	22.359	22.359	22.359	22.359	22.359	22.359	22.359	22.359	22.359
5	22.549	22.549	22.549	22.549	22.549	22.549	22.549	22.549	22.549

STREAM LINE	SIT. NUMBER	PAIR NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. K)
1	1	3	5000.0	1.600	26.460	557.50

OVERALL TURBINE CHARACTERISTICS

STREAM LINE	PRESSURE RATIO TOT/INT	EFFICIENCY TOT/TOT	HEAD COEFFICIENT	SPEED RATIO	DEGREE OF REACTION
1	1.600	.3375	.5496	.76.4640	.1144
2	1.4521	.3561	.5464	.63.0575	.1151
3	1.4503	.3787	.5035	.53.4993	.1367
4	1.7423	.3500	.6009	.44.4772	.1499
5	1.7461	.4062	.6091	.39.3928	.1593

MASS AVERAGED QUANTITIES

HORSE POWER = 40.88 (HP)
 MOMENT = 42.85 (FT-LB)
 FLOW RATE = 3.68 (LB/SEC)

REFLECTED RPM = 4022.34 (RPM)
 REFLECTED HORSE POWER = 31.86 (HP)
 REFLECTED MOMENT = 23.81 (FT-LB)
 REFLECTED FLOW RATE = 2.32 (LB/SEC)

TOTAL/STATIC EFFICIENCY = .3261
 TOTAL/STATIC EFFICIENCY = .3695
 TOTAL/STATIC PRESSURE RATIO = 1.8122
 TOTAL/STATIC PRESSURE RATIO = 1.4494

HEAD COEFFICIENT = 54.9407
 HEAD COEFFICIENT = 1249
 DEGREE OF REACTION = .0538
 MACH NUMBER AT STATION 0 = .2117

SET NO. 1
 CASE NUMBER 1
 RPM 10000.0
 TOTAL/STATIC PRESSURE RATIO 1.800
 INLET TOTAL PRESSURE 26.400
 INLET TOTAL TEMPERATURE 537.30

STATOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION (IN)	X-R/W	RADIAL SHIFT (IN)	BLADE OPENING (IN)	Y=VA /VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	ZETA*	CONTINUITY	FLOW RATE FRACTION
1	5.764	.865	0.0000	1.2126	1.1035	.9052	.0948	.0740	0.0000	0.0000
2	3.803	.940	0.0000	.2337	1.0475	.8991	.1009	.1009	.0544	.0544
3	3.413	1.020	0.0000	.2526	1.0000	.8942	.1058	.1049	.0544	.0544
4	3.627	1.135	0.0000	.2725	.9402	.8911	.1089	.1049	.0544	.0544
5					.8910	.8885	.1115	.1115	1.0000	1.0000

ABSOLUTE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	387.07	-15.53	805.05	936.71	387.07	-15.53	613.85	725.86	241.01
2	367.44	3.49	802.49	892.80	367.44	3.49	540.63	653.68	262.07
3	350.81	8.03	798.64	871.89	350.81	8.03	408.88	595.05	263.46
4	312.54	37.08	708.35	737.56	312.54	37.08	350.30	470.92	299.47
5									410.52

STREAM LINE	MASS NUMBER	FLOW ANGLE (DEG)	TEMPERATURE (DEG. F)	PRESSURE (PSI)	AREA RATIO
1	.87	65.65	557.30	26.400	1.000
2	.81	65.41	557.30	26.400	1.000
3	.76	65.21	557.30	26.400	1.000
4	.71	65.04	557.30	26.400	1.000
5	.66	64.89	557.30	26.400	1.000

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	2	10000.0	1.800	26.460	557.30

ROTOR EXIT SOLUTION

STREAM LINE	POSITION	X=R/RH	RADIAL OPENING	BLADE	Y=VA /VAM EFFICIENCY	LOSS COEFFICIENT	CONFIDENCY	FRACTION RATE
1	2.693	.826	.0718	.1912	.9784	.8332	.1768	0.0000
2	3.020	.926	-.0168	.2216	.9764	.8332	.1768	.2363
3	3.265	1.000	-.0405	.2447	1.0000	.8335	.1745	.4364
4	3.585	1.098	-.1537	.2747	1.0638	.8335	.1666	.7296
5	3.837	1.175	-.2100	.2983	1.1358	.8397	.1603	1.0000

ABSOLUTE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	279.90	-11.23	-438.57	520.40	279.90	-11.23	-673.58	729.51	235.01
2	279.90	-2.65	-377.45	469.40	279.90	-2.65	-648.98	699.09	263.54
3	279.90	26.73	-328.30	432.82	279.90	26.73	-635.33	686.71	284.93
4	324.93	38.55	-314.30	453.71	324.93	38.55	-649.14	726.95	312.88
5									

RELATIVE VELOCITY (FPS)

STREAM LINE	MACH NUMBER	FLOW ANGLE (DEG)	TEMPERATURE (DEG. R)	PRESSURE (PSI)	PRESSURE RATIO
1	.48	-47.46	487.20	16.625	1.5914
2	.43	-51.53	487.20	16.625	1.5756
3	.42	-50.77	486.42	16.624	1.5718
4	.41	-46.75	488.46	16.623	1.5636
5	.42	-44.05	489.53	16.621	1.5638
					1.7647

STREAM LINE	EQUIVALENT TEMPERATURE (DEG. R)	EQUIVALENT INLET PRESSURE (PSI)	EQUIV/STATIC PRESSURE RATIO
1	527.57	28.652	1.5
2	528.07	28.881	1.4
3	528.81	28.975	1.4
4	530.14	21.225	1.4
5	531.50	21.558	

SET NUMBER	RACE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	3	10000.0	1.800	26.460	557.30

OVERALL TURBINE CHARACTERISTICS

STREAM LINE	TOT/STA PRESSURE RATIO	TOT/TOT EFFICIENCY	HEAD COEFFICIENT	BLADE/JET SPEED RATIO	THEORETICAL DEGREE OF REACTION
1	1.5916	.7429	18.8037	.2306	.1102
2	1.5756	.7596	18.8037	.2584	.1576
3	1.5721	.7677	12.9877	.2775	.2350
4	1.5559	.7806	11.0959	.3002	.3105
5	1.5647	.7877	10.0133	.3160	.3900

MASS AVERAGED QUANTITIES

HORSE POWER = 62.51 (HP)
MOMENT = 35.84 (FT-LB)
FLOW RATE = 3.94 (LB/SEC)

REFERRED RPM = 9644.68
REFERRED HORSE POWER = 33.50 (HP)
REFERRED MOMENT = 18.24 (FT-LB)
REFERRED FLOW RATE = 2.04 (LB/SEC)

TOTAL/STATIC EFFICIENCY = .6119
TOTAL/TOTAL EFFICIENCY = .6883
TOTAL/STATIC PRESSURE RATIO = 1.2922

HEAD COEFFICIENT = 13.3686
BLADE/JET SPEED RATIO = .2735
THEORETICAL DEGREE OF REACTION = .2358
MACH NUMBER AT STATION 0 = 1.2036

SET NUMBER 1 PAGE 1 RPM 15000.0 TOTAL/STATIC PRESSURE RATIO 1.800 INLET TOTAL PRESSURE 26.460 INLET TOTAL TEMPERATURE 557.30

STATOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION (IN)	X=R/RM	RADIAL SHIFT (IN)	BLADE OPENING (IN)	Y=VA /VAM	EFFICIENCY	LOSS COEFFICIENT	CONTINITY	ZETA	FLOW RATE FRACTION
1	2.764	.865	0.0000	.2126	1.0986	.9007	.0993	.0993	.0993	0.0000
2	3.003	.940	0.0000	.2347	1.0456	.8995	.1005	.1005	.1005	.2550
3	3.195	1.000	0.0000	.2526	1.0000	.8986	.1014	.1014	.1014	.4750
4	3.422	1.074	0.0000	.2745	.9415	.8984	.1016	.1016	.1016	.7582
5	3.627	1.135	0.0000	.2926	.8929	.8982	.1018	.1018	.1018	1.0000

ABSOLUTE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY
1	367.32	-14.73	811.42	898.81
2	349.52	-3.32	763.74	839.94
3	314.81	27.55	723.92	797.44
4	298.55	35.42	636.97	704.35

RELATIVE VELOCITY (FPS)

AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
367.32	-14.73	449.61	580.76	361.81
349.52	3.32	370.64	509.52	393.10
314.81	27.55	305.62	456.13	418.29
298.55	35.42	225.92	369.03	449.20
		162.19	341.60	474.77

MACH NUMBER FLOW ANGLE (DEG)

STREAM LINE	ABSOLUTE	RELATIVE
1	.82	.57
2	.72	.41
3	.67	.35
4	.63	.31
5	.63	.31

TEMPERATURE (DEG. R)

TOTAL	STATIC	TOTAL	STATIC
557.30	491.27	25.113	16.151
557.30	498.59	25.380	17.111
557.30	504.39	25.522	17.980
557.30	510.95	25.522	18.934
557.30	516.02	25.630	19.578

PRESSURE RATIO

TOT/TOT	TOT/STA
1.0536	1.6383
1.0426	1.5464
1.0367	1.4842
1.0324	1.4049
	1.3515

LET NUMBER CASE NUMBER RPM TOTAL/STATIC PRESSURE RATIO INLET TOTAL PRESSURE (PSI) INLET TOTAL TEMPERATURE (DEG. R)

557.30

NOZON EXIT SOLUTION

STREAM LINE	POSITION	X-W/WM	RADIAL SHOT	BLADE OPENING	Y-VA /VAM	EFFECTIVE WARE	COEFFICIENT	CONTINITY	FRACTION RATE
1	2.693	.605	.0718	.1912	.9852	.8597	.1404	.1404	0.0000
2	3.020	.975	.03168	.1319	.9474	.8666	.1314	.1314	.2301
3	3.265	1.000	.0405	.1247	1.0000	.8719	.1262	.1262	.4266
4	3.585	1.028	.0512	.12747	1.1020	.8786	.1214	.1214	.7217
5	3.837	1.175	.07100	.12983	1.2063	.8839	.1162	.1162	1.0000

RELATIVE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	275.36	-11.05	-667.66	717.68	352.51
2	264.80	-2.52	-608.29	663.43	325.31
3	279.51	6.40	-620.94	689.71	427.33
4	308.81	26.75	-644.10	714.47	466.33
5	337.17	40.00	-673.59	754.32	502.26

TEMPERATURE (DEG. R)

STREAM LINE	ABSOLUTE	RELATIVE	TOTAL	STATIC	TOTAL	STATIC	TOT/10T	TOT/STA
1	491.35	-67.44	491.35	475.92	15.224	13.723	1.7481	1.9281
2	493.37	-66.76	493.37	483.71	15.823	14.771	1.6722	1.7914
3	491.16	-65.76	491.16	483.71	15.875	14.643	1.6668	1.7826
4	493.61	-65.45	493.61	483.71	15.932	14.777	1.6609	1.7987
5	493.65	-63.41	493.65	480.63	15.984	14.586	1.6637	1.8141

EQUIVALENT INLET PRESSURE RATIO

STREAM LINE	EQUIVALENT INLET PRESSURE (PSI)	EQUIVALENT PRESSURE RATIO
1	19.545	1.4
2	19.500	1.4
3	20.200	1.4
4	20.721	1.4
5	21.211	1.5

STREAM LINE	SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)	INLET TOTAL INLET TOTAL DEGREE OF REACTION
1	1	3	15000.0	1.800	26.460	557.30	
2							
3							
4							
5							

OVERALL TURBINE CHARACTERISTICS

STREAM LINE	TOT/STA PRESSURE RATIO	TOT/STA EFFICIENCY	TOT/TOT COEFFICIENT	HEAD SPEED/IFT	THEORETICAL DEGREE OF REACTION
1	1.7381	.7035	.8336	8.7505	.3381
2	1.6722	.7482	.8403	8.4495	.3678
3	1.6668	.7560	.8475	8.3274	.4132
4	1.6639	.7513	.8538	8.0891	.4638
5	1.6141	.7414	.8571	4.6491	.4730

MASS AVERAGED QUANTITIES

HORSE POWER =	26.87	(HP)
MOMENT =	25.51	(FT-LB)
FLOW RATE =	3.51	(LB/SEC)
REFERRED RPM	14467.03	
REFERRED HORSE POWER =	41.19	(HP)
REFERRED MOMENT =	14.95	(FT-LB)
REFERRED FLOW RATE =	2.02	(LB/SEC)
TOTAL/STATIC EFFICIENCY =	.7445	
TOTAL/STATIC EFFICIENCY =	.8455	
TOTAL/STATIC PRESSURE RATIO =	1.8920	
HEAD COEFFICIENT	6.0665	
HEAD/IFT SPEED RATIO	.4060	
THEORETICAL DEGREE OF REACTION =	.3227	
MACH NUMBER AT STATION 8	.2014	

SFT PAGE KPM TOTAL/STATIC INLET TOTAL INLET TOTAL
 NUMBER 1 PRESSURE RATIO PRESSURE TEMPERATURE
 1 1.800 26.460 557.30

STATOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION (IN)	X-R/KM	RADIAL SHIFT (IN)	BLADE OPENING (IN)	Y=VA /VAN	EFFICIENCY	BLADE EFFICIENCY	LOSS COEFFICIENT	CONTINUITY	Z/LIA*	FLOW RATE FRACTION
1	2.774	8.5	0.0000	2.126	1.0996	.9048		.0952	.0952		0.0000
2	3.003	9.40	0.0000	2.147	1.0461	.9034		.0966	.0966		.2565
3	3.142	1.000	0.0250	2.206	1.0000	.9023		.0977	.0977		.4770
4	3.432	1.074	0.0000	2.245	1.0408	.9012		.0988	.0988		.7596
5	3.627	1.115	0.0000	2.266	1.0916	.9002		.0998	.0998		1.0000

ABSOLUTE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHIRL VELOCITY
1	352.41	-14.13	773.26	854.40	352.31	-14.13	295.05	460.27	462.41
2	335.13	3.18	732.20	805.27	335.18	3.18	268.06	394.31	394.31
3	327.48	7.13	691.70	764.16	327.48	7.13	138.48	366.31	366.31
4	301.44	26.18	627.42	713.98	285.67	23.89	-23.53	306.44	306.44
5	285.67	33.89	609.50	673.98				268.64	268.64

RELATIVE VELOCITY (FPS)

STREAM LINE	MACH NUMBER	FLOW ANGLE (DEG)	TEMPERATURE (DEG. K)	PRESSURE (PSI)	TEMPERATURE (DEG. K)	PRESSURE (PSI)	TEMPERATURE (DEG. K)	PRESSURE (PSI)
1	.78	.42	557.30	496.56	557.30	496.56	557.30	496.56
2	.73	.33	557.30	501.71	557.30	501.71	557.30	501.71
3	.69	.28	557.30	514.80	557.30	514.80	557.30	514.80
4	.64	.28	557.30	519.50	557.30	519.50	557.30	519.50
5	.60	.26	557.30	519.50	557.30	519.50	557.30	519.50

SEL NUMBER	PAIR NUMBER	RPM	INLET/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	2	20000.0	1.800	26.460	557.30

KOTON EXIT SOLUTION

STREAM LINE	AXIAL POSITION	X-R/RM	RADIAL SHIFT	FLARE OPENING	Y=VA /VAM	EFFICIENCY	LOSS COEFFICIENT	CONTINUITY	FLOW RATE FRACTION RATE
1	2.493	.825	.0210	.1912	.8932	.8062	.1131	.1131	0.0000
2	3.020	.825	-.0118	.1242	.8045	.8915	.1085	.1085	.2243
3	3.265	1.000	-.0403	.0045	1.0045	.8950	.1050	.1050	.4169
4	3.585	1.098	-.1532	.0247	1.0474	.8761	.1140	.1140	.7142
5	3.837	1.175	-.2100	.0983	1.2882	.8790	.1210	.1210	1.0000

ABSOLUTE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	258.07	-10.25	-175.89	320.36	268.07	-10.25	-645.11	691.62	470.02
2	258.71	2.34	-39.64	249.88	246.71	2.34	-566.72	579.59	579.02
3	262.21	5.17	-39.12	271.40	269.76	5.17	-547.68	579.77	562.55
4	307.53	21.86	-20.91	311.13	309.56	26.62	-647.68	719.23	669.68
5	347.51	41.23	-24.56	350.81	347.51	41.23	-694.24	777.45	

MACH NUMBER

STREAM LINE	ABSOLUTE TEMPERATURE (DEG. R)	RELATIVE TEMPERATURE (DEG. R)	FLOW ANGLE (DEG.)	TEMPERATURE (DEG. R)	PRESSURE (PSI)	PRESSURE RATIO
1	30	30	-34.15	422.58	TOTAL	TOTAL
2	33	33	-34.15	422.58	STATIC	STATIC
3	35	35	-65.48	404.76	14.545	14.545
4	39	39	-65.76	484.51	15.744	15.168
5	43	43	-64.45	482.53	15.789	15.162
			-63.41	480.11	15.759	14.871
					15.619	14.507

EQUIVALENT FLOW/STATIC PRESSURE RATIO

STREAM LINE	EQUIVALENT TEMPERATURE (DEG. R)	FLOW/STATIC PRESSURE RATIO	WHEEL VELOCITY
1	513.20	1.4	1.8191
2	516.55	1.4	1.8305
3	520.42	1.3	1.7483
4	525.35	1.4	1.6791
5	530.41	1.5	1.6940

STREAM LINE	SFT NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	3	20000.0	1.800	26.460	557.30	

OVERALL TURBINE CHARACTERISTICS

EFFICIENCY TOT/STA	EFFICIENCY TOT/TOT	HEAD COEFFICIENT	BLADE/JET SPEED RATIO	THEORETICAL DEGREE OF REACTION
1.8191	.8699	4.9528	.4494	.4000
1.8306	.8766	3.1835	.5283	.2709
1.8421	.8766	3.1835	.5283	.3430
1.8536	.8766	2.8437	.5740	.4425
1.8651	.8593	2.6368	.6158	.5225

MASS AVERAGED QUANTITIES

HORSE POWER = 81.89 (HP)
 MOMENT = 21.30 (FT-LB)
 FLOW RATE = 3.51 (LB/SEC)
 REFERRED RPM = 19289.37
 REFERRED HORSE POWER = 41.45 (HP)
 REFERRED MOMENT = 11.83 (FT-LB)
 REFERRED FLOW RATE = 2.02 (LB/SEC)

TOTAL/STATIC EFFICIENCY = .8020
 TOTAL/TOTAL EFFICIENCY = .8771
 TOTAL/STATIC PRESSURE RATIO = 1.7973
 TOTAL/TOTAL PRESSURE RATIO = 1.6980

HEAD COEFFICIENT = 3.1447
 BLADE/JET SPEED RATIO = 3.4468
 THEORETICAL DEGREE OF REACTION = .3669
 MACH NUMBER AT STATION 0 = .2015

SET NUMBER 1 PAGE 1 RPM 25000.0
TOTAL/STATIC PRESSURE RATIO 1.800 INLET TOTAL PRESSURE 26.460 INLET TOTAL TEMPERATURE 557.30

STATOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION (IN)	X-R/RM	RADIAL SHIFT (IN)	BLADE OPENING (IN)	Y=VA /UAM	EFFICIENCY	LOSS COEFFICIENT	ZETA*	CONTINUITY	FLOW RATE FRACTION
1	2.764	.865	0.0000	.2126	1.1008	.9085	.0915	.0915		0.0000
2	3.083	.908	0.0000	.2147	1.1000	.9077	.0935	.0935		.2567
3	3.195	1.000	0.0000	.2526	1.0000	.9042	.0953	.0953		.4772
4	3.432	1.074	0.0000	.2745	1.0404	.9032	.0958	.0958		.7598
5	3.627	1.135	0.0000	.2926	.6989	.9019	.0981	.0981		1.0000

RELATIVE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	353.56	-14.18	781.02	857.44	603.01
2	336.16	3.19	734.34	807.63	655.17
3	330.62	7.35	695.41	766.04	696.15
4	302.05	26.23	648.72	716.07	731.29
5	286.15	33.95	610.53	675.11	

MACH NUMBER

FLOW ANGLE (DEG)

TEMPERATURE (DEG. R)

PRESSURE (PSI)

PRESSURE RATIO

STREAM LINE	ABSOLUTE	RELATIVE	ABSOLUTE	RELATIVE	TOTAL	STATIC	TOTAL	STATIC	TOT/TOT	TOT/STA
1	.79	.36	65.65	26.73	557.30	496.12	25.138	16.860	1.0447	1.6694
2	.73	.31	65.41	13.25	557.30	503.09	25.443	16.725	1.1108	1.4303
3	.69	.30	65.21	-1.30	557.30	508.49	25.535	19.406	1.0317	1.3615
4	.64	.29	65.04	-18.31	557.30	514.63	25.646	20.106	1.0263	1.3160
5	.60	.30	64.89	-32.28						

NUMBER NUMBER RPM INLET/STATIC PRESSURE INLET TOTAL INLET TOTAL
1 2 25000.0 1.800 26.460 557.30

ROTOR EXIT SOLUTION

STREAM LINE	POSITION	X=R/RM	RADIAL OPENING	BLADE ANGLE	Y=UA/VAM	EFFICIENCY	COEFFICIENT	CONTINUITY	FRACTION RATE
1	2.693	.825	.0710	1212	1.0824	.9035	.0766	.0966	0.0000
2	3.020	.925	-.0168	2218	1.0851	.9025	.1143	.2176	.2176
3	3.265	1.000	-.0405	2447	1.0000	.8728	.1275	.4048	.4048
4	3.505	1.098	-.1537	2742	1.1867	.8819	.1181	.7835	.7835
5	3.837	1.175	-.2100	2983	1.3613	.8893	.1108	1.0000	1.0000

STREAM LINE	ABSOLUTE VELOCITY (FPS)			RELATIVE VELOCITY (FPS)			WHIRL VELOCITY
	AXIAL COMPONENT	RADIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	
1	269.51	-10.81	276.55	269.51	-10.81	-648.58	587.52
2	217.98	2.28	263.10	237.98	2.26	-546.68	558.84
3	268.87	29.73	302.91	268.87	6.31	-597.01	742.31
4	319.86	43.42	349.38	319.86	27.31	-657.19	742.31
5	366.00		366.00	366.00	43.42	-731.19	837.11

STREAM LINE	MACH NUMBER		FLOW ANGLE (DEG)		TEMPERATURE (DEG. R)		PRESSURE (PSI)		PRESSURE RATIO	
	ABSOLUTE	RELATIVE	ABSOLUTE	RELATIVE	TOTAL	STATIC	TOTAL	STATIC	101/101	101/51A
1	.24	.66	-12.72	-67.44	472.95	466.59	13.797	13.158	1.9128	2.0110
2	.27	.55	21.21	-65.76	489.53	483.77	15.720	15.032	1.8832	1.7544
3	.32	.61	19.63	-64.45	491.45	483.67	15.701	14.972	1.8853	1.7673
4	.36	.76	16.14	-63.41	491.88	479.81	15.794	14.736	1.8753	1.7956
5							15.768	14.436	1.8781	1.8329

STREAM LINE	EQUIVALENT TEMPERATURE (DEG. R)		EQUIVALENT INLET PRESSURE (PSI)		EQUIVALENT PRESSURE RATIO	
	ABSOLUTE	RELATIVE	ABSOLUTE	RELATIVE	ABSOLUTE	RELATIVE
1	507.64	18.270	18.270	1.4	1.4	1.4
2	513.35	19.085	19.085	1.3	1.3	1.3
3	519.35	19.950	19.950	1.3	1.3	1.3
4	525.21	21.142	21.142	1.4	1.4	1.4
5	535.21	22.335	22.335	1.5	1.5	1.5

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATION PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	3	25000.0	1.800	24.460	557.30

OVERALL TURBINE CHARACTERISTICS

STREAM LINE	PRESSURE RATIO TOT/STA	EFFICIENCY TOT/TOT	HEAD COEFFICIENT	BLADE/JET SPEED RATIO	THEORETICAL DEGREE OF REACTION
1	2.9110	.8365	3.3126	.5478	.3322
2	1.7540	.8196	2.3150	.6522	.2758
3	1.7673	.8009	2.0490	.7252	.3550
4	1.6923	.8621	1.8400	.7272	.4495
5	1.8329	.8568	1.7001	.7669	.5253

MASS AVERAGED QUANTITIES

HORSE POWER =	91.93 (HP)
MOMENT =	12.53 (FT-LB)
FLOW RATE =	3.52 (LB/SEC)
RPM =	24111.71
REFERRED HORSE POWER =	43.90 (HP)
REFERRED MOMENT =	9.56 (FT-LB)
REFERRED FLOW RATE =	2.03 (LB/SEC)
TOTAL/STATIC EFFICIENCY =	.7941
TOTAL/TOTAL EFFICIENCY =	.6730
TOTAL/STATIC PRESSURE RATIO =	1.8008
TOTAL/TOTAL PRESSURE RATIO =	1.9108
HEAD COEFFICIENT =	2.1851
BLADE/JET SPEED RATIO =	.6765
THEORETICAL DEGREE OF REACTION =	.3773
MACH NUMBER AT STATION 0 =	.2022

SET NUMBER 1
PAGE NUMBER 1
RPM 30000.0
TOTAL/STATIC PRESSURE RATIO 1.800
INLET TOTAL PRESSURE 26.460
INLET TOTAL TEMPERATURE 557.30

STATOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION (IN)	X-R/RM	RADIAL SHIFT (IN)	BLADE OPENING (IN)	Y-UA	UAH	EFFICIENCY	BLADE COEFFICIENT	LOSS	CONTINUITY	ZLIA*	FLOW RATE FRACTION
1	2.764	.865	0.0000	.2126	1.1018		.9124		.0876		.0076	0.0000
2	3.003	1.040	0.0000	.2147	1.0420		.9064		.0904		.0076	.2562
3	3.173	1.000	0.0000	.2526	1.0000		.9073		.0927		.0076	.2562
4	3.275	1.074	0.0000	.2745	.9400		.9055		.0945		.0076	.2562
5		1.135	0.0000	.2926	.8903		.9039		.0961		.0076	1.0000

ABSOLUTE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	362.67	-14.55	881.15	879.53	362.67	-14.55	77.53	371.15	723.62
2	344.62	7.22	775.84	827.97	344.62	7.22	-33.37	346.25	786.24
3	335.37	7.53	795.81	795.81	335.37	7.53	-33.37	357.63	836.58
4	319.41	26.87	733.51	733.51	319.41	26.87	-233.89	368.79	898.41
5	293.04	34.77	691.36	691.36	293.04	34.77	-324.33	438.49	949.55

MACH NUMBER

STREAM LINE	ABSOLUTE	RELATIVE
1	.81	.34
2	.76	.32
3	.71	.32
4	.66	.35
5	.62	.39

TEMPERATURE (DEG. R)

STREAM LINE	TOTAL	STATIC
1	557.30	422.93
2	557.30	422.93
3	557.30	422.93
4	557.30	422.93
5	557.30	422.93

PRESSURE (PSI)

STREAM LINE	TOTAL	STATIC
1	25.317	16.476
2	25.317	16.476
3	25.317	16.476
4	25.317	16.476
5	25.317	16.476

PRESSURE RATIO

STREAM LINE	101/101	101/51A
1	1.0452	1.6040
2	1.0407	1.5187
3	1.0371	1.4519
4	1.0326	1.3843
5	1.0291	1.3336

SET NUMBER PAGE RPM INLET/STATIC PRESSURE INLET TOTAL TEMPERATURE
(DEG. R)

2 30000.0 1.800 26.460 557.30

ROTOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION	X=R/RM	SHOULDER OPENING	BLADE	Y=VA /VAM	EFFICIENCY	COEFFICIENT	CONTINUITY	FRAYLON RATE
1	2.693	.825	.0710	.1912	1.0116	.9130	.0470	.0970	0.0000
2	3.020	.925	.0168	.2218	1.8541	.8930	.1020	.1070	.2084
3	3.265	1.000	-.0405	.2447	1.0000	.8780	.1120	.1221	.3899
4	3.585	1.098	-.1537	.2747	1.2331	.8675	.1135	.1325	.6713
5	3.837	1.175	-.2100	.2983	1.4460	.8950	.1051	.1051	1.0000

ABSOLUTE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	265.45	-10.65	66.22	273.79	265.45	-10.65	-618.81	671.85	705.03
2	275.76	2.13	275.76	355.36	275.76	2.13	-514.85	571.85	790.61
3	272.62	28.10	272.62	378.02	272.62	28.10	-592.66	630.05	838.78
4	333.58	45.02	246.49	417.32	333.58	45.02	-758.03	848.89	1004.53
5	379.44			454.71	379.44				

MACH NUMBER

STREAM LINE	ABSOLUTE	RELATIVE	FLOW ANGLE (DEG)	TEMPERATURE (DEG. R)	PRESSURE (PSI)	PRESSURE RATIO	TOI/10T	TOI/STA
1	.26	.66	-67.44	468.59	13.487	12.793	1.9736	2.0683
2	.35	.59	-68.78	495.08	16.422	15.234	1.6113	1.7169
3	.39	.70	-64.76	466.79	16.490	15.186	1.6047	1.7434
4	.42	.79	-63.41	499.71	16.656	15.023	1.5886	1.7613
5				482.50	16.671	14.747	1.5872	1.7642

EQUIVALENT TEMPERATURE (DEG. R)

STREAM LINE	EQUIVALENT TEMPERATURE (DEG. R)	EQUIVALENT PRESSURE (PSI)	EQUIVALENT PRESSURE RATIO
1	502.18	17.584	1.4
2	510.61	18.744	1.3
3	519.23	19.917	1.4
4	531.26	21.673	1.4
5	542.46	23.394	1.6

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATION PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	3	30000.0	1.800	26.460	557.30

OVERALL TURBINE CHARACTERISTICS

STREAM LINE	PRESSURE RATIO TOT/STA	EFFICIENCY TOT/ST	HEAD COEFFICIENT TOT/ST	BLADE/JET SPEED RATIO	THEORETICAL DEGREE OF REACTION
2	1.2369	.7451	.8201	.6453	.3289
3	1.2424	.7481	.8217	.6453	.3289
4	1.2613	.7820	.8461	.6980	.4020
5	1.2942	.6719	.8359	.9356	.4867

MASS AVERAGED QUANTITIES

HORSE POWER =	75.08 (HP)
MOMENT =	13.44 (FT-LB)
FLOW RATE =	3.53 (LB/SEC)
REFERRED RPM =	28934.05
REFERRED HORSE POWER =	40.23 (HP)
REFERRED MOMENT =	7.30 (FT-LB)
REFERRED FLOW RATE =	2.03 (LB/SEC)
TOTAL/STATIC EFFICIENCY =	.7419
TOTAL/TOTAL EFFICIENCY =	.8626
TOTAL/STATIC PRESSURE RATIO =	1.7428
HEAD COEFFICIENT =	1.4986
BLADE/JET SPEED RATIO =	.8169
THEORETICAL DEGREE OF REACTION =	.3373
MACH NUMBER AT STATION 0 =	.2025

SET NUMBER 1 CASE NUMBER 1 RPM 5000.0 TOTAL/STATION PRESSURE 2.000 INFL/TOTAL TEMPERATURE 591.01

STATOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION (IN)	X=R/RM	RADIAL SHIFT (IN)	BLADE OPENING (IN)	Y=VA /VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	ZETA*	CONTINUITY	FLUX RATE FRACTION
1	2.764	.865	0.0000	.2126	1.1063	.9231	.0769	.0769		0.0000
2	3.003	.940	0.0000	.2147	1.0488	.9158	.0842	.0842		.2493
3	3.195	1.000	0.0290	.2526	1.0000	.9100	.0900	.0900		.4668
4	3.432	1.074	0.0000	.2745	.9385	.9046	.0954	.0954		.7510
5	3.627	1.135	0.0000	.2926	.8879	.9001	.0999	.0999		1.0000

ABSOLUTE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHFEL VELOCITY
1	488.05	-19.58	1878.13	1183.62	488.05	-19.58	957.53	1074.92	120.60
2	462.68	4.40	1010.73	1111.61	462.68	4.40	879.70	993.96	131.03
3	447.96	10.89	955.11	1052.11	447.96	10.89	815.68	930.65	139.43
4	414.81	35.96	882.19	991.51	414.81	35.96	739.46	848.23	149.73
5	391.68	46.47	835.68	924.08	391.68	46.47	677.42	783.88	158.26

MACH NUMBER

STREAM LINE	ABSOLUTE	RELATIVE	FLOW ANGLE (DEG)	TEMPERATURE (DEG. R)	PRESSURE (PSI)	101/TOI	101/STA
1	1.11	1.01	65.65	591.01	27.446	1.0751	2.3197
2	1.03	.92	65.41	591.01	27.456	1.0708	2.0905
3	.96	.85	65.21	591.01	27.564	1.0766	1.9309
4	.87	.77	65.04	591.01	27.732	1.0601	1.7658
5		.70	64.89	591.01	27.869	1.0549	1.6517

SET NUMBER 1 2 5000.0 2.000 29.400 591.01
 PRESSURE RATIO TOTAL TEMPERATURE (DEG. R)

ROTOR EXIT SOLUTION

STREAM LINE	POSITION	X=R/RM	RADIAL OPENING	BLADE	Y=UA	WAVE	EFFICIENCY	COEFFICIENT	CONTINUITY	FRACTION RATE
1	3.693	.825	.0710	.1912	.9713	.7253	.2248	.2248	.2248	0.0000
2	3.828	.825	.0710	.2318	1.0055	.7218	.2248	.2248	.2248	.2393
3	3.865	1.000	.0405	.2447	1.0000	.7692	.2308	.2308	.2308	.4434
4	3.585	1.098	.1537	.2747	1.0194	.7655	.2345	.2345	.2345	.7357
5	3.837	1.175	.2100	.2983	1.0538	.7627	.2374	.2374	.2374	1.0000

ABSOLUTE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	RELATIVE VELOCITY (FPS)	WHEEL VELOCITY
1	336.20	-13.49	-691.57	769.08	-13.49	117.50
2	348.06	3.31	-667.76	753.03	3.31	131.77
3	346.15	7.92	-627.16	715.52	7.92	137.44
4	352.86	30.65	-581.39	680.78	30.65	167.42
5	364.76	43.28	-561.29	670.80	43.28	167.42

FLOW ANGLE (DEG)

STREAM LINE	ABSOLUTE	RELATIVE	TEMPERATURE (DEG. R)	PRESSURE (PSI)	PRESSURE RATIO
1	.70	.79	555.85	19.365	1.5182
2	.68	.77	554.34	19.235	1.5085
3	.65	.74	554.90	19.227	1.5133
4	.61	.71	511.70	17.819	1.4995
5	.60	.73	553.76	19.651	1.4986

STREAM LINE	EQUIVALENT TEMPERATURE (DEG. R)	EQUIVALENT INLET PRESSURE (PSI)	EQUIV/STATIC PRESSURE RATIO
1	570.52	24.169	1.7
2	570.41	24.250	1.7
3	571.08	24.440	1.7
4	571.53	24.759	1.8

SET NUMBER	RACE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	3	5000.0	2.000	29.400	591.01

OVERALL TURBINE CHARACTERISTICS

STREAM LINE	TOT/STA PRESSURE RATIO	TOT/STA EFFICIENCY	HEAD COEFFICIENT	BLADE/JET SPEED RATIO	THEORETICAL DEGREE OF REACTION
1	2.1902	.3115	93.2818	.1035	-.1186
2	1.8869	.3274	78.4130	.1129	-.0021
3	1.5133	.3496	65.4437	.1236	.0439
4	1.9294	.3686	54.2298	.1358	.1241
5	1.9119	.3769	47.9336	.1444	.2098

MASS AVERAGED QUANTITIES

HORSE POWER	=	50.34	(HP)
MOMENT	=	52.68	(FT-LB)
FLOW RATE	=	4.02	(LB/SEC)

REFERRED RPM	=	4682.79	(RPM)
REFERRED HORSE POWER	=	23.58	(HP)
REFERRED MOMENT	=	26.41	(FT-LB)
REFERRED FLOW RATE	=	2.15	(LB/SEC)

TOTAL/STATIC EFFICIENCY	=	.3475
TOTAL/STATIC PRESSURE RATIO	=	2.045
TOTAL/STATIC PRESSURE RATIO	=	3.5119

HEAD COEFFICIENT	=	67.1736
BLADE/JET SPEED RATIO	=	.1220
THEORETICAL DEGREE OF REACTION	=	.0529
MACH NUMBER AT STATION 0	=	.2146

SET
NUMBER 1
PAGE NUMBER 1
RPM 10000.0
TOTAL/STATIC
PRESSURE RATIO 2.000
INLET TOTAL
PRESSURE 29.400
INLET TOTAL
TEMPERATURE 591.01

STATOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION (IN)	X=R/RM	RADIAL OPENING (IN)	BLADE ANGLE (IN)	Y=VA /VAM	EFFICIENCY	LOSS COEFFICIENT	CONTINUITY	FLUX RATE FRACTION
1	2.764	.865	0.0000	.2126	1.1048	.9122	.0878	.0070	0.0000
2	3.073	.940	0.0000	.2147	1.0081	.9055	.0944	.0944	.2519
3	3.115	1.000	0.0290	.2526	1.0000	.8955	.0998	.0998	.5711
4	3.432	1.074	0.0000	.2745	.9394	.8921	.1043	.1043	.7554
5	3.627	1.135	0.0000	.2926	.8895	.8921	.1079	.1079	1.0000

ABSOLUTE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	430.56	-17.27	951.13	1044.19	430.56	-17.27	709.93	830.47	241.21
2	408.48	3.88	892.34	981.40	408.48	3.88	730.54	752.08	262.07
3	374.59	8.92	843.80	929.50	374.59	8.92	506.84	689.16	298.86
4	346.15	31.80	786.31	867.95	346.15	31.80	406.84	540.51	299.47
5	346.65	41.13	739.61	817.85	346.65	41.13	423.09	540.51	316.52

MACH NUMBER

STREAM LINE	ABSOLUTE VELOCITY	RELATIVE VELOCITY	TEMPERATURE (DEG. R)	STATIC PRESSURE (PSI)	TOTAL PRESSURE (PSI)	WHEEL VELOCITY
1	.85	.76	591.01	500.28	27.643	1.0626
2	.89	.82	591.01	519.12	27.750	1.0379
3	.83	.80	591.01	528.32	28.003	1.0626
4	.77	.74	591.01	535.35	28.126	1.0492
5	.72	.68	591.01	535.35	28.126	1.0453

NET NUMBER PAGE KPM PRESSURE RATIO INLET TOTAL TEMPERATURE (DEG. R) TOTAL PRESSURE (PSI)

591.01

29.400

2.000

10000.0

2

1

ROTOR EXIT SOLUTION

STREAM LINE	POSITION	X=R/RM	RADIAL OPEN	BLADE	Y=U/V	EFFICIENCY	COEFFICIENT	CONTINUITY	FRAC TION RATE
1	3.623	.825	.0710	.1912	.9767	.8373	.1227	.1227	0.9000
2	3.620	.925	.0710	.2318	.9818	.8374	.1226	.1226	.2366
3	3.265	1.000	.0405	.2447	1.0000	.8375	.1225	.1225	.4377
4	3.585	1.098	.1537	.2747	1.0531	.8322	.1678	.1678	.7312
5	3.837	1.175	.2100	.2983	1.1159	.8359	.1641	.1641	1.0000

RELATIVE VELOCITY (FPS)

ABSOLUTE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	325.69	-13.06	-548.77	638.28	325.69	-13.06	-781.78	848.86	235.81
2	327.49	-3.11	-488.54	588.50	327.49	-3.11	-782.07	850.55	264.54
3	334.42	30.50	-421.52	549.43	334.42	30.50	-734.33	814.56	304.73
4	322.11	44.15	-408.55	554.38	322.11	44.15	-743.40	832.58	334.84

MACH NUMBER

FLOW ANGLE (DEG)

TEMPERATURE (DEG. R)

PRESSURE (PSI)

PRESSURE RATIO

STREAM LINE	ABSOLUTE	RELATIVE	ABSOLUTE	RELATIVE	TOTAL	STATIC	TOTAL	STATIC	101/101	101/514
1	.58	.78	-57.12	-67.44	541.37	497.47	17.424	13.833	1.6074	2.1153
2	.51	.74	-53.60	-66.48	530.66	501.88	17.529	14.421	1.6722	2.0685
3	.50	.74	-50.20	-65.76	529.25	504.04	17.580	14.722	1.6723	1.9970
4	.50	.76	-47.68	-64.45	529.88	504.76	17.674	14.911	1.6634	1.9717
5	.50	.76	-47.68	-63.41	529.28	503.71	17.655	14.846	1.6652	1.9804

STREAM LINE	EQUIVALENT INLET TEMPERATURE (DEG. R)	EQUIVALENT INLET PRESSURE (PSI)	EQUIVALENT PRESSURE RATIO
1	557.43	22.524	1.6
2	557.87	22.675	1.6
3	559.42	22.907	1.6
4	559.97	23.185	1.6
5	561.38	23.492	1.6

SET
NUMBER

RACE
NUMBER

KPH

TOTAL/STATIC
PRESSURE RATIO

INLET TOTAL
PRESSURE
(PSI)

INLET TOTAL
TEMPERATURE
(DEG. R)

591.01

29.400

2.000

3

1

10000.0

OVERALL TURBINE CHARACTERISTICS

STREAM
LINE

PRESSURE RATIO
TOT/STA

EFFICIENCY
TOT/STA

HEAD
COEFFICIENT
TOT/TOY

BLADE/JET
SPEED RATIO

THEORETICAL
DEGREE OF REACTION

1315

1862

2571

2820

2056

23.656

19.043

16.3753

13.9658

12.5727

1704

1.6652

1.6634

1.9217

1.9970

2.0386

2.1253

MASS AVERAGED QUANTITIES

HORSE POWER = 81.03 (HP)

MOMENT = 42.53 (FT-LB)

FLOW RATE = 3.93 (LB/SEC)

REFERRED RPM = 9365.59 (HP)

REFERRED HORSE POWER = 37.95 (HP)

REFERRED MOMENT = 21.20 (FT-LB)

REFERRED FLOW RATE = 2.10 (LB/SEC)

TOTAL/STATIC EFFICIENCY = .5624

TOTAL/TOTAL EFFICIENCY = .5624

TOTAL/STATIC PRESSURE RATIO = 2.0523

TOTAL/TOTAL PRESSURE RATIO = 1.6723

HEAD COEFFICIENT = 16.8734

BLADE/JET SPEED RATIO = .2434

THEORETICAL DEGREE OF REACTION = .2574

MACH NUMBER AT STATION 0 = .2093

SET NUMBER 1 PAGE NUMBER 1 RPM 15000.0 TOTAL/STATIC PRESSURE RATIO 2.000 INLET TOTAL PRESSURE 29.400 INLET TOTAL TEMPERATURE 591.01

STATOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION (IN)	X=R/RM	RADIAL SHIFT (IN)	BLADE OPENING (IN)	Y=VA /VAM	EFFICIENCY	BLADE COEFFICIENT	LOSS COEFFICIENT	CONTINUITY	FLOW RATE FRACTION
1	2.704	.845	0.0000	.2126	1.1015	.9011		.0939	.0939	0.0000
2	3.004	.840	0.0000	.2347	1.0467	.9025		.0978	.0978	.2274
3	3.195	1.074	0.0000	.2526	1.0000	.8982		.1010	.1010	.4234
4	3.432	1.074	0.0000	.2745	.9413	.8989		.1011	.1011	.7566
5	3.627	1.135	0.0000	.2926	.8928	.8988		.1011	.1011	1.0000

ABSOLUTE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY
1	402.85	-16.16	889.91	976.98
2	382.80	3.64	814.24	819.70
3	369.75	8.37	791.86	872.28
4	344.25	29.90	739.37	802.13
5	326.51	38.74	696.63	778.13

RELATIVE VELOCITY (FPS)

AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
402.85	-16.16	529.11	664.41	561.81
382.80	3.64	421.12	585.59	393.10
369.75	8.37	321.76	525.68	418.29
344.25	29.90	220.76	411.22	449.20
326.51	38.74	221.86	396.85	474.77

MACH NUMBER

STREAM LINE	ABSOLUTE	RELATIVE
1	.89	.68
2	.82	.52
3	.72	.47
4	.60	.39
5	.55	.35

TEMPERATURE (DEG. R)

TOTAL	STATIC
591.01	511.58
591.01	520.63
591.01	527.90
591.01	535.59
591.01	541.63

PRESSURE (PSI)

TOTAL	STATIC
27.718	16.742
27.718	17.615
28.036	18.465
28.220	19.293
28.358	20.896

PRESSURE RATIO

TOT/TOT	TOT/STA
1.0584	1.1539
1.0531	1.1413
1.0487	1.1591
1.0418	1.1705
1.0388	1.4070

SET NUMBER PAGE RPM TOTAL/STATIC PRESSURE INLET TOTAL TEMPERATURE
NUMBER 1 2 15000.0 2.000 29.400 591.01

MOTOR EXIT SOLUTION

STREAM LINE	POSITION	X=H/RM	RAPID OPENING	Y=VA/VAM	EFFICIENCY	COEFFICIENT	CONTINUITY	FRACTION RATE
1	2.493	.825	.0710	.9831	.8552	.1443	.1443	0.0000
2	3.220	1.000	-.0148	.9567	.8627	.1373	.1373	.0012
3	3.562	1.098	-.0405	1.0000	.8680	.1320	.1320	.0093
4	3.837	1.175	-.1537	1.0885	.8750	.1250	.1250	.0043
5			-.2180	1.1810	.8805	.1195	.1195	1.0000

RELATIVE VELOCITY (FPS)

ABSOLUTE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	312.83	-12.55	-400.31	508.20	312.83	-12.55	-752.83	815.33	352.51
2	314.44	2.89	-304.34	430.27	316.22	7.28	-699.34	762.74	395.31
3	318.22	30.88	-274.83	433.15	346.38	30.88	-704.60	774.98	427.33
4	346.38	44.59	-254.55	452.78	375.82	44.59	-724.30	803.42	469.33
5	375.82		-248.55				-750.81	840.81	502.26

PRESSURE RATIO

TEMPERATURE (DEG. R)

FLOW ANGLE (DEG)

TEMPERATURE (DEG. R)

FLOW ANGLE (DEG)

TEMPERATURE (DEG. R)

STREAM LINE	ABSOLUTE RELATIVE	ABSOLUTE	RELATIVE	TOTAL	STATIC	TOTAL	STATIC	TOT/TOI	TOT/STA
1	.47	-52.00	-67.44	513.94	492.45	15.931	13.719	1.845	2.141
2	.39	-44.97	-66.48	516.30	500.89	16.478	14.621	1.982	1.982
3	.39	-41.27	-65.76	516.03	501.35	16.529	14.942	1.972	1.9676
4	.41	-36.36	-64.45	515.82	500.35	16.594	14.756	1.970	1.9697
5		-33.48	-63.41	515.19	498.13	16.574	14.751	1.9739	1.9958

STREAM LINE	EQUIVALENT TEMPERATURE (DEG. R)	EQUIVALENT INLET PRESSURE (PSI)	EQUIVALENT STATIC PRESSURE RATIO
1	549.77	21.291	1.6
2	549.31	21.610	1.5
3	549.31	21.982	1.5
4	549.02	22.513	1.5
5	556.96	23.039	1.6

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INITIAL TOTAL PRESSURE (PSI)	INITIAL TOTAL TEMPERATURE (DEG. R)
1	3	15000.0	2.000	29.400	591.01

OVERALL TURBINE CHARACTERISTICS

STREAM LINE	PRESSURE RATIO TOT/STA	EFFICIENCY TOT/STA	HEAD COEFFICIENT TOT/TOT	SPEED/VELO RATIO	THEORETICAL DEGREE OF REACTION
1	2.1431	.6664	.8120	10.6175	.3069
2	1.9837	.7112	.8292	8.1692	.3499
3	1.9625	.7216	.8363	7.1371	.3743
4	1.9627	.7225	.8447	6.1975	.4017
5	1.9956	.7160	.8493	5.6453	.4289

MASS AVERAGED QUANTITIES

HORSE POWER = 98.79 (HP)
MOMENT = 34.59 (FT-LB)
FLOW RATE = 3.86 (LB/SEC)

RECEIVED RPM = 14048.3R
RECEIVED HORSE POWER = 46.26 (HP)
RECEIVED MOMENT = 32.67 (FT-LB)
RECEIVED FLOW RATE = 2.66 (LB/SEC)

TOTAL/STATIC EFFICIENCY = .7116
TOTAL/TOTAL EFFICIENCY = .8352
TOTAL/STATIC PRESSURE RATIO = 1.9776
TOTAL/TOTAL PRESSURE RATIO = 1.9858

HEAD COEFFICIENT = 7.489R
BLADE/JET SPEED RATIO = .874
THEORETICAL DEGREE OF REACTION = .372
MACH NUMBER AT STATION 6 = .2657

SET NUMBER PAGE RPM INLET TOTAL INLET TOTAL
1 1 2000.0 PRESSURE RATIO 29.400 PRESSURE 591.01
INLET TOTAL TEMPERATURE 591.01

STATOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION (IN)	X=R/RM	RADIAL SHIFT (IN)	BLADE OPENING (IN)	Y=VA /VAM	EFFICIENCY	LOSS COEFFICIENT	CONTINUITY	FLOW RATE FRACTION
1	2.764	.865	0.0000	.2126	1.1007	.0088	.0912	.0912	0.0000
2	3.093	.940	0.0000	.2137	1.0465	.0085	.0916	.0916	.0543
3	3.135	1.000	0.0000	.2125	1.0000	.0085	.0955	.0955	.4742
4	3.427	1.074	0.0000	.2125	.9814	.0084	.0976	.0976	.7576
5		1.135	0.0000	.2926	.8914	.0024	.0976	.0976	1.0000

ABSOLUTE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	392.34	-15.74	866.69	951.49	482.41
2	373.03	3.54	814.87	895.20	524.14
3	361.55	8.16	771.71	850.89	557.72
4	335.27	29.12	720.07	794.83	598.94
5	317.71	37.69	677.85	749.56	633.03

180

RELATIVE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	392.34	-15.74	384.28	549.41	482.41
2	373.03	3.54	298.73	472.95	524.14
3	361.55	8.16	213.99	420.21	557.72
4	335.27	29.12	151.13	357.67	598.94
5	317.71	37.69	44.82	323.06	633.03

TEMPERATURE (DEG. R)

STREAM LINE	ABSOLUTE	RELATIVE	TEMPERATURE (DEG. R)	WHEEL VELOCITY
1	85	49	515.48	482.41
2	88	42	524.18	524.14
3	75	37	530.88	557.72
4	70	31	538.44	598.94
5	66	28	544.26	633.03

MACH NUMBER

STREAM LINE	ABSOLUTE	RELATIVE	TEMPERATURE (DEG. R)	WHEEL VELOCITY
1	85	49	515.48	482.41
2	88	42	524.18	524.14
3	75	37	530.88	557.72
4	70	31	538.44	598.94
5	66	28	544.26	633.03

PRESSURE RATIO

STREAM LINE	ABSOLUTE	RELATIVE	TEMPERATURE (DEG. R)	WHEEL VELOCITY
1	85	49	515.48	482.41
2	88	42	524.18	524.14
3	75	37	530.88	557.72
4	70	31	538.44	598.94
5	66	28	544.26	633.03

SET NUMBER PAGE RPM PRESSURE RATIO INLET TOTAL INLET TOTAL
 NUMBER 1 2 20000.0 2.000 29.400 591.01

ROTOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION	X=R/RM	RADIAL SHIFT	BLADE OPENING	Y=VA /VAM	EFFICIENCY	COEFFICIENT	LOSS	CONTINITY	FLOW RATE
1	2.593	.825	.0710	.1912	.8898	.8838	.1162	.1162	.1162	0.0000
2	2.825	.868	.1018	.2218	.8920	.8870	.1110	.1110	.1110	.2267
3	3.085	1.000	.1645	.2447	1.0000	.8929	.1071	.1071	.1071	.4220
4	3.285	1.198	.1512	.2747	1.1264	.8880	.1121	.1121	.1121	.7188
5	3.837	1.175	.2100	.2983	1.2511	.8841	.1159	.1159	.1159	1.0000

ABSOLUTE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	307.44	-12.33	-269.85	409.26	307.44	-12.33	-239.87	401.30	470.02
2	298.90	-7.74	-136.58	319.57	298.90	-7.74	-263.65	373.81	429.82
3	310.61	7.11	-119.86	333.92	310.61	7.11	-287.68	390.56	458.92
4	349.86	30.39	-105.81	366.78	349.86	30.39	-297.68	419.56	485.97
5	388.62	46.11	-106.70	405.63	388.62	46.11	-276.38	469.44	469.68

FLOW ANGLE (DEG)

STREAM LINE	ABSOLUTE RELATIVE	ABSOLUTE	RELATIVE
1	.38	-41.28	-67.44
2	.39	-45.78	-68.28
3	.30	-41.81	-64.45
4	.28	-41.81	-64.45
5	.37	-15.35	-63.41

TEMPERATURE (DEG. R)

STREAM LINE	TOTAL	STATIC	TOTAL	STATIC	101/101	101/51A
1	500.32	486.78	14.810	13.416	1.9051	2.1914
2	507.32	489.81	15.898	14.986	1.8493	1.9618
3	508.61	497.02	15.942	14.984	1.8442	1.9621
4	508.22	497.02	15.910	14.717	1.8479	1.9977
5	507.71	494.81	15.732	14.324	1.8652	2.0525

TEMPERATURE (DEG. R)

PRESSURE RATIO

EQUIV/STATIC PRESSURE RATIO

STREAM LINE	EQUIVALENT INLET PRESSURE (PSI)	EQUIV/STATIC PRESSURE RATIO
1	23.131	1.5
2	20.872	1.4
3	21.468	1.4
4	21.289	1.5
5	23.112	1.6

EQUIVALENT TEMPERATURE (DEG. R)

STREAM LINE	EQUIVALENT TEMPERATURE (DEG. R)
1	237.85
2	243.75
3	251.82
4	256.92

SET PAGE RPM INLET TOTAL INLET TOTAL
NUMBER NUMBER PRESSURE RATIO PRESSURE PRESSURE
(DEG. R)

591.01

29.400

2.000

20000.0

OVERALL TURBINE CHARACTERISTICS

STREAM LINE	PRESSURE RATIO TOT/STA	EFFICIENCY TOT/TOT	HEAD COEFFICIENT	SPEED RATIO	THEORETICAL DEGREE OF REACTION
1	2.1914	.8625	6.1204	.4039	.3015
2	1.9851	.8724	4.5275	.4700	.3828
3	1.8442	.8754	3.9997	.5000	.4519
4	1.8479	.8796	3.5516	.5305	.5280
5	1.8552	.8840	3.2914	.5512	

MASS AVERAGED QUANTITIES

HORSE POWER = 109.74 (HP)
MOMENT = 28.82 (FT-LB)
FLOW RATE = 3.85 (LB/SEC)

REVERSED RPM = 18731.18 (RPM)
REVERSED HORSE POWER = 51.39 (HP)
REVERSED MOMENT = 14.41 (FT-LB)
REVERSED FLOW RATE = 2.06 (LB/SEC)

TOTAL/STATIC EFFICIENCY = .7067
TOTAL/STATIC EFFICIENCY = .8704
TOTAL/STATIC PRESSURE RATIO = 2.0102
TOTAL/STATIC PRESSURE RATIO = 1.8886

HEAD COEFFICIENT RATIO = 4.1973
THEORETICAL DEGREE OF REACTION = .4881
MACH NUMBER AT STATION 0 = .3778
MACH NUMBER AT STATION 0 = .2052

AD-A101 102

NAVAL POSTGRADUATE SCHOOL MONTEREY CA
COMPUTER EVALUATION OF THE ON-AND-OFF DESIGN PERFORMANCE OF AN --ETC(11)
MAR 81 R CIRONE

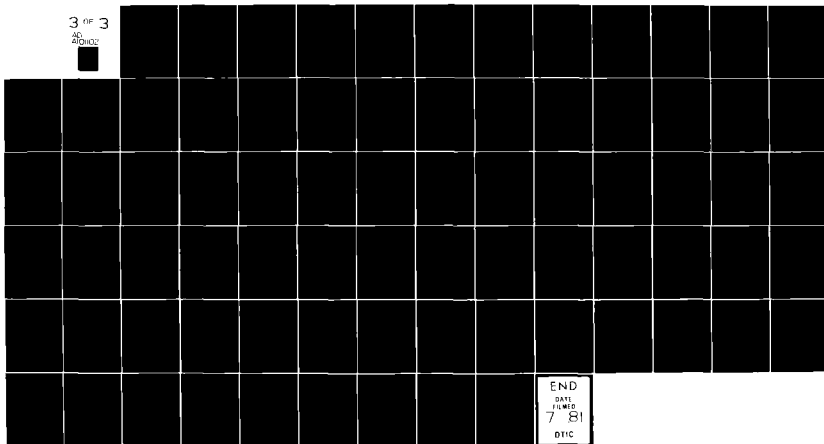
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SET PAGE
NUMBER 1
RPM 25000.0
TOTAL/STATIC
PRESSURE RATIO 2.600
INLET TOTAL
PRESSURE 29.400
INLET TOTAL
TEMPERATURE 591.01

STATOR EXIT SOLUTION

STREAM LINE	AXIAL POSITION (IN)	X=R/RM	RADIAL OPENING (IN)	BLADE Y=VA /VAM	EFFICIENCY	LOSS COEFFICIENT	CONTINUITY	FLUX RATE FRACTION
1	2.764	.865	0.0000	1.1023	.9134	.0866	.0866	0.0000
2	3.063	.940	0.0000	1.0472	.9101	.0899	.0899	.0000
3	3.195	1.000	0.0270	1.0000	.9075	.0925	.0925	.0000
4	3.432	1.074	0.0000	.9401	.9058	.0942	.0942	.0000
5	3.627	1.135	0.0000	.8904	.9044	.0956	.0956	1.0000

ABSOLUTE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHFPL VELOCITY
1	386.00	-15.48	852.69	936.12	386.00	-15.48	249.68	454.98	603.01
2	366.71	3.48	801.07	881.02	366.71	3.48	145.90	394.68	655.17
3	350.19	8.01	758.19	835.20	350.19	8.01	61.04	355.56	697.15
4	329.28	39.57	702.94	780.45	329.28	39.57	-125.99	433.05	748.67
5	311.83	37.00	665.30	735.68	311.83	37.00			791.29

MACH NUMBER

STREAM LINE	ABSOLUTE	RELATIVE
1	.84	.41
2	.78	.35
3	.74	.31
4	.68	.27
5	.64	.26

FLOW ANGLE (DEG)

ABSOLUTE	RELATIVE
65.65	32.90
65.41	21.70
65.21	9.89
65.04	-7.21
64.89	-22.00

TEMPERATURE (DEG. R)

TOTAL	STATIC
591.01	518.09
591.01	532.42
591.01	538.97
591.01	540.33
591.01	545.97

PRESSURE (PSI)

TOTAL	STATIC
28.049	17.691
28.123	19.789
28.408	19.690
28.512	20.757
	21.605

PRESSURE RATIO

101/101	101/51A
1.0482	1.5610
1.0436	1.5648
1.0349	1.4912
1.0349	1.4164
1.0311	1.3608

SET PAGE RPM INLET TOTAL INLET TOTAL
NUMBER NUMBER PRESSURE/STATIC PRESSURE TEMPERATURE TEMPERATURE
(PSI) (DEG. R)

1 2 25000.0 2.000 29.400 591.01

ROTOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION	X=R/RM	RADIAL SHIFT	BLADE OPENING	Y=VA/VAM	EFFICIENCY	COEFF. LOSS	COMP. LOSS	CONJUGATE	FLOW RATE FRACTION
1	2.693	.825	.0710	.1912	.9982	.0119	.0981	.0981	.0981	0.0000
2	2.020	.825	.0710	.1912	.9982	.0119	.0981	.0981	.0981	.0000
3	2.265	1.060	.0465	.2447	1.0000	.0612	.1059	.1059	.1059	.0000
4	3.585	1.098	.1537	.2747	1.1623	.0821	.1179	.1179	.1179	.0000
5	3.837	1.175	.2100	.2983	1.3268	.0885	.1115	.1115	.1115	1.0000

ABSOLUTE VELOCITY (FPS)

RELATIVE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	300.44	-12.05	-135.50	329.81	300.44	-12.05	-723.03	783.96	507.57
2	271.49	-2.58	35.19	273.78	271.49	-2.58	-658.36	700.19	507.57
3	301.00	6.89	43.66	304.27	301.00	6.89	-658.36	711.04	507.57
4	351.34	30.51	47.55	355.85	351.34	30.51	-734.67	814.83	507.57
5	399.12	47.35	39.75	403.88	399.12	47.35	-797.35	892.92	507.57

STREAM LINE	MACH NUMBER	FLOW ANGLE (DEG)	TEMPERATURE (DEG. R)	PRESSURE (PSI)	PRESSURE RATIO
1	.31	-24.28	492.19	14.198	13.305
2	.25	7.39	507.52	15.995	15.318
3	.28	8.31	508.25	15.995	15.163
4	.33	7.71	509.10	16.028	14.896
5	.37	5.69	508.94	15.922	14.484

STREAM LINE	EQUIVALENT INLET TEMPERATURE (DEG. R)	EQUIVALENT INLET PRESSURE (PSI)	EQUIVALENT PRESSURE RATIO
1	534.16	19.687	1.5
2	539.78	20.512	1.3
3	545.29	21.326	1.4
4	553.93	23.689	1.5
5	561.71	23.884	1.6

STREAM LINE	SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	1	3	25000.0	2.000	29.400	591.01

OVERALL TURBINE CHARACTERISTICS

STREAM LINE	PRESSURE RATIO TOT/STA	EFFICIENCY TOT/TOT	HEAD COEFFICIENT	BLADE/IFT SPEED RATIO	THEORETICAL DEGREE OF REACTION
1	2.2097	.8249	3.9791	.5026	.3335
2	1.9194	.8312	2.8121	.5963	.3614
3	1.8390	.8124	2.5189	.6301	.3721
4	1.9737	.7850	2.2371	.6686	.4637
5	2.0298	.7584	2.0771	.6939	.5399

WASS AVERAGED QUANTITIES

HORSE POWER =	108.40	(HP)
MOMENT =	22.79	(FT-LB)
FLOW RATE =	3.77	(LB/SEC)
REFERRED RPM =	23413.97	(RPM)
REFERRED HORSE POWER =	11.60	(HP)
REFERRED MOMENT =	1.60	(FT-LB)
REFERRED FLOW RATE =	2.02	(LB/SEC)

TOTAL/STATIC EFFICIENCY =	.8051
TOTAL/STATIC EFFICIENCY =	.8776
TOTAL/STATIC PRESSURE RATIO =	1.9879
TOTAL/STATIC PRESSURE RATIO =	1.8673

HEAD COEFFICIENT =	2.4465
BLADE/IFT SPEED RATIO =	.5845
THEORETICAL DEGREE OF REACTION =	.3915
MACH NUMBER AT STATION 0	.3015

SET PAGE RPM TOTAL/STATIC INLET TOTAL
NUMBER 1 30000.0 PRESSURE RATIO 2.000 PRESSURE 29.400 TEMPERATURE 591.01

STATOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION (IN)	X-R/RH SHIFT (IN)	RADIAL OPENING (IN)	BLADE Y-VA /VAM EFFICIENCY	LOSS COEFFICIENT	ZETA* CONTINUITY	FLOW RATE FRACTION
1	2.764	.865	.0000	1.043	.0799	.0799	0.0000
2	3.083	.868	.0000	1.040	.0844	.0844	.2548
3	3.195	1.000	.0000	1.040	.0881	.0881	.4748
4	3.432	1.074	.0000	1.039	.0925	.0925	.7580
5	3.627	1.135	.0000	.8893	.0925	.0925	1.0000

ABSOLUTE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	397.01	-15.93	872.82	942.83	397.01	-15.93	153.40	425.92	723.62
2	376.77	13.58	821.06	905.21	376.77	13.58	176.85	378.59	786.21
3	352.11	8.23	778.40	857.45	352.11	8.23	-179.08	336.98	846.58
4	337.72	29.33	725.33	800.63	337.72	29.33	-267.43	320.65	899.51
5	319.71	37.93	682.12	754.28	319.71	37.93		418.55	949.55

MACH NUMBER

STREAM LINE	ABSOLUTE	RELATIVE
1	.87	.38
2	.81	.34
3	.76	.32
4	.78	.33
5	.66	.37

FLOW ANGLE (DEG)

ABSOLUTE	RELATIVE
65.65	21.13
65.41	5.59
65.21	-9.38
65.04	-27.14
64.89	-39.91

TEMPERATURE (DEG. R)

TOTAL	STATIC
591.01	513.87
591.01	522.83
591.01	529.83
591.01	537.67
591.01	543.67

PRESSURE (PSI)

TOTAL	STATIC
28.080	17.211
28.181	18.549
28.248	19.284
28.397	20.394
28.497	21.276

PRESSURE RATIO

TOT/TOT	TOT/STA
1.0470	1.7082
1.0430	1.6922
1.0410	1.6746
1.0353	1.6466
1.0317	1.5819

SET CASE RPM INITIAL TOTAL INLET TOTAL
NUMBER NUMBER PRESSURE PRESSURE PRESSURE
(DEG. R) (DEG. R) (DEG. R)

1 2 30000.0 2.000 29.400 591.01

MOTOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION	X=R/RH	RADIAL OPENING	BLADE	Y=VA /VAM	EFFICIENCY	COEFFICIENT	LOSS	CONTINUITY	FRACTION RATE
1	2.623	.825	.0710	.1912	1.0060	.9114	.0886	.0886	.0886	0.0000
2	3.020	.925	.0168	.2218	1.0756	.8932	.1069	.1069	.1069	.2130
3	3.265	1.000	.0405	.2447	1.0000	.8795	.1206	.1206	.1206	.3983
4	3.505	1.098	.1537	.2747	1.2880	.8912	.1089	.1089	.1089	.6982
5	3.837	1.175	.2100	.2983	1.4017	.9004	.0997	.0997	.0997	1.0000

ABSOLUTE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	297.96	-11.95	-12.01	298.44	297.96	-11.95	-717.94	776.52	705.03
2	297.34	2.46	194.87	324.40	297.34	2.46	-595.75	649.75	790.61
3	357.88	10.18	196.46	373.83	357.88	10.18	-626.69	689.34	834.78
4	415.14	49.20	175.12	453.27	415.14	49.20	-629.40	728.61	1004.53

MACH NUMBER

STREAM LINE	ABSOLUTE	RELATIVE	FLOW ANGLE (DEG)	TEMPERATURE (DEG. R)	PRESSURE (PSI)	PRESSURE RATIO
1	.38	.73	-12.31	483.08	13.461	2.4041
2	.50	.74	-17.44	476.57	16.265	1.8131
3	.57	.76	-25.70	468.50	18.327	1.7513
4	.62	.85	-34.45	458.57	18.351	1.7981
5	.65	.85	-33.41	455.40	18.351	2.0248

EQUIVALENT INLET PRESSURE

STREAM LINE	EQUIVALENT INLET PRESSURE (PSI)	EQUIVALENT INLET PRESSURE (DEG. R)
1	19.769	1.5
2	19.082	1.3
3	21.014	1.4
4	22.915	1.5
5	24.675	1.7

SET NUMBER	PAGE NUMBER	RPM	TOTAL STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	3	30000.0	2.000	29.400	591.01

OVERALL TURBINE CHARACTERISTICS

STREAM LINE	TOT/STA PRESSURE RATIO	EFFICIENCY TOT/TOT	HEAD COEFFICIENT	BLADE/JET SPEED RATIO	THEORETICAL DEGREE OF REACTION
1	2.3053	.8531	2.8795	.5893	.3117
2	1.9527	.8126	1.9632	.7137	.3425
3	1.9217	.7819	1.7444	.7520	.3471
4	1.9217	.8640	1.5528	.8025	.4377
5	2.8240	.7278	1.4379	.8339	.5164

MASS AVERAGED QUANTITIES

HORSE POWER	=	105.42	(HP)
MOMENT	=	18.46	(FT-LB)
FLOW RATE	=	3.75	(LB/SEC)
REFERRED RPM	=	28896.77	(RPM)
REFERRED HORSE POWER	=	49.37	(HP)
REFERRED MOMENT	=	2.03	(FT-LB)
REFERRED FLOW RATE	=	2.00	(LB/SEC)

TOTAL/STATIC EFFICIENCY	=	.7849
TOTAL/STATIC PRESSURE RATIO	=	.8775
TOTAL/STATIC PRESSURE RATIO	=	2.8040

HEAD COEFFICIENT	=	1.8509
BLADE/JET SPEED RATIO	=	.5133
THEORETICAL DEGREE OF REACTION	=	.3478
MACH NUMBER AT STATION 0	=	.1995

SET NUMBER PAGE RPM TOTAL/STATIC INLET TOTAL INLET TOTAL
1 1 15000.0 PRESSURE RATIO PRESSURE PRESSURE
2.208 35.340 603.80

STATOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION (IN)	X=R/RM	RADIAL SHIFT (IN)	BLADE OPENING (IN)	Y=VA	EFFICIENCY	LOSS COEFFICIENT	CONTINUITY	FLOW RATE FRACTION
1	2.714	.865	0.0000	.2126	1.1032	.9106	.0894	.0894	0.0000
2	3.003	.940	0.0000	.2326	1.0473	.9052	.0948	.0948	.2320
3	3.193	1.000	0.0000	.2526	1.0000	.9000	.0992	.0992	.4640
4	3.432	1.074	0.0000	.2745	.9408	.8882	.0998	.0998	.7552
5	3.627	1.135	0.0000	.2926	.8920	.8996	.1004	.1004	1.0000

RELATIVE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	427.56	-17.15	582.70	722.94	361.41
2	405.92	3.86	493.63	639.11	393.10
3	387.58	8.87	428.85	572.20	418.29
4	364.63	31.67	333.93	495.44	449.20
5	345.74	41.02	262.88	436.26	474.77

ABSOLUTE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY
1	427.56	944.51	1036.92	1036.92
2	405.92	886.73	975.24	975.24
3	387.58	839.15	924.37	924.37
4	364.63	783.13	864.44	864.44
5	345.74	737.65	815.69	815.69

STREAM LINE	MACH NUMBER	FLOW ANGLE (DEG)	TEMPERATURE (DEG. R)	PRESSURE (PSI)	PRESSURE RATIO
1	.93	.65	514.13	30.446	101/101
2	.87	.57	524.46	30.586	1.0622
3	.82	.51	532.50	30.707	1.0574
4	.76	.43	541.42	30.921	1.0512
5	.71	.38	548.24	31.082	1.0459
					1.0405
					1.4570

SEL PAGE
NUMBER NUMBER RPM TOTAL/STATIC INLET TOTAL INLET TOTAL
PRESSURE RATIO PRESSURE PRESSURE TEMPERATURE
(PSI) (DEG. R)

603.60

32.340

2.200

15000.0

2

MOTOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION	X-R/RM	RADIAL SHIFT	BLADE OPENING	Y=VA /VAM	EFFICIENCY	LOSS COEFFICIENT	CONTINUITY	TEMPERATURE (DEG. R)	FLOW RATE FRACTION
1	3.693	.825	.0718	.1912	.9817	.8545	.1436	.1436		0.0000
2	3.620	.825	.0718	.2216	.9631	.8623	.1331	.1331		.2117
3	3.265	1.000	-.0405	.2447	1.0000	.8669	.1331	.1331		.4304
4	3.585	1.098	-.1537	.2742	1.0807	.8754	.1247	.1247		.7254
5	3.837	1.175	-.2100	.2983	1.1669	.8820	.1180	.1180		1.0000

RELATIVE VELOCITY (FPS)

ABSOLUTE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	340.83	-13.67	-462.70	578.87	340.83	-13.67	-820.21	888.31	352.51
2	334.38	3.18	-372.80	500.80	334.38	3.18	-768.11	817.24	305.31
3	337.19	7.94	-383.55	488.50	337.19	7.94	-770.93	845.55	427.39
4	375.22	32.59	-315.28	491.18	375.22	32.59	-784.61	870.33	469.33
5	405.14	48.87	-307.12	510.66	405.14	48.87	-1009.38	906.39	502.26

FLOW ANGLE
(DEG)

TEMPERATURE
(DEG. R)

PRESSURE
(PSI)

PRESSURE
RATIO

STREAM LINE	ABSOLUTE	RELATIVE	ABSOLUTE	RELATIVE	TOTAL	STATIC	TOTAL	STATIC	TOT/TOT	TOT/STA
1	.53	.82	-53.92	-67.44	519.29	491.41	16.612	13.694	1.9468	2.3437
2	.46	.76	-48.11	-66.48	521.06	500.19	17.117	14.835	1.8893	2.1799
3	.45	.77	-44.70	-65.76	520.75	500.89	17.172	14.988	1.8832	2.1578
4	.45	.79	-48.04	-64.45	520.43	500.35	17.274	15.952	1.8722	2.1486
5	.47	.83	-37.17	-63.41	519.64	497.94	17.246	14.854	1.8752	2.1772

STREAM LINE	EQUIVALENT TEMPERATURE (DEG. R)	EQUIVALENT INLET PRESSURE (PSI)	EQUIV/STATIC PRESSURE RATIO
1	557.07	22.993	1.7
2	558.59	23.320	1.6
3	568.38	23.676	1.6
4	563.30	24.291	1.6
5	566.31	24.864	1.7

SET NUMBER	PAGE	RPM	INLET/STATION PRESSURE RATIO	INLET/STATION PRESSURE (PSI)	TOTAL TEMPERATURE (DEG. R)
1	3	15000.0	2.200	32.340	603.60

OVERALL TURBINE CHARACTERISTICS

STREAM LINE	PRESSURE RATIO TOT/STA	EFFICIENCY TOT/INT	HEAD COEFFICIENT	BLADE/JET SPEED RATIO	THEORETICAL DEGREE OF REACTION
1	2.3617	.8059	12.0635	.2878	.2623
2	2.1578	.8227	9.3694	.3267	.2793
3	2.1486	.8297	8.1781	.3497	.2771
4	2.1772	.8400	7.0560	.3765	.2170
5		.8460	6.4139	.3949	.4684

MASS AVERAGED QUANTITIES

HORSE POWER = 118.32 (HP)
 MOMENT = 41.43 (FT-LB)
 FLOW RATE = 4.19 (LB/SEC)

REFERRED RPM = 13900.10
 REFERRED HORSE POWER = 149.81 (HP)
 REFERRED MOMENT = 19.83 (FT-LB)
 REFERRED FLOW RATE = 2.05 (LB/SEC)

TOTAL/STATIC EFFICIENCY = .6892
 TOTAL/TOTAL EFFICIENCY = .8396
 TOTAL/STATION PRESSURE RATIO = 2.1882

HEAD COEFFICIENT = 8.4406
 BLADE/JET SPEED RATIO = 14.19
 THEORETICAL DEGREE OF REACTION = .3497
 MACH NUMBER AT STATION 0 = .2049

SET NUMBER PAGE RPM INLET/STATION INLET TOTAL INLET TOTAL
 1 1 20000.0 PRESSURE RATIO 2.200 PRESSURE 32.340 TEMPERATURE 603.60

STATION EXIT SOLUTION

STREAM LINE	RADIAL POSITION (IN)	X=R/RM	RADIAL SHIFT (IN)	BLADE OPENING (IN)	BLADE EFFICIENCY	Y=VA /VAM	LOSS COEFFICIENT	ZETA	FLOW RATE FRACTION
1	2.764	.865	0.0000	.2126	.9111	1.1014	.0009	.0009	0.0000
2	3.003	.740	0.0000	.2347	.9081	1.0468	.0019	.0019	.2500
3	3.412	1.020	0.0000	.2528	.9076	1.0000	.0043	.0043	.424
4	3.627	1.020	0.0000	.2528	.9076	.8912	.0075	.0075	.7564
5		1.135	0.0000	.2926	.9035		.0065	.0065	1.0000

RELATIVE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	INLET VELOCITY
1	414.83	-16.61	432.20	599.75	482.41
2	393.50	1.74	335.46	517.10	432.14
3	381.15	8.60	266.17	459.31	357.74
4	353.54	30.71	160.37	389.42	299.94
5	335.01	39.75	81.72	347.11	633.03

MACH NUMBER FLOW ANGLE (DEG)

TEMPERATURE (DEG. R)

PRESSURE (PSI)

STREAM LINE	ABSOLUTE	RELATIVE	ABSOLUTE	RELATIVE	TOTAL	STATIC	100/100	100/51A
1	.90	.54	65.65	46.23	603.60	519.20	30.592	1.0572
2	.84	.46	65.41	40.45	603.60	519.23	30.756	1.2489
3	.79	.40	65.21	33.91	603.60	536.72	30.696	1.0319
4	.73	.34	65.04	24.40	603.60	545.15	31.072	1.0407
5	.69	.30	64.89	13.71	603.60	551.62	31.215	1.0360

SET NUMBER PAGE RPM INLET/STATIC PRESSURE TOTAL INLET/STATIC PRESSURE TOTAL INLET/STATIC PRESSURE TOTAL INLET/STATIC PRESSURE TOTAL
 (DEG. R) (DEG. R) (DEG. R) (DEG. R) (DEG. R) (DEG. R) (DEG. R) (DEG. R) (DEG. R) (DEG. R)

603.60

32.340

2.200

20000.0

2

1

ROTOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION	X=R/RM	RADIAL SHIFT	BLADE OPENING	BLADE	Y=VA	WAM	EFFICIENCY	LOSS	COEFFICIENT	CONTINUITY	FLUX RATE
1	2.693	.825	.0710	.1912	.1912	.9876	.8852	.1148	.1148	.1148	.1148	0.0000
2	3.020	.925	.0168	.2218	.2218	.9391	.8856	.1104	.1104	.1104	.1104	.2272
3	3.265	1.000	-.0405	.2447	.2447	1.0000	.8929	.1071	.1071	.1071	.1071	.4235
4	3.585	1.078	-.1537	.2747	.2747	1.1131	.8986	.1014	.1014	.1014	.1014	.7201
5	3.837	1.175	-.2300	.2983	.2983	1.2264	.9036	.0970	.0970	.0970	.0970	1.0000

ABSOLUTE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	338.22	-13.57	-343.92	482.56	330.22	-13.57	-613.94	881.52	470.02
2	321.49	-5.86	-327.35	385.81	321.49	-5.86	-738.74	804.73	427.07
3	311.30	33.11	-344.41	419.26	311.30	33.11	-769.42	844.91	502.95
4	319.97	49.83	-341.33	455.56	319.97	49.83	-819.02	884.80	582.77
5									669.66

202

STREAM LINE	MACH NUMBER	FLOW ANGLE (DEG)	TEMPERATURE (DEG. R)	PRESSURE (PSI)	PRESSURE RATIO
1	.45	.82	503.22	15.238	101.514
2	.33	.74	510.05	16.320	2.4463
3	.36	.76	509.98	16.307	2.4463
4	.38	.81	510.07	16.361	2.4463
5	.42	.86	509.43	16.291	2.4463

STREAM LINE	EQUIVALENT TEMPERATURE (DEG. R)	EQUIVALENT PRESSURE (PSI)	EQUIVALENT PRESSURE RATIO
1	548.55	21.890	1.6
2	551.73	22.460	1.5
3	555.41	23.090	1.5
4	560.50	23.979	1.6
5	565.62	24.864	1.7

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	3	20000.0	2.200	32.340	603.60

OVERALL TURBINE CHARACTERISTICS

STREAM LINE	PRESSURE RATIO TOT/STA	EFFICIENCY TOT/TOT	HEAD COEFFICIENT	BLADE/VELOCITY SPEED RATIO	DEGREE OF REACTION
1	2.432	.7400	2.0014	.3779	.3208
2	2.142	.7824	2.2302	.4373	.3150
3	2.162	.7843	4.6517	.4657	.3814
4	2.185	.7726	4.6517	.4986	.4660
5	2.238	.7562	3.7248	.5181	.5368

MASS AVERAGED QUANTITIES

HORSE POWER =	136.30	(HP)
MOMENT =	35.79	(FT-LB)
FLOW RATE =	4.25	(LB/SEC)
REFERRED RPM =	18534.80	(RPM)
REFERRED HORSE POWER =	57.42	(HP)
REFERRED MOMENT =	16.27	(FT-LB)
REFERRED FLOW RATE =	2.09	(LB/SEC)

TOTAL/STATIC EFFICIENCY =	.7722
TOTAL/TOTAL EFFICIENCY =	.8716
TOTAL/STATIC PRESSURE RATIO =	2.2032
TOTAL/TOTAL PRESSURE RATIO =	2.0005

HEAD COEFFICIENT	4.4149
BLADE/JET SPEED RATIO	.4557
THEORETICAL DEGREE OF REACTION	.3978
MACH NUMBER AT STATION 0	.2082

SET NUMBER 1 PAGE 1
 INLET TOTAL PRESSURE 32.340
 INLET TOTAL TEMPERATURE 603.60
 TOTAL/STATIC PRESSURE RATIO 2.208
 RPM 2500.0

STATOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION (IN)	X=R/RM	RADIAL SHFT (IN)	BLADE OPENING (IN)	BLADE EFFICIENCY	Y=VA/VAM	LOSS COEFFICIENT	CONTINUITY	RELATIVE FLOW RATE FRACTION
1	2.764	.865	0.0000	.2126	.9153	1.1029	.0847	.0847	0.0000
2	3.003	.940	0.0000	.2147	.9115	1.0474	.0895	.0895	.2543
3	3.135	1.020	0.0000	.2145	.9089	1.0000	.0916	.0916	.4741
4	3.435	1.074	0.0000	.2125	.9062	.9989	.0926	.0926	.7275
5	3.627	1.135	0.0000	.2926	.9053	.8903	.0947	.0947	1.0000

RELATIVE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	403.36	-16.18	891.84	978.23	603.01
2	393.07	15.44	876.81	970.33	605.17
3	365.73	8.37	791.85	873.27	597.16
4	343.77	29.86	718.33	814.99	548.17
5	325.61	38.63	694.71	768.20	591.29

ABSOLUTE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY
1	403.36	-16.18	891.84	978.23
2	393.07	15.44	876.81	970.33
3	365.73	8.37	791.85	873.27
4	343.77	29.86	718.33	814.99
5	325.61	38.63	694.71	768.20

STREAM LINE	ABSOLUTE RELATIVE	RELATIVE	TEMPERATURE (DEC. R)	PRESSURE (PSI)	PRESSURE RATIO
1	.87	.44	523.97	30.726	1.0500
2	.81	.37	533.12	30.910	1.0565
3	.77	.33	540.29	31.023	1.0635
4	.71	.30	548.33	31.181	1.0722
5	.67	.30	554.49	31.303	1.0831

SET PAGE RPM TOTAL/STATIC INLET TOTAL INLET TOTAL
NUMBER NUMBER PRESSURE RATIO PRESSURE (PSI) TEMPERATURE (DEG. R)

1 2 25000.0 2.200 32.340 603.60

ROTOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION	X=R/RM	RADIAL SHIFT	BLADE OPENING	Y=VA /VAM	EFFICIENCY	BLADE COEFFICIENT	LOSS CONTINUITY	FLOW RATE FRACTION
1	2.693	.825	-.0710	.1912	.9747	.9071	.0969	.0969	0.0000
2	3.020	.925	-.0468	.2316	.9747	.9049	.0951	.0951	.2222
3	3.365	1.000	-.0405	.2447	1.0000	.8862	.0938	.0938	.4165
4	3.585	1.098	-.1537	.2742	1.1508	.8681	.1019	.1019	.7149
5	3.837	1.175	-.2100	.2983	1.2961	.8918	.1083	.1083	1.0000

ABSOLUTE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY
1	331.43	-210.08	-392.63	507.52
2	304.47	-40.56	-307.17	458.64
3	313.18	-27.51	-314.41	437.51
4	383.43	-19.55	-385.37	509.36
5	431.85	-25.64	-435.64	587.51

RELATIVE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY
1	331.43	-13.29	-797.60	863.87
2	304.47	-2.89	-699.40	762.81
3	313.18	33.50	-639.83	811.43
4	383.43	51.24	-641.76	809.36
5	431.85	51.24	-642.75	966.15

FLOW ANGLE (DEG)

STREAM LINE	ABSOLUTE RELATIVE	ABSOLUTE	RELATIVE
1	.37	-32.37	-67.44
2	.58	-7.59	-66.48
3	.51	-4.72	-65.26
4	.81	-2.92	-64.45
5	.48	-3.40	-63.41

TEMPERATURE (DEG. R)

STREAM LINE	TOTAL	STATIC
1	473.64	400.81
2	507.91	500.01
3	508.42	499.16
4	509.06	496.78
5	508.54	492.75

PRESSURE RATIO

STREAM LINE	TOTAL	STATIC
1	14.498	13.222
2	16.300	15.435
3	16.300	15.410
4	16.300	14.948
5	16.300	14.381

EQUIV/STATIC PRESSURE RATIO

STREAM LINE	EQUIV/STATIC PRESSURE RATIO
1	1.6
2	1.4
3	1.5
4	1.6
5	1.8

EQUIVALENT INLET TEMPERATURE (DEG. R)

STREAM LINE	EQUIVALENT INLET TEMPERATURE (DEG. R)
1	546.90
2	548.48
3	553.92
4	553.53
5	576.42

SET NUMBER	RACE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	TOTAL/STATIC PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. F)	INLET TOTAL TEMPERATURE (DEG. C)
1	3	25000.0	2.200	32.340	603.60	

OVERALL TURBINE CHARACTERISTICS

STREAM LINE	PRESSURE TOT/STA	TOT/STA	EFFICIENCY TOT/101	COEFFICIENT TOT/101	SPEED/RATIO	DEGREE OF REACTION
1	2.4469	.8029	.8893	4.4985	.4215	.3409
2	2.0953	.8322	.8917	3.3191	.5574	.3475
3	2.1096	.8286	.8904	2.8666	.5906	.3989
4	2.1635	.7916	.8803	2.5607	.6249	.4096
5	2.2488	.7620	.8680	2.3944	.6462	.5652

MISS AVERAGED QUANTITIES

HORSE POWER = 137.41 (HP)
 MOMENT = 29.87 (FT-LB)
 FLOW RATE = 4.18 (LR/SEC)

REFERRED RPM = 23168.50 (RPM)
 REFERRED HORSE POWER = 57.88 (HP)
 REFERRED MOMENT = 13.12 (FT-LB)
 REFERRED FLOW RATE = 2.05 (LR/SEC)

TOTAL/STATIC EFFICIENCY = .8873
 TOTAL/STATIC PRESSURE RATIO = 2.1723

HEAD COEFFICIENT RATIO = 3.0932
 THEORETICAL DEGREE OF REACTION = .4198
 MACH NUMBER AT STATION 0 = .2047

SET NUMBER 1 PAGE 1 RPM 3000.0
 TOTAL/STATIC PRESSURE RATIO 2.200
 INLET TOTAL TEMPERATURE 803.50
 INLET STATIC PRESSURE 32.340

STATOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION (IN)	X=R/RM	RADIAL SHIFT (IN)	BLADE OPENING (IN)	Y=VA/VAM	EFFICIENCY	LOSS COEFFICIENT	CONTINUITY	FLOW RATE FRACTION
1	2.764	.865	0.0000	.3124	1.1037	.9129	.0824	.0824	0.0000
2	2.082	.860	0.0000	.3127	1.1077	.9136	.0864	.0864	.2545
3	2.423	1.029	0.0000	.3074	1.0880	.9102	.0898	.0898	.4743
4	2.627	1.079	0.0000	.3045	1.0896	.9081	.0919	.0919	.7577
5		1.135	0.0000	.2926	.8898	.9065	.0935	.0935	1.0000

ABSOLUTE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY
1	403.41	-16.18	891.15	978.34
2	362.94	3.64	836.55	920.04
3	370.16	8.36	791.33	871.70
4	343.44	29.83	737.61	814.19
5	325.22	38.58	693.87	767.27

RELATIVE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY
1	403.41	-16.18	167.54	437.11
2	362.94	3.64	50.34	386.25
3	370.16	8.36	-45.25	373.01
4	343.44	29.83	-168.80	300.39
5	325.22	38.58	-255.68	415.48

MACH NUMBER

STREAM LINE	ABSOLUTE	RELATIVE
1	.87	.39
2	.81	.34
3	.76	.33
4	.71	.33
5	.66	.36

TEMPERATURE (DEG. R)

STREAM LINE	TOTAL	STATIC
1	603.60	523.95
2	603.60	533.19
3	603.60	540.85
4	603.60	548.44
5	603.60	559.61

PRESSURE RATIO

STREAM LINE	TOT/TOT	TOT/STA
1	1.0490	1.7213
2	1.0415	1.6403
3	1.0341	1.5473
4	1.0264	1.4473
5	1.0326	1.3006

SET NUMBER PAGE RPM TOTAL/STATIC PRESSURE RATIO INLET TOTAL PRESSURE (PSI) INLET TEMPERATURE (DEG. R)

1 2 30000.0 2.200 32.340 603.60

ROTOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION	X=R/RM	RADIAL SHIFT	BLADE OPENING	Y=VA /VAP	EFFICIENCY	FLANGY	LOSS COEFFICIENT	CONTINUITY	7F108	FLOW RATE
1	2.693	.825	.0710	.1912	1.0024	.9152		.0849	.0849	.0849	0.0000
2	3.020	.925	-.0169	.2218	1.0083	.8969		.1072	.1072	.1072	.2168
3	3.265	1.000	-.0485	.2447	1.0000	.8831		.1169	.1169	.1169	.7051
4	3.585	1.098	-.1537	.2742	1.1837	.8931		.0897	.0897	.0897	.7051
5	3.937	1.175	-.2100	.2983	1.3551	.9010		.0991	.0991	.0991	1.0000

RELATIVE VELOCITY (FPS)

ABSOLUTE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	COMPONENT	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	COMPONENT	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	COMPONENT	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY
1	331.81	-13.31	344.99	331.81	331.81	-13.31	344.99	331.81	331.81	331.81	-13.31	344.99	331.81	331.81	331.81	-13.31	344.99	331.81
2	331.81	-13.31	344.99	331.81	331.81	-13.31	344.99	331.81	331.81	331.81	-13.31	344.99	331.81	331.81	331.81	-13.31	344.99	331.81
3	331.81	-13.31	344.99	331.81	331.81	-13.31	344.99	331.81	331.81	331.81	-13.31	344.99	331.81	331.81	331.81	-13.31	344.99	331.81
4	331.81	-13.31	344.99	331.81	331.81	-13.31	344.99	331.81	331.81	331.81	-13.31	344.99	331.81	331.81	331.81	-13.31	344.99	331.81
5	331.81	-13.31	344.99	331.81	331.81	-13.31	344.99	331.81	331.81	331.81	-13.31	344.99	331.81	331.81	331.81	-13.31	344.99	331.81

STREAM LINE	ABSOLUTE	RELATIVE	FLOW ANGLE (DEG)	TEMPERATURE (DEG. R)	PRESSURE (PSI)	PRESSURE RATIO
1	331.81	-13.31	344.99	331.81	331.81	331.81
2	331.81	-13.31	344.99	331.81	331.81	331.81
3	331.81	-13.31	344.99	331.81	331.81	331.81
4	331.81	-13.31	344.99	331.81	331.81	331.81
5	331.81	-13.31	344.99	331.81	331.81	331.81

STREAM LINE	EQUIVALENT INLET PRESSURE (PSI)	EQUIVALENT INLET PRESSURE (DEG. R)	EQUIVALENT INLET PRESSURE RATIO
1	331.81	331.81	331.81
2	331.81	331.81	331.81
3	331.81	331.81	331.81
4	331.81	331.81	331.81
5	331.81	331.81	331.81

SET NUMBER	PAGE NUMBER	KPH	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	3	30000.0	2.200	32.340	603.60

OVERALL TURBINE CHARACTERISTICS

STREAM LINE	TOT/STA PRESSURE RATIO	TOT/TOT EFFICIENCY	HEAD COEFFICIENT	BLADE/IE SPEED RATIO	THEORETICAL DEGREE OF REACTION
1	2.5249	.8429	3.2209	.5572	.3617
2	2.0805	.8273	2.3142	.4317	.4012
3	2.1109	.8028	1.9922	.7085	.4892
4	2.1553	.8210	1.7704	.7516	.5611
5	2.2222	.7434	1.6410	.7806	

MASS AVERAGED QUANTITIES

HORSE POWER =	136.86 (HP)
MOMENT =	125.98 (FT-LB)
FLOW RATE =	4.22 (LB/SEC)
REFERRED RPM =	27807.20
REFERRED HORSE POWER =	57.65 (HP)
REFERRED MOMENT =	10.89 (FT-LB)
REFERRED FLOW RATE =	2.07 (LB/SEC)

TOTAL/STATIC EFFICIENCY =	.7095
TOT/TOT EFFICIENCY =	.6940
TOTAL/STATIC PRESSURE RATIO =	2.3110

HEAD COEFFICIENT =	2.1024
BLADE/JET SPEED RATIO =	.6897
THEORETICAL DEGREE OF REACTION =	.4214
MACH NUMBER AT STATION 0 =	.2868

SET NUMBER 1 PAGE 1 RPM 10000.0 TOTAL/STATIC PRESSURE RATIO 2.400 INLET TOTAL TEMPERATURE 615.30

STATOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION (IN)	X-R/M	RADIAL SHIFT (IN)	BLADE OPENING (IN)	Y-VA	WAM	BLADE EFFICIENCY	LOSS COEFFICIENT	CONTINITY	ZETA	FLOW RATE FRACTION
1	2.764	.865	0.0000	.2126	1.1059		.9195	.0805	.0805	.0805	0.0000
2	3.003	.940	0.0000	.2144	1.1086		.9122	.0875	.0875	.0875	.2499
3	3.135	1.000	0.0000	.2237	1.0000		.9068	.0932	.0932	.0932	.4680
4	3.432	1.000	0.0000	.2255	1.0387		.9015	.0985	.0985	.0985	.7531
5	3.827	1.135	0.0000	.2926	.8883		.8972	.1028	.1028	.1028	1.0000

RELATIVE VELOCITY (FPS)

ABSOLUTE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHFEL VELOCITY
1	473.88	-19.01	805.62	934.85	243.71
2	449.34	4.27	719.52	848.31	248.07
3	428.49	9.80	644.87	778.89	278.89
4	402.24	34.74	495.54	627.67	268.49
5	388.61	45.16	45.16	628.47	316.52

PRESSURE RATIO

PRESSURE (PSI)

TEMPERATURE (DEG. R)

FLOW ANGLE (DEG)

STREAM LINE	ABSOLUTE	RELATIVE	ABSOLUTE	RELATIVE	TOTAL	STATIC	TOTAL	STATIC	101/TOT	101/STA
1	1.04	.85	65.65	59.54	615.30	505.40	32.995	15.566	1.0696	2.1296
2	.97	.76	65.41	58.02	612.30	238.36	33.113	19.467	1.0654	1.9419
3	.91	.69	65.21	56.50	612.30	238.36	33.113	19.467	1.0654	1.9419
4	.84	.61	65.09	54.98	612.30	238.36	33.113	21.115	1.0555	1.8708
5	.78	.55	64.89	52.48	612.30	238.36	33.113	22.415	1.0507	1.8739

SET PAGE RPM TOTAL/STATIC INLET TOTAL INLET TOTAL
NUMBER NUMBER PRESSURE RATIO PRESSURE (PSI) TEMPERATURE (DEC. R) TEMPERATURE (DEC. R)

1 2 10000.0 2.400 35.280 615.30

ROTOR EX11 SOLUTION

STREAM LINE	RADIAL POSITION	X=R/RM	RADIAL SHIFT	BLADE OPENING	BLADE Y=VA /UAM EFFICIENCY	LOSS COEFFICIENT	CONTINUITY	FLOW RATE FRACTION
1	3.693	.825	.0718	.1912	.9754	.1624	.1221	0.0000
2	3.628	.822	-.0462	.2219	.9888	.1613	.1227	.2359
3	3.265	1.000	-.0189	.2747	1.0000	.1649	.1449	.2371
4	3.585	1.098	-.1597	.2983	1.0449	.1599	.1599	.2371
5	3.837	1.175	-.2100	.2983	1.1009	.1559	.1559	1.0000

ABSOLUTE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	376.07	-15.09	-670.81	748.48	376.07	-15.09	-905.01	980.16	235.01
2	391.24	7.62	-612.23	725.23	391.24	7.62	-875.27	955.16	263.54
3	395.57	8.82	-571.23	686.23	395.57	8.82	-856.15	934.01	284.93
4	492.88	34.99	-529.56	666.31	492.88	34.99	-842.44	934.47	312.88
5	424.47	50.36	-513.15	667.86	424.47	50.36	-848.00	949.63	334.84

MACH NUMBER

STREAM LINE	ABSOLUTE	RELATIVE	FLOW ANGLE (DEG)	TEMPERATURE (DEC. R)	PRESSURE (PSI)	PRESSURE RATIO
1	.70	.80	-60.70	497.93	TOTAL	101/TOT
2	.64	.82	-58.09	502.35	STATIC	101/STA
3	.63	.85	-55.99	505.63	TOTAL	1.8023
4	.68	.85	-52.74	507.73	STATIC	1.8022
5	.61	.86	-50.41	506.81	TOTAL	1.7950
					STATIC	1.7914
					TOTAL	1.7825
					STATIC	1.7828

STREAM LINE	EQUIVALENT INLET TEMPERATURE (DEC. R)	EQUIVALENT INLET PRESSURE (PSI)	EQUIV/STATIC PRESSURE RATIO
1	577.87	28.481	1.9
2	578.27	26.447	1.8
3	579.00	26.865	1.8
4	580.39	27.242	1.8
5	581.85	27.612	1.8

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	3	10000.0	2.400	35.280	615.30

OVERALL TURBINE CHARACTERISTICS

STREAM LINE	TOT/STA PRESSURE RATIO	TOT/STA EFFICIENCY	TOT/STA COEFFICIENT	SPEED RATIO	DEGREE OF REACTION
1	2.5054	.4804	.7159	29.3338	.1844
2	2.4058	.5182	.7310	23.6934	.2046
3	2.3361	.5296	.7406	20.4693	.2210
4	2.2779	.5477	.7548	17.2807	.2406
5	2.2828	.5522	.7620	15.5053	.2540

MASS AVERAGED QUANTITIES

HORSE POWER	=	109.48	(HP)
MOMENT	=	57.50	(FT-LB)
FLOW RATE	=	4.60	(LB/SEC)

REFERRED RPM	=	9178.87	(RPM)
REFERRED MOMENT	=	41.87	(FT-LB)
REFERRED FLOW RATE	=	23.76	(LB/SEC)

TOTAL/STATIC EFFICIENCY	=	.5259
TOTAL/STATIC PRESSURE RATIO	=	2.3337

HEAD COEFFICIENT	=	21.9157
THEORETICAL DEGREE OF REACTION	=	.2843
MACH NUMBER AT STATION 0	=	.2084

STATOR EXIT SOLUTION

STREAM LINE	NADIAL POSITION (IN)	X=R/RM	RADIAL SHIFT (IN)	BLADE OPENING (IN)	Y=VA	/VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	CFR# CONTINUITY	FLOW RATE FRACTION
1	2.764	.865	0.0000	.2126	1.1043		.9122	.0878	.0878	0.0000
2	2.683	.940	0.0000	.2347	1.1047		.9056	.0948	.0948	.2515
3	1.952	1.000	0.0000	.2524	1.0000		.8802	.1000	.1000	.4703
4	3.432	1.074	0.0000	.2745	.9409		.8990	.1002	.1002	.7546
5	3.432	1.135	0.0000	.2926	.8923		.8990	.1002	.1002	1.0000

Stream Line	Absolute Velocity (FPS)			Relative Velocity (FPS)		
	Axial Component	Tangential Component	Overall Velocity	Axial Component	Tangential Component	Overall Velocity
1	439.56	17.63	456.08	439.59	609.26	751.50
2	439.56	19.13	460.96	437.04	577.93	664.72
3	439.56	20.63	469.34	434.49	546.61	629.30
4	439.56	22.13	480.64	431.94	515.29	597.82
5	439.56	23.63	494.19	429.39	483.97	566.31
6	439.56	25.13	510.64	426.84	452.65	534.82
7	439.56	26.63	529.19	424.29	421.33	503.33
8	439.56	28.13	550.64	421.74	390.01	471.84
9	439.56	29.63	574.19	419.19	358.69	440.35
10	439.56	31.13	600.64	416.64	327.37	408.86
11	439.56	32.63	629.19	414.09	296.05	377.37
12	439.56	34.13	660.64	411.54	264.73	345.88
13	439.56	35.63	694.19	408.99	233.41	314.39
14	439.56	37.13	730.64	406.44	202.09	282.90
15	439.56	38.63	769.19	403.89	170.77	251.41
16	439.56	40.13	810.64	401.34	139.45	220.92
17	439.56	41.63	854.19	398.79	108.13	190.43
18	439.56	43.13	900.64	396.24	76.81	160.94
19	439.56	44.63	950.19	393.69	45.49	131.45
20	439.56	46.13	1002.64	391.14	14.17	101.96

STREAM LINE	MACH NUMBER		FLOW ANGLE (DEG)		TEMPERATURE (DEG. R)		PRESSURE (PSI)		PRESSURE RATIO	
	ABSOLUTE	RELATIVE	ABSOLUTE	RELATIVE	TOTAL	STATIC	TOTAL	STATIC	TOT/STOT	101/51A
1	.95	.67	65.65	54.19	615.30	520.23	33.169	19.496	1.6646	1.9875
2	.89	.62	65.41	51.16	615.30	531.26	33.247	19.496	1.7656	1.9656
3	.83	.52	65.21	48.10	615.30	540.30	33.247	21.203	1.8657	1.8657
4	.77	.45	65.04	43.48	615.30	549.33	33.270	23.493	1.9647	1.9647
5	.72	.39	64.89	38.55	615.30	558.87	33.858	24.877	1.0430	1.4775

SET CASE
NUMBER NUMBER RPM
1 2 15000.0
TOTAL/STATIC
PRESSURE RATIO 2.400
INLET TOTAL
PRESSURE (PSI) 35.280
INLET TOTAL
TEMPERATURE
(DEG. R) 615.50

MOTOR EX11 SOLUTION

STREAM LINE	RADIAL POSITION	X=R/RM	SHIFT	RADIAL OPENING	BLADE	Y=VA/VAM	HEAD EFFICIENCY	LOSS COEFFICIENT	CONTINITY	ZIOM	FLOW RATE FRACTION RATE
1	2.693	.825	.0710	.1912	.1912	.9810	.8603	.1327	.1327	.1327	0.0000
2	3.820	.925	.0168	.2218	.2218	.9666	.8647	.1324	.1324	.1354	.2320
3	3.562	1.000	.0405	.2447	.2447	1.0000	.8679	.1324	.1324	.1354	.4312
4	3.582	1.098	.1537	.2747	.2747	1.0753	.8761	.1318	.1318	.1354	.6282
5	3.837	1.175	.2100	.2983	.2983	1.1567	.8825	.1175	.1175	.1175	1.0000

ABSOLUTE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	341.49	-14.51	-517.91	611.88	361.69	-14.51	-870.43	942.70	352.51
2	354.38	1.70	-183.34	553.39	356.38	3.39	-818.65	892.64	306.31
3	368.69	8.73	-156.28	537.82	368.69	8.44	-818.62	892.58	306.31
4	394.46	34.73	-356.58	553.83	426.46	34.43	-829.02	919.58	477.33
5	426.46	50.68	-349.72	553.83	426.46	50.60	-851.98	954.10	502.26

FLOW ANGLE (DEG)

STREAM LINE	ABSOLUTE	RELATIVE	ABSOLUTE	RELATIVE	TOTAL	STATIC	TOTAL	STATIC	TOTAL/100	100/100
1	.58	.87	-55.07	-67.44	526.44	493.22	17.627	14.031	2.001	2.1143
2	.50	.81	-49.91	-66.48	526.44	502.37	10.099	15.221	1.944	2.1143
3	.49	.82	-46.71	-65.76	526.44	503.43	18.143	15.409	1.944	2.1143
4	.50	.87	-42.22	-64.45	526.44	503.43	18.265	15.522	1.944	2.1143
5	.50	.87	-39.36	-63.41	526.44	503.43	18.265	15.522	1.944	2.1143

STREAM LINE	EQUIVALENT TEMPERATURE (DEG. R)	EQUIVALENT INLET PRESSURE (PSI)	EQUIVALENT PRESSURE RATIO
1	567.17	24.942	1.8
2	578.20	25.277	1.7
3	578.20	25.649	1.7
4	578.20	26.321	1.7
5	578.41	26.942	1.8

SET NUMBER	PAGE	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	3	15000.0	2.400	35.280	615.30

OVERALL TURBINE CHARACTERISTICS

STATION LINE	TOT/STA PRESSURE RATIO	TOT/STA EFFICIENCY	TOT/STT COEFFICIENT	SPEED/RATIO	DEGREE OF REACTION
1	2.5144	2.0014	.8031	13.0814	.2765
2	2.3179	1.9493	.8186	10.2166	.3159
3	2.2896	1.9445	.8249	8.9067	.3351
4	2.2729	1.9316	.8363	7.6624	.3613
5	2.3824	1.9347	.8428	6.9546	.3792

MASS AVERAGED QUANTITIES

HORSE POWER = 135.97 (HP)
 MOMENT = 47.61 (FT-LB)
 FLOW RATE = 4.54 (LB/SEC)

REFERRED HORSE POWER = 13769.10 (HP)
 REFERRED MOMENT = 10.84 (FT-LB)
 REFERRED FLOW RATE = 2.06 (LB/SEC)

TOTAL/STATIC EFFICIENCY = .6705
 TOTAL/STT EFFICIENCY = .8217
 TOTAL/STT PRESSURE RATIO = 2.3322
 TOTAL/STT PRESSURE RATIO = 1.9484

HEAD COEFFICIENT RATIO = 9.2889
 BLADE/JET AREA = .289
 THEORETICAL DEGREE OF REACTION = .2691
 MACH NUMBER AT STATION 0 = .2057

SET NUMBER 1 PAGE 10000.0 RPM 20000.0 PRESSURE 2.400 TOTAL/STATION PRESSURE 35.280 TOTAL TEMPERATURE 615.30

STATOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION (IN)	X=R/KM	RADIAL SHIFT (IN)	BLADE OPENING (IN)	Y=VA /VAM	EFFICIENCY	LOSS COEFFICIENT	CONTINUITY	RELATIVE FLOW RATE
1	2.764	.845	0.0000	.5126	1.1817	.9133	.0067	.0067	0.0000
2	3.003	1.000	0.0000	.5126	1.0470	.9104	.0096	.0096	.0000
3	3.433	1.000	0.0000	.5126	1.0000	.9080	.0020	.0020	.0000
4	3.433	1.074	0.0000	.5126	.9401	.9061	.0049	.0039	.0000
5	3.627	1.135	0.0000	.5126	.8985	.9045	.0055	.0055	1.0000

RELATIVE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	DIFF. VELOCITY
1	429.69	-17.24	949.28	1042.07	429.69	-17.24	949.28	1042.07	482.41
2	408.34	3.88	892.02	981.05	408.34	3.88	892.02	981.05	527.72
3	398.02	8.92	844.44	930.20	398.02	8.92	844.44	930.20	528.64
4	366.68	31.85	787.54	869.30	366.68	31.85	787.54	869.30	533.03
5	347.33	41.21	741.95	819.45	347.33	41.21	741.95	819.45	533.03

TEMPERATURE (DEG. R)

STREAM LINE	ABSOLUTE	RELATIVE	RELATIVE	RELATIVE	RELATIVE	RELATIVE	RELATIVE	RELATIVE	RELATIVE
1	93	.57	.57	.57	.57	.57	.57	.57	.57
2	.87	.48	.48	.48	.48	.48	.48	.48	.48
3	.81	.42	.42	.42	.42	.42	.42	.42	.42
4	.75	.32	.32	.32	.32	.32	.32	.32	.32
5	.71	.32	.32	.32	.32	.32	.32	.32	.32

PRESSURE (PSI)

STREAM LINE	ABSOLUTE	RELATIVE	RELATIVE	RELATIVE	RELATIVE	RELATIVE	RELATIVE	RELATIVE	RELATIVE
1	93	.57	.57	.57	.57	.57	.57	.57	.57
2	.87	.48	.48	.48	.48	.48	.48	.48	.48
3	.81	.42	.42	.42	.42	.42	.42	.42	.42
4	.75	.32	.32	.32	.32	.32	.32	.32	.32
5	.71	.32	.32	.32	.32	.32	.32	.32	.32

PRF. CORR. FACTOR

STREAM LINE	ABSOLUTE	RELATIVE	RELATIVE	RELATIVE	RELATIVE	RELATIVE	RELATIVE	RELATIVE	RELATIVE
1	93	.57	.57	.57	.57	.57	.57	.57	.57
2	.87	.48	.48	.48	.48	.48	.48	.48	.48
3	.81	.42	.42	.42	.42	.42	.42	.42	.42
4	.75	.32	.32	.32	.32	.32	.32	.32	.32
5	.71	.32	.32	.32	.32	.32	.32	.32	.32

SET NUMBER PAGE NUMBER RPM TOTAL/STATIC PRESSURE RATIO INLET TOTAL PRESSURE (PSI) INLET TOTAL TEMPERATURE (DEG. R)

1 2 20000.0 2.400 35.280 615.30

MOTOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION	X=R/RM	RADIAL SHIFT	BLADE OPENING	Y=VA	BLADE EFFICIENCY	LOSS COEFFICIENT	CONTINUITY	FLOW RATE FRACTION
1	3.693	.825	.0710	.1912	.9855	.1112	.1112	.1112	0.0000
2	3.820	.925	.0168	.2218	.9479	.1071	.1071	.1071	.0279
3	3.285	1.000	.0405	.2447	1.0000	.1040	.1040	.1040	.4256
4	3.385	1.098	.1537	.2687	1.1024	.0970	.0970	.0970	.7221
5	3.837	1.175	.2100	.2983	1.2069	.0914	.0914	.0914	1.0000

ABSOLUTE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	UNIT VELOCITY
1	371.69	-14.91	-424.45	564.39	371.69	-14.91	-424.45	564.39	420.02
2	357.57	3.40	-294.20	463.02	357.57	3.40	-294.20	463.02	537.07
3	377.17	8.63	-267.65	485.37	377.17	8.63	-267.65	485.37	569.85
4	415.28	36.11	-243.64	517.29	415.28	36.11	-243.64	517.29	625.77
5	455.28	54.01	-239.71	545.20	455.20	54.01	-239.71	545.20	669.68

MACH NUMBER

STREAM LINE	ABSOLUTE	RELATIVE	FLOW ANGLE (DEG)	TEMPERATURE (DEG. R)	PRESSURE (PSI)	PRESSURE RATIO
1	53	.90	-48.80	505.89	15.616	12.945
2	42	.82	-39.45	511.68	16.589	14.651
3	44	.84	-35.36	511.54	16.632	14.693
4	.48	.89	-30.37	511.43	16.693	14.766
5		.94	-27.77	510.51	16.610	14.809

STREAM LINE	EQUIVALENT TEMPERATURE (DEG. R)	EQUIVALENT INLET PRESSURE (PSI)	EQUIVALENT PRESSURE RATIO
1	552.48	23.576	1.8
2	560.61	24.180	1.7
3	561.94	24.802	1.7
4	569.39	25.982	1.8
5	574.55	26.746	1.9

SET RACE KPM TOTAL/STATIC INLET TOTAL INLET TOTAL
NUMBER NUMBER PRESSURE RATIO PRESSURE TEMPERATURE
(DEG. R)

615.30

35.280

2.400

20000.0

3

1

OVERALL TURBINE CHARACTERISTICS

STREAM LINE	PRESSURE RATIO	EFFICIENCY	HEAD COEFFICIENT	SPEED/IFT	THEORETICAL DEGREE OF REACTION
1	2.7374	.8560	7.9194	.3554	.3548
2	2.4080	.8683	5.9763	.4091	.4561
3	2.4013	.8723	5.2634	.4359	.4179
4	2.4204	.8770	4.6002	.4662	.4746
5	2.4829	.8795	4.2221	.4867	.5612

MASS AVERAGED QUANTITIES

HORSE POWER = 163.10 (HP)
MOMENT = 42.11 (FT-LB)
FLOW RATE = 4.54 (LB/SEC)

REFERRED RPM = 18357.73 (RPM)
REFERRED HORSE POWER = 61.61 (HP)
REFERRED MOMENT = 17.63 (FT-LB)
REFERRED FLOW RATE = 2.06 (LB/SEC)

TOTAL/STATIC EFFICIENCY = .7513
TOTAL/STATIC EFFICIENCY = .6013
TOTAL/STATIC PRESSURE RATIO = 2.4303

HEAD COEFFICIENT = 5.4273
HEAD/IFT RATIO = .4317
THEORETICAL DEGREE OF REACTION = .2055
MACH NUMBER AT STATION 0

SEI NUMBER 1 CASE NUMBER 1 RPM 30000.0 TORQUE/STATION 2.400 PRESSURE TOTAL 35.280 TEMPERATURE TOTAL 815.50

STATOR IXXII SOLUTION

STREAM LINE	RADIAL POSITION (IN)	X-R/RM	RADIAL SHIFT (IN)	BLADE OPENING (IN)	Y=UA /VAM EFFICIENCY	LOSS COEFFICIENT	CONTINUITY	FLOW RATE FRACTION
1	2.764	.865	0.0000	.2126	1.1040	.0806	.0006	0.0000
2	3.003	.940	0.0000	.2347	1.0479	.0851	.0007	.0000
3	3.195	1.000	0.0000	.2526	1.0000	.0887	.0007	.0000
4	3.432	1.074	0.0000	.2745	.9395	.0910	.0010	.0000
5	3.627	1.135	0.0000	.2926	.8895	.0929	.0029	1.0000

ABSOLUTE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	416.68	-16.71	920.47	1010.53	416.68	-16.71	196.86	461.15	734.62
2	325.43	-3.76	823.95	950.17	325.43	-3.76	177.74	403.03	706.71
3	377.43	30.80	717.25	900.14	377.43	30.80	-19.43	378.02	836.58
4	354.58	39.83	716.29	792.08	354.58	39.83	-136.86	381.33	808.41
5	335.72	39.83	716.29	792.08	335.72	39.83	-233.26	410.74	949.55

MACH NUMBER

STREAM LINE	ABSOLUTE	RELATIVE	FLOW ANGLE (DEG)	TEMPERATURE (DEG. R)	PRESSURE (PSI)	TOTAL	STATIC	TOTAL/100	TOTAL/100
1	.90	.41	65.65	615.30	530.33	33.573	19.958	1.0509	1.7677
2	.83	.35	62.41	615.30	540.17	33.708	21.370	1.0406	1.6509
3	.78	.33	62.61	615.30	547.08	33.822	22.532	1.0431	1.5658
4	.73	.33	62.61	615.30	556.50	33.991	23.916	1.0379	1.4743
5	.68	.35	64.89	615.30	563.10	34.123	25.019	1.0339	1.4101

SET NUMBER PAGE RPM TOTAL/STATIC PRESSURE RATIO INLET TOTAL PRESSURE (PSI) INLET TOTAL TEMPERATURE (DEG. R)

615.30

ROTOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION	X=R/RM	RADIAL SHIFT	BLADE OPENING	BLADE Y=UA /UAM	EFFICIENCY	LOSS COEFFICIENT	CONTINUITY	FLUX RATE
1	2.623	.825	.0710	.1912	1.0001	.9163	.0837	.0837	0.0000
2	2.623	.825	.0710	.1912	1.0001	.9163	.0837	.0837	0.0000
3	3.565	1.060	.0168	.2218	1.0000	.8989	.1012	.1012	.0000
4	3.565	1.060	.0168	.2218	1.0000	.8989	.1012	.1012	.0000
5	3.837	1.098	.0537	.2447	1.3731	.8982	.1018	.1018	.0000
		1.175	.2100	.2963	1.3365	.9080	.0920	.0920	1.0000

ABSOLUTE VELOCITY (FPS)

RELATIVE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	351.32	-19.09	-140.43	378.60	351.32	-14.09	-845.45	915.65	785.03
2	315.07	8.04	76.87	328.60	315.07	2.99	-723.75	789.36	790.61
3	351.28	35.79	76.77	369.34	351.28	8.04	-740.01	855.50	854.78
4	412.09	55.70	66.63	420.54	412.09	35.79	-861.69	955.82	930.25
5	469.47			477.43	469.47	55.70	-937.90	1050.31	1004.53

MACH NUMBER

FLOW ANGLE (DEG)

TEMPERATURE (DEG. R)

PRESSURE (PSI)

PRESSURE RATIO

STREAM LINE	ABSOLUTE	RELATIVE	ABSOLUTE	RELATIVE	TOTAL	STATIC	TOTAL	STATIC	TOTAL/101	TOTAL/514
1	.35	.86	-21.79	-67.44	487.97	476.05	14.027	13.047	2.4798	2.7041
2	.39	.72	11.98	-66.48	511.06	507.42	16.897	15.919	2.0079	2.2163
3	.33	.78	12.02	-65.76	512.12	507.42	16.840	15.636	2.0950	2.2503
4	.38	.87	10.58	-64.45	513.46	498.73	16.923	15.332	2.0782	2.2311
5	.44	.96	8.08	-63.41	513.25	494.28	16.923	14.833	2.0847	2.2378

EQUIVALENT TEMPERATURE (DEG. R)

EQUIVALENT INLET PRESSURE (PSI)

EQUIV/STATIC PRESSURE RATIO

TEMPERATURE (DEG. R)

PRESSURE (PSI)

PRESSURE RATIO

STREAM LINE	EQUIVALENT TEMPERATURE (DEG. R)	EQUIVALENT INLET PRESSURE (PSI)	EQUIV/STATIC PRESSURE RATIO	TEMPERATURE (DEG. R)	PRESSURE (PSI)	PRESSURE RATIO
1	545.81	22.073	1.7	476.05	14.027	2.4798
2	554.27	23.386	1.5	507.42	16.897	2.0079
3	562.33	24.681	1.6	507.42	16.840	2.0950
4	574.75	26.776	1.7	498.73	16.923	2.0782
5	586.07	28.778	1.9	494.28	16.923	2.0847

SET PAGE RPM TOTAL/STATIC INLET TOTAL INLET TOTAL
NUMBER NUMBER PRESSURE PRESSURE PRESSURE PRESSURE PRESSURE
(PSI) (PSI) (DEG. R)

615.30

35.280

2.400

30000.0

1

3

OVERALL TURBINE CHARACTERISTICS

STREAM LINE	PRESSURE RATIO TOT/STA	EFFICIENCY TOT/TOT	HEAD COEFFICIENT	SHOCK/JET SPEED RATIO	THEORETICAL DEGREE OF REACTION
1	2.7041	.8455	3.4236	.5350	.3928
2	2.2162	.8331	3.4328	.7411	.3438
3	2.2563	.8080	2.1916	.6755	.4283
4	2.3011	.7812	1.9410	.7178	.5038
5	2.3784	.7564	1.7983	.7457	.5735

MASS AVERAGED QUANTITIES

HORSE POWER = 161.72 (HP)
 MOMENTUM = 28.42 (FT-LB)
 FLOW RATE = 4.63 (LB/SEC)

REFERRED RPM = 27576.69 (RPM)
 REFERRED HORSE POWER = 20.50 (HP)
 REFERRED MOMENTUM = 11.80 (FT-LB)
 REFERRED FLOW RATE = 2.05 (LB/SEC)

TOTAL/STATIC EFFICIENCY = .8047
 TOTAL/STATIC EFFICIENCY = .8854
 TOTAL/STATIC PRESSURE RATIO = 2.3387
 TOTAL/STATIC PRESSURE RATIO = 2.1358

HEAD COEFFICIENT RATIO = 2.3020
 THEORETICAL DEGREE OF REACTION = .4328
 MACH NUMBER AT STATION 0 = .3045

SET NUMBER 1 PAGE 1 RPM 2000.0 TOTAL/STATIC PRESSURE RATIO 2.600 INLET TOTAL PRESSURE 38.220 INLET TOTAL TEMPERATURE 626.18

STATOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION (IN)	X=R/RM	RADIAL SHIFT (IN)	BLADE OPENING (IN)	Y=VA /VAM	EFFICIENCY	LOSS COEFFICIENT	CONTINUITY	7-16*	FLOW RATE FRACTION
1	3.764	.865	0.0000	.2126	1.1017	.9134	.0866	.0866		0.0000
2	3.803	.940	0.0000	.2337	1.0469	.9105	.0895	.0895		.2518
3	3.843	1.000	0.0000	.2525	1.0000	.9082	.0918	.0918		.4710
4	3.883	1.050	0.0000	.2698	.9581	.9062	.0938	.0938		.7554
5	3.927	1.135	0.0000	.2926	.8985	.9046	.0954	.0954		1.0000

ABSOLUTE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHIFT VELOCITY
1	436.14	-17.50	963.46	1057.73	436.14	-17.50	401.05	649.57	487.41
2	414.48	1.90	985.46	1056.01	414.48	1.90	398.31	633.21	524.14
3	395.98	9.04	857.16	944.37	395.98	9.04	379.44	483.87	487.41
4	372.19	42.33	799.38	862.77	372.19	42.33	360.44	433.97	524.14
5	352.54	41.83	752.17	831.74	352.54	41.83	119.14	374.47	633.03

222

MACH NUMBER FLOW ANGLE (DEG.)

STREAM LINE	ABSOLUTE	RELATIVE	ABSOLUTE	RELATIVE	TEMPERATURE (DEG. R)	TOTAL	STATIC	TOTAL	STATIC	101/101	101/STA
1	.93	.57	65.65	47.81	533.08	626.18	533.08	36.051	20.524	1.0602	1.6622
2	.87	.49	65.41	42.62	543.66	626.18	543.66	36.243	23.413	1.0491	1.7394
3	.82	.43	65.21	37.16	551.69	626.18	551.69	36.433	25.002	1.0431	1.8311
4	.76	.37	65.04	28.31	561.39	626.18	561.39	36.640	25.002	1.0429	1.9201
5	.71	.32	64.89	18.67	568.61	626.18	568.61	36.811	26.266	1.0463	1.4551

PRESSURE RATIO

SET
NUMBER

PAGE
NUMBER

RPM

INLET/STATIC
PRESSURE RATIO

INLET TOTAL
PRESSURE
(PSI)

INLET TOTAL
TEMPERATURE
(DEG. K)

1 2 20000.0 2.600 38.220 626.18

MOTOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION	X=R/RM	RADIAL SHIFT	BLADE OPENING	Y=U/V	EFFICIENCY	COEFFICIENT	CONTINUITY	FRACTION RATE
1	2.693	.825	.0718	.1912	.9841	.8925	.1026	.1026	0.5000
2	3.023	1.068	-.0168	.2218	.9534	.8923	.1039	.1039	.5004
3	3.365	1.307	-.0468	.2447	1.0000	.8990	.1031	.1031	.5004
4	3.585	1.498	-.1157	.2577	1.0944	.9058	.1043	.1043	.7293
5	3.837	1.175	-.2100	.2983	1.1922	.9111	.1089	.1089	1.0000

ABOLUTE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	399.16	-16.01	-490.56	632.64	399.16	-16.01	-490.56	1040.34	470.82
2	384.22	9.28	-461.25	629.23	384.22	9.28	-461.25	969.88	472.07
3	405.61	9.28	-370.81	538.57	405.61	9.28	-370.81	987.82	472.07
4	443.92	18.56	-382.49	570.84	443.92	18.56	-382.49	1029.87	472.07
5	483.56	57.37	-296.36	570.84	483.56	57.37	-296.36	1081.83	669.68

MACH NUMBER

STREAM LINE	ABSOLUTE TEMPERATURE	RELATIVE TEMPERATURE	FLOW ANGLE (DEG)
1	.59	.87	-67.44
2	.49	.87	-66.48
3	.48	.91	-65.76
4	.50	.95	-64.45
5	.53	1.00	-63.41

TEMPERATURE (DEG. K)

STREAM LINE	ABSOLUTE TEMPERATURE	RELATIVE TEMPERATURE	FLOW ANGLE (DEG)
1	.59	.87	-67.44
2	.49	.87	-66.48
3	.48	.91	-65.76
4	.50	.95	-64.45
5	.53	1.00	-63.41

PRESSURE RATIO

STREAM LINE	ABSOLUTE TEMPERATURE	RELATIVE TEMPERATURE	FLOW ANGLE (DEG)
1	.59	.87	-67.44
2	.49	.87	-66.48
3	.48	.91	-65.76
4	.50	.95	-64.45
5	.53	1.00	-63.41

STREAM LINE	ABSOLUTE TEMPERATURE	RELATIVE TEMPERATURE	FLOW ANGLE (DEG)
1	.59	.87	-67.44
2	.49	.87	-66.48
3	.48	.91	-65.76
4	.50	.95	-64.45
5	.53	1.00	-63.41

STREAM LINE	ABSOLUTE TEMPERATURE	RELATIVE TEMPERATURE	FLOW ANGLE (DEG)
1	.59	.87	-67.44
2	.49	.87	-66.48
3	.48	.91	-65.76
4	.50	.95	-64.45
5	.53	1.00	-63.41

SET NUMBER	PAGE NUMBER	KP	TOTAL/STATIC PRESSURE RATIO	INITIAL TOTAL PRESSURE (PSI)	INITIAL TOTAL TEMPERATURE (DEG. R)
1	3	20000.0	2.600	18.220	626.18

OVERALL TURBINE CHARACTERISTICS

STREAM LINE	PRESSURE RATIO TOT/STA	EFFICIENCY TOT/TOT	HEAD COEFFICIENT	BLADE/JET SPEED RATIO	THEORETICAL DEGREE OF REACTION
1	2.9731	.6985	8.6546	.3399	.3719
2	2.2217	.7367	6.5718	.3901	.3768
3	2.2163	.8711	5.7231	.4162	.4513
4	2.2085	.8765	5.8333	.4452	.4842
5	2.2214	.8793	4.6155	.4655	.5865

MASS AVERAGED QUANTITIES

HORSE POWER = 185.30 (HP)
MOMENT = 48.66 (FT-LB)
FLOW RATE = 4.89 (LB/SEC)

REFLECTED HORSE POWER = 18197.55 (HP)
REFLECTED MOMENT = 64.84 (FT-LB)
REFLECTED FLOW RATE = 18.72 (LB/SEC)

TOTAL/STATIC EFFICIENCY = .733
TOTAL/TOTAL EFFICIENCY = .3702
TOTAL/STATIC PRESSURE RATIO = 2.6330

HEAD COEFFICIENT = 6.8033
BLADE/JET SPEED RATIO = .4001
THEORETICAL DEGREE OF REACTION = .4659
MACH NUMBER AT STATION 0 = .2061

SET NUMBER 1 PAGE 1 RPM 30000.0 TOTAL/STATIC PRESSURE RATIO 2.600 INLET TOTAL PRESSURE 56.220 INLET TOTAL TEMPERATURE 826.18

STATOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION (IN)	X=R/RM	RADIAL SHIFT (IN)	BLADE OPENING (IN)	Y=VA /VAM	EFFICIENCY	MADE	LOSS COEFFICIENT	CONTINUITY	ZETA*	FLOW RATE FRACTION
1	2.744	.865	0.0000	.2126	1.1042	.9205		.0795	.0795		0.0000
2	3.003	.940	0.0000	.2327	1.0480	.9159		.0841	.0841		.2532
3	3.195	1.000	0.0000	.2525	1.0000	.9123		.0877	.0877		.4227
4	3.432	1.074	0.0000	.2725	.9373	.9098		.0902	.0902		.7566
5	3.627	1.135	0.0000	.2926	.8892	.9077		.0923	.0923		1.0000

ABSOLUTE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY
1	427.64	-17.15	944.68	1037.11
2	405.86	3.86	886.61	975.10
3	387.29	8.86	838.53	923.69
4	363.80	31.60	781.35	863.47
5	344.40	40.86	734.79	812.52

RELATIVE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	427.64	-17.15	221.06	481.71	723.62
2	405.86	3.86	100.40	419.12	786.21
3	387.29	8.86	1.94	391.47	866.58
4	363.80	31.60	-117.06	383.47	948.41
5	344.40	40.86	-214.76	407.92	949.55

MACH NUMBER

STREAM LINE	ABSOLUTE RELATIVE
1	.91
2	.85
3	.80
4	.74
5	.69

FLOW ANGLE (DEG)

ABSOLUTE RELATIVE
27.34
13.90
13.29
-17.84
-31.95

TEMPERATURE (DEG. R)

STREAM LINE	TOTAL	STATIC
1	626.18	536.68
2	626.18	547.06
3	626.18	555.18
4	626.18	564.28
5	626.18	571.24

PRESSURE (PSI)

STREAM LINE	TOTAL	STATIC
1	36.326	21.173
2	36.474	22.733
3	36.601	24.620
4	36.784	25.554
5	36.927	26.778

PRESSURE RATIO

STREAM LINE	TOT/TOT	TOT/STA
1	1.0521	1.8882
2	1.0479	1.6813
3	1.0382	1.5913
4	1.0300	1.4957
5	1.0350	1.4273

SET. WAGE RPM TOTAL TOTAL TOTAL
NUMBER NUMBER PRESSURE RATIO PRESSURE TEMPERATURE
(DEG. R)

626.18

38.220

2.600

30000.0

2

1

MOTOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION	X=R/RM	RADIAL SHIF	BLADE OPENING	BLADE	Y=VA /VAM	EFFICIENCY	LOSS COEFFICIENT	ZETA	CONTINUITY	FLOW RATE FRACTION
1	2.693	.825	-.0710	.1912	.9466	.9218	.8790	.0790	.0790	.0790	.0790
2	3.020	1.000	-.0168	.2218	.9100	.8658	.0745	.0745	.0745	.0745	.0745
3	3.265	1.000	-.0405	.2447	1.0000	.8938	.0663	.0663	.0663	.0663	.0663
4	3.585	1.098	-.1537	.2747	1.1548	.9052	.0949	.0949	.0949	.0949	.0949
5	3.837	1.175	-.2100	.2983	1.3010	.9141	.0859	.0859	.0859	.0859	.0859

ABSOLUTE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	491.31	-236.68	457.59	391.31	-15.70	-741.70	1019.89	205.01
2	367.39	-30.13	368.57	357.39	3.39	-830.24	895.14	200.61
3	392.64	-18.87	393.19	352.64	8.98	-871.65	956.23	854.94
4	451.10	-15.98	454.85	431.10	39.35	-947.45	1050.96	978.65
5	510.82	-15.98	514.65	510.82	60.61	-1020.51	1142.82	1004.53

MACH NUMBER

STREAM LINE	ABSOLUTE	RELATIVE	FLOW ANGLE (DEG)	TEMPERATURE (DEG. R)	PRESSURE (PSI)	PRESSURE RATIO
1	.43	.96	-31.17	TOTAL	14.009	101/101
2	.33	.82	-27.48	STATIC	12.324	2.783
3	.36	.89	-25.76	462.82	15.400	2.3181
4	.42	.97	-24.45	467.55	14.978	2.517
5	.48	1.06	-23.41	490.76	14.626	2.3160
				465.55	14.853	2.3162

STREAM LINE	EQUIVALENT TEMPERATURE (DEG. R)	EQUIVALENT INLET PRESSURE (PSI)	EQUIV/STATIC PRESSURE RATIO
1	553.28	23.629	1.9
2	552.19	25.010	1.6
3	570.23	26.377	1.8
4	582.67	28.589	2.0
5	594.83	30.786	2.2

SET NUMBER	PAISE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	3	30000.0	2.600	38.220	626.18

OVERALL TURBINE CHARACTERISTICS

STREAM LINE	PRESSURE RATIO TOT/STA	EFFICIENCY TOT/TOT	HEAD COEFFICIENT TOT/TOT	MADE/VEY SPEED RATIO	THEORETICAL DEGREE OF REACTION
1	3.182	.862	3.9206	.508	.4174
2	2.498	.835	2.8019	.574	.4006
3	2.3323	.8105	2.5248	.6293	.4707
4	2.3160	.8856	2.2375	.6685	.5473
5	2.7198	.8844	2.0751	.6942	.6112

MASS AVERAGED QUANTITIES

HORSE POWER = 201.29 (HP)
MOMENT = 35.54 (FT-LB)
FLOW RATE = 4.88 (LB/SEC)

REFLECTED RPM POWER = 27226.32 (HP)
REFLECTED MOMENT = 70.44 (FT-LB)
REFLECTED FLOW RATE = 13.55 (LB/SEC)

TOTAL/STATIC EFFICIENCY = .8050
TOTAL/TOTAL EFFICIENCY = .8709
TOTAL/STATIC PRESSURE RATIO = 2.6433
TOTAL/TOTAL PRESSURE RATIO = 2.3236

HEAD COEFFICIENT = 2.6467
MADE/VEY SPEED RATIO = .6147
THEORETICAL DEGREE OF REACTION = .4858
MACH NUMBER AT STATION 0 = .2058

SET PAGE RPM TOTAL/STATIC INLET TOTAL INLET TOTAL
 NUMBER 1 15000.0 PRESSURE RATIO PRESSURE TEMPERATURE
 1 2.800 41.160 656.67

STATOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION (IN)	X-R/RM	RADIAL SHIFT (IN)	BLADE OPENING (IN)	Y=VA./VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	CONTINITY	ZETA*	FLOW RATE FRACTION
1	2.744	.845	0.0000	.2126	1.1050	.9160	.0840	.0840	.0840	0.0000
2	3.003	.940	0.0000	.2347	1.0481	.9091	.0909	.0909	.0909	.2504
3	3.195	1.000	0.0290	.2526	1.0000	.9036	.0964	.0964	.0964	.4688
4	3.432	1.074	0.0000	.2745	.9401	.9019	.0981	.0981	.0981	.7536
5	3.627	1.135	0.0000	.2926	.8910	.9005	.0995	.0995	.0995	1.0000

ABSOLUTE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	464.88	-18.65	1026.95	1127.43	464.88	-18.65	665.14	811.71	361.81
2	440.92	4.19	963.20	1059.33	440.92	4.19	570.09	720.72	393.10
3	420.78	9.63	910.85	1003.36	420.70	9.63	492.56	647.84	418.29
4	395.51	34.35	849.46	937.65	395.51	34.35	400.25	563.75	419.20
5	374.84	44.47	799.73	884.34	374.84	44.47	324.96	498.07	474.77

MACH NUMBER

STREAM LINE	ABSOLUTE	RELATIVE	TEMPERATURE (DEG. R)	PRESSURE (PSI)	TOTAL	STATIC	TOTAL/STG	WHEEL VELOCITY
1	1.00	.72	65.65	530.90	38.586	20.430	1.0667	2.0146
2	.93	.63	65.41	543.29	38.737	23.235	1.0626	1.8511
3	.87	.56	65.21	552.90	38.878	25.546	1.0589	1.7347
4	.81	.48	65.04	563.51	39.161	28.999	1.0510	1.6112
5	.75	.42	64.89	571.59	39.376	31.546	1.0453	1.5245

SET NUMBER PAGE NUMBER RPM TOTAL/STATIC PRESSURE RATIO INLET TOTAL PRESSURE (PSI) INLET TOTAL TEMPERATURE (DEG. R) TOTAL PRESSURE RATIO

636.67

41.160

2.800

1

2

15000.0

ROTOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION	X-R/RM	RADIAL SHIFT	BLADE OPENING	BLADE EFFICIENCY	LOSS COEFFICIENT	CONTINUITY	RELATIVE VELOCITY (FPS)	WIREL VELOCITY
1	2.693	.825	.0710	.1912	.8773	.1327	.1272	0.0000	
2	3.020	.925	.0810	.2210	.8768	.1327	.1237	.2333	
3	3.265	1.000	.0905	.2447	.8768	.1327	.1237	.4333	
4	3.585	1.098	.1037	.2683	.8807	.1194	.1194	.7281	
5	3.837	1.175	.1210	.2983	.8841	.1168	.1168	1.0000	

RELATIVE VELOCITY (FPS)

ABSOLUTE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WIREL VELOCITY
1	430.45	-17.27	807.84	430.45	-17.27	-1035.90	1121.91	352.51
2	429.72	-18.08	730.28	429.72	4.08	-986.08	1075.48	357.31
3	429.72	10.06	703.62	429.72	10.06	-976.54	1071.05	419.33
4	427.02	40.56	690.69	467.79	59.06	-994.47	1113.86	400.00
5	497.79	59.06	782.53	497.79	59.06	-994.47	1113.86	502.26

STREAM LINE	MACH NUMBER	FLOW ANGLE (DEG)	TEMPERATURE (DEG. R)	PRESSURE (PSI)	PRESSURE RATIO
1	1.04	-67.44	488.44	18.800	2.1894
2	1.09	-66.48	490.41	18.800	2.1894
3	1.08	-65.76	493.82	19.002	2.1575
4	1.09	-64.45	493.82	19.002	2.1559
5	1.03	-63.41	491.27	19.006	2.1565

STREAM LINE	EQUIVALENT TEMPERATURE (DEG. R)	EQUIVALENT INLET PRESSURE (PSI)	EQUIV/STATIC PRESSURE RATIO
1	585.17	28.723	2.2
2	586.66	29.092	2.1
3	588.46	29.513	2.0
4	591.50	30.268	2.1
5	594.47	30.974	2.1

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	3	15000.0	2.800	41.140	636.67

OVERALL TURBINE CHARACTERISTICS

STREAM LINE	TOT/STA PRESSURE RATIO	TOT/STA EFFICIENCY	HEAD COEFFICIENT	BLADE/JET SPEED RATIO	THEORETICAL DEGREE OF REACTION
1	3.1847	.7981	16.4484	.3464	.3563
2	2.6550	.8113	17.3549	.3267	.3895
3	2.1156	.8267	8.7736	.3272	.4177
4	2.0551	.8313		.3372	.4819
5					.5619

AVERAGED QUANTITIES

INLET POWER =	182.97 (HP)
FLOW RATE =	64.05 (LB/SEC)
REFERRED RPM =	13535.26 (RPM)
REFERRED HORSE POWER =	58.96 (HP)
REFERRED MOMENT =	22.88 (FT-LB)
REFERRED FLOW RATE =	2.08 (LB/SEC)
TOTAL/STATIC EFFICIENCY =	.6124
TOTAL/TOTAL EFFICIENCY =	.8124
TOTAL/STATIC PRESSURE RATIO =	2.1529
HEAD COEFFICIENT =	11.6793
BLADE/JET SPEED RATIO =	.2926
THEORETICAL DEGREE OF REACTION =	.4468
MACH NUMBER AT STATION 0 =	.2072

SET NUMBER 1
 CASE NUMBER 1
 RPM 20000.0
 TOTAL/STATOR PRESSURE 21600
 INLET TOTAL PRESSURE 41.160
 INLET TOTAL TEMPERATURE 636.67

STATOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION (IN)	X=R/RM	RADIAL SHIFT (IN)	BLADE OPENING (IN)	Y=VA /VAM	EFFICIENCY	LOSS COEFFICIENT	ZETA	CONTINUITY	FLOW RATE FRACTION
1	2.764	.865	0.0000	.2126	1.1018	.9146	.0054	.0854		0.0000
2	3.003	.940	0.0000	.2347	1.0470	.9117	.0053	.0853		.2509
3	3.195	1.000	0.0290	.2526	1.0000	.9074	.0050	.0850		.7598
4	3.432	1.074	0.0000	.2745	.9400	.9071	.0029	.0829		.7598
5	3.627	1.135	0.0000	.2926	.8902	.9052	.0048	.0948		1.0000

ABSOLUTE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	450.26	-18.06	994.65	1091.97	450.26	-18.06	512.24	682.24	482.41
2	427.89	4.06	934.73	1028.02	427.89	4.06	410.59	593.04	524.14
3	408.68	9.35	884.83	974.69	408.68	9.35	327.11	523.55	557.77
4	383.79	33.36	825.04	910.70	384.14	33.36	226.10	446.99	598.94
5	363.79	43.16	776.17	858.29	363.79	43.16	143.14	393.32	633.03

MACH NUMBER

FLOW ANGLE (DEG)

TEMPERATURE (DEG. R)

PRESSURE (PSI)

PRESSURE RATIO

STREAM LINE	ABSOLUTE	RELATIVE	ABSOLUTE	RELATIVE	TOTAL	STATIC	TOTAL	STATIC	TOT/TOT	TOT/STA
1	.96	.68	65.65	48.69	636.67	537.45	38.729	21.405	1.0428	1.9329
2	.94	.52	65.41	43.82	636.67	548.73	38.967	21.161	1.0563	1.771
3	.94	.45	65.21	38.68	636.67	557.62	39.161	24.622	1.0510	1.771
4	.78	.35	65.04	30.48	636.67	567.66	39.394	26.365	1.0448	1.5611
5	.73	.33	64.89	21.48	636.67	575.37	39.575	27.768	1.0400	1.4823

SET PAGE RPM INLET/STATIC PRESSURE RATIO INLET TOTAL TEMPERATURE
NUMBER NUMBER (DEG. R)

1 2 20000.0 2.800 41.160 636.67

MOTOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION	X-R/RM	RADIAL SHIFT	BLADE OPENING	BLADE Y-U/A	/UAM EFFICIENCY	LOSS COEFFICIENT	75104 CONTINUITY	FLOW RATE FRACTION
1	2.693	.825	.0710	.1912	.9833	.8933	.1067	.1067	0.0008
2	3.020	.925	-.0168	.2218	.9561	.8933	.1037	.1037	.2289
3	3.265	1.000	-.0405	.2447	1.0000	.8985	.1015	.1015	.4274
4	3.585	1.098	-.1537	.2747	1.0908	.9038	.0962	.0962	.7235
5	3.837	1.175	-.2100	.2983	1.1853	.9080	.0920	.0920	1.0000

ABSOLUTE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	413.86	-16.60	-525.94	669.45	413.86	-16.60	-995.95	1078.65	470.02
2	402.41	3.82	-377.32	565.52	402.41	3.82	-924.39	1008.19	527.07
3	458.89	9.63	-344.22	557.81	420.89	9.63	-934.57	1025.02	569.85
4	458.89	39.87	-324.23	569.26	459.89	39.87	-959.98	1064.86	625.77
5	478.88	59.19	-326.97	599.41	498.88	59.19	-996.65	1116.11	669.68

RELATIVE VELOCITY (FPS)

STREAM LINE	ABSOLUTE RELATIVE	FLOW ANGLE (DEG)	TEMPERATURE (DEG. R)	PRESSURE (PSI)	TOTAL	STATIC	101/TO1	101/STA
1	.62	1.01	51.80	515.68	17.000	13.072	2.4311	3.1486
2	.73	1.01	44.64	520.28	17.922	14.914	2.2966	2.7599
3	.74	1.01	40.91	519.93	17.922	15.029	2.2916	2.7580
4	.94	1.03	38.24	519.63	18.003	14.240	2.5861	2.7951
5	1.03	1.03	33.24	518.46	17.872	14.517	2.5031	2.8152

STREAM LINE	EQUIVALENT TEMPERATURE (DEG. R)	EQUIVALENT INLET PRESSURE (PSI)	EQUIV/STATIC PRESSURE RATIO
1	275.20	27.146	2.1
2	278.25	27.821	1.9
3	280.25	28.326	1.9
4	287.82	30.919	2.1

SET NO. 1
 PRESSURE RATIO 2.800
 INLET TOTAL TEMPERATURE (DEG. R) 636.67

OVERALL TURBINE CHARACTERISTICS

STREAM LINE	PRESSURE RATIO TOT/STA	EFFICIENCY TOT/STA	HEAD COEFFICIENT TOT/STA	BLADE/IFT SPEED RATIO	THEORETICAL DEGREE OF REACTION
1	3.1486	.8513	9.1843	.3399	.3902
2	2.7559	.8446	7.6119	.3726	.3982
3	2.7168	.8691	6.1525	.4032	.4541
4	2.7551	.8731	5.1619	.4319	.5247
5	2.8352	.8755	4.9165	.4510	.5859

MASS AVERAGED QUANTITIES

HP/SEC = 288.81
 (FT-LB/SEC) = 54.86

HP/SEC = 18047.01
 (FT-LB/SEC) = 19.59

TOTAL/STATIC EFFICIENCY = .7227
 TOTAL/STATIC PRESSURE RATIO = 2.8063

HEAD COEFFICIENT RATIO = 6.3944
 THEORETICAL DEGREE OF REACTION = .4664
 MACH NUMBER AT STATION 0 = .2869

SET PAGE RPM TOTAL/STATIC PRESSURE TOTAL TEMPERATURE TOTAL
 NUMBER 1 25000.0 2.800 41.160 636.67

STATOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION (IN)	X=R/RM	RADIAL SHIFT (IN)	BLADE OPENING (IN)	BLADE EFFICIENCY	LOSS COEFFICIENT	CONTINUITY	FLOW RATE FRACTION
1	2.764	.865	0.0000	.2126	.9128	.0822	.0822	0.0000
2	3.083	.840	0.0000	.2126	.9128	.0861	.0861	.2527
3	3.135	1.000	0.0000	.2527	.9108	.0892	.0892	.4221
4	3.225	1.074	0.0000	.2745	.9085	.0915	.0915	.7562
5	3.627	1.135	0.0000	.2926	.9065	.0935	.0935	1.0000

ABSOLUTE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY
1	434.12	-17.41	950.99	1052.81
2	412.21	3.92	900.48	990.35
3	393.49	9.00	851.94	938.46
4	369.73	32.11	794.09	876.54
5	350.89	41.54	746.93	825.95

RELATIVE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY
1	434.12	-17.41	355.97	561.67
2	412.21	3.92	245.31	479.78
3	393.49	9.00	154.79	423.89
4	369.73	32.11	45.42	351.59
5	350.89	41.54	-44.36	355.52

FLOW ANGLE (DEG)

STREAM LINE	ABSOLUTE RELATIVE	ABSOLUTE	RELATIVE
1	.92	65.65	39.35
2	.86	65.41	30.76
3	.81	65.21	21.47
4	.75	65.04	-7.20
5	.70	64.89	-7.22

TEMPERATURE (DEG. R)

STREAM LINE	TOTAL	STATIC
1	636.67	544.44
2	636.67	523.58
3	636.67	503.58
4	636.67	479.78
5	636.67	444.44

PRESSURE (PSI)

STREAM LINE	TOTAL	STATIC
1	39.017	22.561
2	39.159	24.261
3	39.353	25.551
4	39.562	27.316
5	39.724	28.648

PRESSURE (ATM)

STREAM LINE	101/101	101/516
1	1.0549	1.8344
2	1.0500	1.6971
3	1.0459	1.6645
4	1.0404	1.5069
5	1.0361	1.4357

SET NUMBER 1 2 25000.0 RPM TOTAL/STATIC PRESSURE RATIO INLET TOTAL PRESSURE (PSI) INLET TOTAL TEMPERATURE (DEG. R) 41.160 636.67

ROTOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION	X=R/RM	RADIAL SHIFT	BLADE OPENING	Y=U/V	EFFICIENCY	LOSS COEFFICIENT	CONTINUITY	FLOW RATE FRACTION
1	2.693	.825	.0710	.1912	.2888	.9114	.0886	.0886	0.0000
2	3.020	.925	-.0148	.2216	.9357	.9126	.0875	.0875	.2258
3	3.265	1.000	-.0405	.2447	1.0000	.9134	.0866	.0866	.4237
4	3.585	1.098	-.1537	.2747	1.1196	.9075	.0926	.0926	.7210
5	3.837	1.175	-.2100	.2983	1.2386	.9028	.0972	.0972	1.0000

ABSOLUTE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	411.86	-16.49	-401.70	574.98	411.86	-16.49	-401.70	574.98	587.52
2	388.97	-3.70	-388.97	464.28	388.97	-3.70	-388.97	464.28	648.84
3	415.73	8.53	-400.25	566.48	415.73	8.53	-400.25	566.48	715.21
4	493.87	40.53	-461.50	652.72	493.87	40.53	-461.50	652.72	785.31
5	514.87	61.09	-491.50	692.72	514.87	61.09	-491.50	692.72	837.31

235

STREAM LINE	MACH NUMBER	FLOW ANGLE (DEG)	TEMPERATURE (DEG. R)	PRESSURE (PSI)	PRESSURE RATIO
1	.54	-44.34	501.15	15.742	101/101
2	.52	-41.80	512.87	17.425	101/101
3	.43	-35.87	512.87	17.425	101/101
4	.40	-28.31	512.87	17.425	101/101
5	.51	-25.40	512.87	17.425	101/101

STREAM LINE	EQUIVALENT INLET TEMPERATURE (DEG. R)	EQUIVALENT INLET PRESSURE (PSI)	EQUIVALENT PRESSURE RATIO
1	574.15	25.359	2.0
2	574.15	25.359	2.0
3	574.15	25.359	2.0
4	574.15	25.359	2.0
5	574.15	25.359	2.0

STREAM LINE	SET NUMBER	PAGE NUMBER	RPM	INLET/STATION PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	1	3	25000.0	2.800	41.160	636.67

OVERALL TURBINE CHARACTERISTICS

STREAM LINE	PRESSURE RATIO TOT/STA	EFFICIENCY TOT/TOT	HEAD COEFFICIENT TOT/TOT	BLADE/JET SPEED RATIO	THEORETICAL DEGREE OF REACTION
1	3.1838	.7556	.8970	5.9273	.4107
2	2.6332	.7923	.8931	4.3511	.4794
3	2.6784	.7928	.8932	3.8622	.5088
4	2.7601	.7723	.8958	3.4370	.5394
5	2.9832	.7482	.8770	3.2078	.5583

MASS AVERAGED QUANTITIES

HORSE POWER = 221.79 (HP)
 MOMENT = 46.59 (FT-LB)
 FLOW RATE = 5.21 (LB/SEC)

REFERRED RPM = 22558.76 (HP)
 REFERRED HORSE POWER = 71.48 (HP)
 REFERRED MOMENT = 16.64 (FT-LB)
 REFERRED FLOW RATE = 2.06 (LB/SEC)

TOTAL/STATIC EFFICIENCY = .7885
 TOTAL/STATIC PRESSURE RATIO = 2.7863
 TOTAL/STATIC PRESSURE RATIO = 2.4070

HEAD COEFFICIENT = 4.0544
 BLADE/JET SPEED RATIO = .4966
 THEORETICAL DEGREE OF REACTION = .5009
 MACH NUMBER AT STATION 0 = .2058

SET CASE PAGE
NUMBER 1 1
RPM 30000.0
TOTAL/STATIC
PRESSURE RATIO 2.800
INLET TOTAL
PRESSURE 41.160
INLET TOTAL
TEMPERATURE 636.67

STATOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION (IN)	X=R/RM	RADIAL SHIFT (IN)	BLADE OPENING (IN)	Y=VA /VAM	EFFICIENCY	LOSS COEFFICIENT	CONTINUITY	FLOW RATE FRACTION
1	2.1764	.865	0.0000	.2126	1.1042	.9209	.0791	.0791	0.0000
2	2.883	.940	0.0000	.2347	1.0486	.9127	.0816	.0816	.2529
3	3.413	1.000	0.0000	.2526	1.0000	.9101	.0823	.0823	.4724
4	3.627	1.074	0.0000	.2745	.9393	.9079	.0829	.0829	.7564
5		1.135	0.0000	.2926	.8891		.0921	.0921	1.0000

ABSOLUTE VELOCITY (FPS)

STREAM LINE	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	434.48	-12.43	434.48	-12.43	236.17	494.82	723.62
2	412.35	3.92	412.35	3.92	115.31	421.88	786.21
3	393.47	32.10	393.47	32.10	-104.65	385.67	836.58
4	369.58	41.51	369.58	41.51	-203.14	365.25	898.41
5						406.67	949.55

MACH NUMBER

STREAM LINE	ABSOLUTE	RELATIVE	TEMPERATURE (DEG. R)	PRESSURE (PSI)	PRESSURE RATIO
1	.92	.43	TOTAL	TOTAL	TOTAL/101
2	.86	.37	544.28	39.897	1.0524
3	.81	.34	555.00	39.257	1.0221
4	.75	.33	563.39	39.596	1.0000
5	.70	.34	572.79	39.594	1.0000
			579.98	39.749	1.0355
				28.680	1.4352

SET NUMBER 1 2 30000.0 2.800 41.160 636.67

MOTOR EX11 SOLUTION

STREAM LINE	POSITION	X-R/MM	RADIAL OPENING	BLADE	Y-U/A	U/VAN	EFFICIENCY	COEFFICIENT	CONTINUITY	FLOW RATE
1	2.693	.825	.0710	.1912	.9952	.9230	.0270	.0270	.0770	0.0000
2	3.820	1.000	-.0168	.2216	.9152	.9000	.0926	.0926	.0720	.0000
3	3.365	1.000	-.0485	.2447	1.0000	.8975	.1032	.1032	.0720	.0000
4	3.585	1.000	-.1517	.2747	1.1467	.9052	.0942	.0942	.0720	.0000
5	3.837	1.175	-.2100	.2983	1.2872	.9112	.0888	.0888	.0720	.0000

ABSOLUTE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	DIFF. VELOCITY
1	409.70	-16.43	-280.93	492.03	409.70	-16.43	-280.93	492.03	205.03
2	376.73	3.58	-74.78	384.05	376.73	3.58	-74.78	384.05	205.03
3	411.68	9.42	-59.36	416.95	411.68	9.42	-59.36	416.95	205.03
4	472.07	41.00	-48.47	476.32	472.07	41.00	-48.47	476.32	205.03
5	529.93	62.87	-54.16	536.39	529.93	62.87	-54.16	536.39	205.03

RELATIVE VELOCITY (FPS)

STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	DIFF. VELOCITY
1	409.70	-16.43	-280.93	492.03	409.70	-16.43	-280.93	492.03	205.03
2	376.73	3.58	-74.78	384.05	376.73	3.58	-74.78	384.05	205.03
3	411.68	9.42	-59.36	416.95	411.68	9.42	-59.36	416.95	205.03
4	472.07	41.00	-48.47	476.32	472.07	41.00	-48.47	476.32	205.03
5	529.93	62.87	-54.16	536.39	529.93	62.87	-54.16	536.39	205.03

MACH NUMBER

STREAM LINE	ABSOLUTE	RELATIVE
1	.42	1.01
2	.38	.86
3	.44	.92
4	.50	1.01
5	.50	1.10

FLOW ANGLE (DEG)

STREAM LINE	ABSOLUTE	RELATIVE
1	-34.44	-67.44
2	-11.23	-66.48
3	-8.21	-65.76
4	-5.86	-64.45
5	-5.84	-63.41

TEMPERATURE (DEG. R)

STREAM LINE	TOTAL	STATIC
1	488.13	467.57
2	508.97	496.69
3	509.62	495.22
4	510.42	491.54
5	509.66	485.72

PRESSURE (PSI)

STREAM LINE	TOTAL	STATIC
1	14.532	12.501
2	17.006	15.613
3	16.885	15.272
4	16.943	14.849
5	16.788	14.186

PRESSURE RATIO

STREAM LINE	TOTAL	STATIC
1	2.4377	2.0433
2	2.4377	2.4377
3	2.4377	2.4377
4	2.4377	2.4377
5	2.4377	2.4377

EQUIVALENT INLET PRESSURE (PSI)

STREAM LINE	EQUIVALENT INLET PRESSURE (PSI)
1	25.336
2	26.790
3	28.233
4	29.676
5	32.585

TEMPERATURE (DEG. R)

STREAM LINE	TEMPERATURE (DEG. R)
1	562.45
2	578.82
3	578.86
4	578.86
5	578.86

EQUIVALENT PRESSURE RATIO

STREAM LINE	EQUIVALENT PRESSURE RATIO
1	2.9
2	1.7
3	1.8
4	2.1
5	2.3

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	3	30000.0	2.000	41.160	636.67

OVERALL TURBINE CHARACTERISTICS

STREAM LINE	PRESSURE RATIO TOT/STA	EFFICIENCY TOT/TOT	HEAD COEFFICIENT	BLADE/JET SPEED RATIO	THEORETICAL DEGREE OF REACTION
1	3.2824	.8065	4.2145	.4920	.4539
2	3.2124	.8091	3.6964	.5070	.4803
3	2.6550	.8040	3.3954	.6461	.5637
4	2.7219	.7847	2.2265	.6702	.6262
5	2.9014	.7603			

MASS AVERAGED QUANTITIES

HORSE POWER =	229.28	(HP)
MOMENT =	40.14	(FT-LB)
FLOW RATE =	5.32	(LB/SEC)
REFERRED RPM =	27070.52	
REFERRED HORSE POWER =	73.89	(HP)
REFERRED MOMENT =	14.34	(FT-LB)
REFERRED FLOW RATE =	2.07	(LB/SEC)

TOTAL/STATIC EFFICIENCY =	.8018
TOTAL/TOTAL EFFICIENCY =	.8917
TOTAL/STATIC PRESSURE RATIO =	2.0021
TOTAL/TOTAL PRESSURE RATIO =	2.4024

HEAD COEFFICIENT	2.8370
BLADE/JET SPEED RATIO	.5948
THEORETICAL DEGREE OF REACTION	.5035
MACH NUMBER AT STATION 0	.2062

APPENDIX: G

COMPUTER LISTING

MAIN T=00004 IS ON CR00025 USING 00147 BLKS R=0000

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0001 FTN4;L
0002 BLOCK DATA
0003 COMMON/ARA/RA17,BLEX
0004 COMMON/CUR/COSL(10)
0005 COMMON/TOL/TOL1,TOL2,TOL3,TOL4
0006 COMMON/TRS/TRAS
0007 COMMON/GAS/CP,GAM,FHMF,ERRE,EXP1,EXP2,VIS2,VIS3
0008 COMMON/COZ/ICOR,IC07,IINC,IAI,ICL,IAN,ICON
0009 COMMON/MAC/IN
0010 COMMON/IW/IND,INZ,IWR
0011 COMMON/AUS/XCL
0012 COMMON/CSS/CJ,G,Q1
0013 COMMON/VAR1/RC(10),RSOLD2,RSOLD3,RSOLD4,ASFO,RSFO,RRFO,ARFO,
0014 *RR(10),RR0LD2,RR0LD3,RR0LD4,CV,CK,VA1(10),DALF(10),DBET(10),
0015 *ASF,AMS,B1(20)
0016 COMMON/VAR2/B6(20),ZR,ZS,ARF,R2(20),PR,AMR,UU1(10)
0017 COMMON/VAR3/PTE(10),RS1,RS3,RSE,T2(10)
0018 COMMON/VAR4/BR1,RR2,RR3,RR1,RR3,RR5,VA2(10)
0019 COMMON/VAR5/PRA11(10),RINC1(10),ALFA11(10),BETA11(10),ZETA1(10),
0020 *U2(10),ALFA22(10),BETA22(10)
0021 COMMON/VAR6/PT2(10),TT2(10),PT1(10),DELH(10),ALFA2(10),UU2(10),
0022 *UR2(10),T2S(10),T2TS(10)
0023 COMMON/VAR7/TTIS(5),PRTAT(5),ETAT(5),ETAI(10),ETAS(10),ETAR(10),
0024 *RSTAR(10),AKIS(10),PRTR(10)
0025 COMMON/VAR8/DR1(10),AMW1(10),AMU2(10),PFTET(10),PRAT1T(10),AMR2(
0026 *10),YS(10),X1(10),AREA1(10),ZETAPS(10),WPER1(10),YR(10),X2(10)
0027 COMMON/VAR9/ZETAR(10),ZETAPR(10),AS(10),AR(10),SI1(10),SI2(10),
0028 *S1(10),DSDX1(10),W11(10),HE(10)
0029 COMMON/VAR10/WU1(10),DHEDX(10),DSDX2(10),RI1(10),RI2(10),
0030 *RI3(10),RI4(10),RI(10),SR1(10),SR2(10)
0031 COMMON/VAR11/YOLD(10),AA(10),SR(10),PRAT2(10),WPER2(10),
0032 *RWDX(10),TTIS(10),PRAT3(10),SS(10),ALFA(10)
0033 COMMON/VAR12/BETA(10),DELH(10),WPERO(10),ZETAS(10),ZETAR1(20),
0034 *ZETAR3(20),ZETAR5(20),R1(20),A1(20),T10(20)
0035 COMMON/VAR13/ST1(20),IRR(20),RP(20),A2(20),RINC(20),DR(10),
0036 *BETO(10),STALI(10),AREA2(10),VR1(10)
0037 COMMON/VAR14/WLBM,PRATS,OMEG
0038 COMMON/AL1/ALFA1(10),V1(10),TT0,RPM,RS(10),SI,TNT,H,D,CI,T1(10),
0039 *P1(10),TD,TEI,ALI,RESP,XX,ANG20,AMS1(10),S,TN,C,T2,AL,SD,TNO,
0040 *CO,TEU,U(10),D11,D10,D21,D20,ANG21,ALFAX,T11,PTD,A10,AMC
0041 COMMON/AL2/BETA2(10),BETA1(10),BETA0(10),W2(10),TTF(10),U2(10),
0042 *SR,INIR,HR,DZ,CIR,TTFC,SZ,TNR,CR,SOR,TNOR,COR,ALTR,ALK,ALOR,
0043 *P2(10),W12(10),W1(10),TEIR,TER,TEUR,D1TR,D1OR,BETAZ,BETA1,ANA,
0044 *TTR,TR,TOR,STALI(10)
0045 COMMON/ARE/REE
0046 COMMON/TRA/XP01(5,8),XP02(6,8),ALF1(8),ALF01(5),ALF02(6),
0047 *Y(10),Y1(10),Q(6),RX(30),RY(30),IR(30),Z(6),C1(4,8),C2(4,8)
0048 DATA ALF1/ 10.,15.,20.,25.,30.,40.,50.,60./
0049 DATA ALF01/ 40.,50.,60.,70.,80./
0050 DATA ALF02/ 80.,90.,100.,120.,150.,170./
0051 DATA XP01/ .0570,.0465,.0440,.0428,.0424,
0052 * .0530,.0415,.0350,.0330,.0323,
0053 * .0495,.0380,.0312,.0296,.0285,
0054 * .0475,.0355,.0295,.0267,.0250,
0055 * .0440,.0335,.0273,.0245,.0225,
0056 * .0420,.0312,.0224,.0205,.0183,
0057 * .0420,.0300,.0213,.0185,.0152,
0058 * .0420,.0300,.0206,.0155,.0125,
0059 DATA XP02/ .0424,.0422,.0420,.0402,.0313,.0000,
0060 * .0323,.0320,.0318,.0295,.0200,.0000,
0061 * .0283,.0280,.0275,.0250,.0143,.0000,
0062 * .0250,.0246,.0242,.0208,.0070,.0000,
0063 * .0225,.0216,.0203,.0168,.0000,.0000,
0064 * .0183,.0170,.0154,.0106,.0100,.0000,
0065 * .0150,.0136,.0104,.0050,-.015,.0000,
0066 * .0125,.0099,.0073,.0000,-.020,.0000,
0067 DATA VIS2,VIS3,CP,FHMF,GAM/.000013,.000013,.24,28.97,1.4/
0068 DATA G,CJ,EXP1,EXP2,ERRE/32.174,778.16,3.5,.2857,53.3459/
0069 END
0070 PROGRAM THESS
0071
0072 CC
0073 DIMENSION INAM(3)
0074 COMMON/ARA/RA17,BLEX
0075 COMMON/CUR/COSL(10)
0076 COMMON/TOL/TOL1,TOL2,TOL3,TOL4
0077 COMMON/TRS/TRAS
0078 COMMON/GAS/CP,GAM,FHMF,ERRE,EXP1,EXP2,VIS2,VIS3

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0079      COMMON/CO7/ICOR,IC07,IINC,IAI,ICL,IAN,ICON
0080      COMMON/MAC/IN
0081      COMMON/IWI/IND,INZ,IWR
0082      COMMON/AUS/XCL
0083      COMMON/CSS/CJ,G,Q1
0084      COMMON/VAR1/RC(10),RS01,D2,RS01,D3,RS01,D4,ASFO,KSFO,RRFO,ARFO,
0085      *RR(10),RR01,D2,RR01,D3,RR01,D4,CV,CK,VA1(10),DALF(10),DBET(10),
0086      *ASF,AMS,R1(20)
0087      COMMON/VAR2/B6(20),ZR,ZS,ARF,R2(20),PR,AMR,VU1(10)
0088      COMMON/VAR3/PTE(10),RS1,RS3,RS5,T2(10)
0089      COMMON/VAR4/RR1,RR2,RR3,RR1,RR3,RR5,VA2(10)
0090      COMMON/VAR5/PRA1(10),KINCI(10),ALFA1(10),BETA1(10),ZETA1(10),
0091      *V2(10),ALFA2(10),HETA2(10)
0092      COMMON/VAR6/PT2(10),TT2(10),PT1(10),DELH(10),ALFA2(10),VU2(10),
0093      *WR2(10),TPS(10),TPIS(10)
0094      COMMON/VAR7/TTIS(5),HETAT(5),ETAT(5),ETAI(10),ETAS(10),ETAR(10),
0095      *STAR(10),AKIS(10),PSIR(10)
0096      COMMON/VAR8/UK1(10),AMW1(10),AMU2(10),HETET(10),PRAT1T(10),
0097      *AMR2(10),YS(10),X1(10),AREA1(10),ZETAPS(10),WPER1(10),YR(10),
0098      *X2(10)
0099      COMMON/VAR9/ZETAR(10),ZETAPR(10),AS(10),AR(10),SI1(10),SI2(10),
0100      *S1(10),DSDX1(10),WT1(10),HE(10)
0101      COMMON/VAR10/WU1(10),DHDX(10),DSDX2(10),RI1(10),RI2(10),
0102      *RI3(10),RJ4(10),R1(10),SR1(10),SR2(10)
0103      COMMON/VAR11/YOLD(10),AA(10),SR(10),PRAT2(10),WPER2(10),
0104      *DWDX(10),TTIS(10),PRAT3(10),SS(10),ALFA(10)
0105      COMMON/VAR12/BETA(10),DELR(10),WPERO(10),ZETAS(10),ZETAR1(20),
0106      *ZETAR3(20),ZETAR5(20),R1(20),A1(20),T10(20)
0107      COMMON/VAR13/ST1(20),IRR(20),R2(20),A2(20),RINC(20),DR(10),
0108      *RFTO(10),STALII(10),AREA2(10),VR1(10)
0109      COMMON/VAR14/WLBM,PRATS,OMEG
0110      COMMON/AL1/ALFA1(10),V1(10),TT0,KPM,RS(10),SI,TNT,H,D,CI,T1(10),
0111      *S1(10),TO,TEI,ALI,REFP,XX,ANG20,AMS1(10),S,TN,C,TF,AL,SO,TNO,
0112      *CO,TEO,U(10),D11,D10,D21,D20,ANG21,ALFAX,T1,T,PFO,ALO,AMC
0113      COMMON/AL2/BETA2(10),BETA1(10),BETA0(10),W2(10),TTE(10),U2(10),
0114      *STR,INIR,HP,DZ,CIR,TIPC,SZ,TNR,CR,SOP,TNOR,COR,ALTR,ALR,ALOR,
0115      *P2(10),WU2(10),W1(10),TEIR,TER,TEOR,D1TR,D1OR,BETAZ,BETAT,ANM,
0116      *TIR,TR,TOR,STALI(10)
0117      COMMON/ARF/REE
0118      COMMON/TRA/XP01(5,8),XP02(6,8),ALF1(8),ALF01(5),ALF02(6),
0119      *XY(10),Y1(10),Q(6),RX(30),RY(30),IR(30),Z(6),C1(4,8),C2(4,8)
0120      DATA INAM /2HSH,2HOR,2HT /
0121      TRAS=1
0122      XX=1.25
0123      CALL EXEC(8,INAM)
0124      END
0125
0126      C
0127      SUBROUTINE CHAN(TTO,AMC,PTO,RC,WLBM,WCHAN,WPERO)
0128      DIMENSION RC(10),WPERO(10)
0129      COMMON/GAS/CP,GAM,EMME,ERKE,EXP1,EXP2,VIS2,VIS3
0130      COMMON/CSS/CJ,G,Q1
0131      TC=TTO/(1+(GAM-1)/2)*AMC*AMC
0132      VC=SQRT(GAM*ERRE*G*TC)*AMC
0133      PC=PTO/(1+(GAM-1)*AMC**2/2)**EXP1
0134      RHO=PC/ERRE/TC
0135      AREA=3.1416*(RC(5)**2-RC(1)**2)
0136      WLBM=RHO*AREA*VC
0137      WCHAN=WLBM/(PTO*SQRT(G/ERRE/TTO))
0138      WPERO(1)=0
0139      WPERO(2)=.25
0140      WPERO(3)=.5
0141      WPERO(4)=.75
0142      WPERO(5)=1.0
0143      RETURN
0144      END
0145
0146      C
0147      SUBROUTINE STATK (ALFA1,X,TTO,PTO,AM,T,P,V1,VA1,SI1,SI2,Y,S,DSDX,
0148      *VU1,PRAT,TTIS,SS,DALF,RSF,DELR,CL,CK,ZETAPS,R,RS1,RS3,RS5,
0149      *ZETA,DR,ZETAS,AMS,NS,VR1)
0150      DIMENSION ALFA1(10),X(10),T(10),P(10),V1(10),VA1(10),SI1(10),
0151      *SI2(10),Y(10),DSDX(10),VU1(10),PRAT(10),TTIS(10),SS(10),S(10),
0152      *DALDX(10),ALFA(10),ALFAM(10),DALF(10),AMS(10),DALFDX(10),DELR(
0153      *10),ZETAS(10),ETA(10),ZETAPS(10),R(10),ZETA(10),DR(10),VR1(10)
0154      COMMON/GAS/CP,GAM,EMME,ERKE,EXP1,EXP2,VIS2,VIS3
0155      COMMON/CSS/CJ,G,Q1
0156      COMMON/IWI/IND,INZ,IWR
0157      CB=0.0
0158      C9=0.0
0159      Q1=2.*CJ*G*CP
0160      C2=VA1(3)**2/(Q1*TTO)

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0159 DO 303 I=1,5
0160 IF(R(I)-RS1) 300,301,302
0161 300 ZF1AS(1)=ZETA(1)+((R(I)-RS1)/(RS3-RS1))*(ZETA(3)-ZETA(1))
0162 ALFA1(1)=ALFA1(3)+((R(I)-RS3)/(RS1-RS3))*DALF(1)
0163 ZETAPS(I)=ZETAPS(1)+((R(I)-RS1)/(RS3-RS1))*(ZETAPS(3)-ZETAPS(1))
0164 GO TO 303
0165 301 ZF1AS(1)=ZETA(3)
0166 ALFA1(1)=ALFA1(3)
0167 GO TO 303
0168 302 ZF1AS(1)=ZETA(3)+((R(I)-RS3)/(RS5-RS3))*(ZETA(5)-ZETA(3))
0169 ALFA1(1)=ALFA1(3)+((R(I)-RS3)/(RS5-RS3))*DALF(5)
0170 ZETAPS(I)=ZETAPS(3)+((R(I)-RS3)/(RS5-RS3))*(ZETAPS(5)-ZETAPS(3))
0171 303 CONTINUE
0172 DO 305 I=1,5
0173 ETA(I)=1.-ZETAS(I)
0174 M=I-1
0175 N=I+1
0176 IF(I-1) 307,307,309
0177 307 DALFDX(1)=(ALFA1(2)-ALFA1(1))/(X(2)-X(1))
0178 GO TO 315
0179 309 IF(I-5) 311,313,313
0180 311 DALFDX(I)=5*((ALFA1(N)-ALFA1(I))/(X(N)-X(I))+(ALFA1(I)-ALFA1(M))/
0181 *(X(I)-X(M)))
0182 GO TO 315
0183 313 DALFDX(5)=(ALFA1(5)-ALFA1(4))/(X(5)-X(4))
0184 315 TAN1=-2.*TAN(ALFA1(I))
0185 PROD=TAN1*DALFDX(I)
0186 SINSQ=-2.*SIN(ALFA1(I))*2/X(I)
0187 SI1(I)=PROD+SINSQ
0188 305 CONTINUE
0189 304 DO 332 J=1,5
0190 IF(J-1) 306,306,310
0191 306 IF(NS-1) 317,310,310
0192 317 DO 308 I=1,5
0193 SS(I)=0.
0194 308 SI2(I)=SI1(I)
0195 GO TO 318
0196 310 DO 312 I=1,5
0197 AA=C2*Y(I)**2/COS(ALFA1(I))**2
0198 AB=(1.-AA)/(1.-AA/ETA(I))
0199 S(I)=ALOG(AB)
0200 314 DSDX(1)=(S(2)-S(1))/(X(2)-X(1))
0201 DSDX(2)=0.5*(DSDX(1)+(S(3)-S(2))/(X(3)-X(2)))
0202 DSDX(3)=0.5*((S(4)-S(3))/(X(4)-X(3))+(S(3)-S(2))/(X(3)-X(2)))
0203 DSDX(4)=0.5*((S(5)-S(4))/(X(5)-X(4))+(S(4)-S(3))/(X(4)-X(3)))
0204 DSDX(5)=(S(5)-S(4))/(X(5)-X(4))
0205 DO 316 I=1,5
0206 IF(NS-1) 319,321,321
0207 319 SS(I)=(1.-COS(ALFA1(I))**2/(C2*Y(I)**2))*DSDX(I)
0208 GO TO 316
0209 321 SS(I)=((-COS(ALFA1(I))**2/(C2*Y(I)**2))+SIN(ALFA1(I))**2+COS(AL
0210 *FA1(I))**2*(CL**2+(DR(I)/2.0)**2)/CL**2)*DSDX(I)+COS(ALFA1(I))**2*
0211 *CK**2.*RSF*DELTA(I)/CL**2
0212 316 SI2(I)=SS(I)+SI1(I)
0213 SUM1=(SI2(1)+SI2(2))*(X(2)-X(1))/4.
0214 SUM2=(SI2(2)+SI2(3))*(X(3)-X(2))/4.
0215 SUM3=(SI2(3)+SI2(4))*(X(4)-X(3))/4.
0216 SUM4=(SI2(4)+SI2(5))*(X(5)-X(4))/4.
0217 EN2=-SUM2
0218 EN1=-SUM2-SUM1
0219 EN3=SUM3
0220 EN4=SUM3+SUM4
0221 Y(2)=EXP(EN2)
0222 Y(1)=EXP(EN1)
0223 Y(4)=EXP(EN3)
0224 Y(3)=1.0
0225 Y(5)=EXP(EN4)
0226 IF(IND-1) 332,323,323
0227 323 IF(J-1) 324,324,320
0228 320 IF(J-3) 322,324,322
0229 322 IF(J-5) 322,324,322
0230 324 WRITE(6,326)
0231 326 FORMAT(/57H SLINE C8 C9 ITERATION I'ALFA I'DSDX I'TOTAL
0232 * Y)
0233 DO 330 I=1,5
0234 328 FORMAT(14,F4.2,F4.2,I9,F12.4,F9.5,F9.4,2F8.4)
0235 330 WRITE(6,328) 1,C8,C9,J,SI1(I),SS(I),SI2(I),Y(1),ALFA1(I)
0236 332 CONTINUE
0237 DO 334 I=1,5
0238 VAL(I)=VAL(I)*Y(I)

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0239      VU1(I)=VA1(I)*TAN(ALFA1(I))
0240      V1(I)=VA1(I)/COS(ALFA1(I))
0241      VR1(I)=-VA1(I)*DR(I)/2./CL
0242      V1(I)=SQRT(VU1(I)*V1(I)+VR1(I)*VR1(I))
0243      T(I)=T10-V1(I)**2/O1
0244      T1S(I)=T10-(T10-T(I))/ETA(I)
0245      P(I)=PT0*(T1S(I)/T10)**EXP1
0246      334 PRA1(I)=P(I)/PT0
0247      336 DO 352 I=1,5
0248      AMS(I)=V1(I)/SQRT(GAM*ERRE*G*T(I))
0249      352 CONTINUE
0250      356 RETURN
0251      END
0252
0253 C
0254      SUBROUTINE ROTO1 (VU1,VA1,RPM,U,BETA1,HE,TTE,PTF,X2,P1,T1,W1,WU1,
0255      *X1,RS,ZETAR,ZETAPR,RR,DHEDX,DSDX,S,U2,OMEG,RR1,RR2,RR3,FS1,FS2,
0256      *ZETA,B4,RS1,RS3,RS5,BF10,STALI,RINC,VR1)
0257      DIMENSION VU1(5),VA1(5),U(5),BETA1(5),HE(5),TTE(5),PTF(5),
0258      *X2(5),P(5),T1(5),W1(5),WU1(5),X1(5),RS(5),ZETAR(5),
0259      *ZETAPR(5),RR(5),DHEDX(5),DSDX(5),S(5),U2(5),ZETA(5),
0260      *VR1(5),R4(10),BETO(5),STALI(5),RINC(5)
0261      COMMON/CSS/CJ,G,Q1
0262      COMMON/GAS/CP,GAM,EMME,ERRE,EXP1,EXP2,VIS2,VIS3
0263      COMMON/IWI/IND,INZ,IWR
0264      C=2.*32.174*778.16*CP
0265      OMEG=RPM*3.1416/30.
0266      DO 520 I=1,5
0267      U(I)=OMEG*RS(I)/12.
0268      U2(I)=U(I)*RR(I)/RS(I)
0269      WU1(I)=VU1(I)-U(I)
0270      BETA1(I)=ATAN(WU1(I)/VA1(I))
0271      W1(I)=VA1(I)/COS(BETA1(I))
0272      W1(I)=SQRT(VR1(I)*VR1(I)+W1(I)*W1(I))
0273      TTF(I)=T1(I)+W1(I)**2/O+(U2(I)**2-U(I)**2)/C
0274      PTF(I)=P1(I)*(TTF(I)/T1(I))**EXP1
0275      HE(I)=TTE(I)*.24
0276      IF(RS(1)-RS3) 512 514 516
0277      512 ZETAR(I)=ZETA(I)+(RS(1)-RS1)/(RS3-RS1)*(ZETA(3)-ZETA(1))
0278      GO TO 518
0279      514 ZETAR(I)=ZETA(3)
0280      GO TO 518
0281      516 ZETAR(I)=ZETA(3)+(RS(I)-RS3)/(RS5-RS3)*(ZETA(5)-ZETA(3))
0282      518 ZETAPR(I)=ZETAR(I)/2.0
0283      520 CONTINUE
0284      DSDX(1)=(S(2)-S(1))/(X2(2)-X2(1))
0285      DSDX(2)=.5*(DSDX(1)+(S(3)-S(2))/(X2(3)-X2(2)))
0286      DSDX(3)=.5*(DSDX(2)+(S(4)-S(3))/(X2(4)-X2(3)))
0287      DSDX(4)=.5*(DSDX(3)+(S(5)-S(4))/(X2(5)-X2(4)))
0288      DHEDX(1)=(HE(2)-HE(1))/(X2(2)-X2(1))
0289      DHEDX(2)=.5*(DHEDX(1)+(HE(3)-HE(2))/(X2(3)-X2(2)))
0290      DHEDX(3)=.5*(DHEDX(2)+(HE(4)-HE(3))/(X2(4)-X2(3)))
0291      * (X2(5)-X2(4)))
0292      DHEDX(4)=.5*(DHEDX(3)+(HE(5)-HE(4))/(X2(5)-X2(4)))
0293      DHEDX(5)=.5*(DHEDX(4)+(HE(5)-HE(4))/(X2(5)-X2(4)))
0294      522 CONTINUE
0295      RETURN
0296      END
0297
0298 C
0299      SUBROUTINE ROTO2 (BETA2,HE,DHEDX,DSDX1,DSDX2,VA2,WU2,W2,VU2,U2,
0300      *T29,INDS,DBET,KPF,DELR,CL,CK,DR,K,RR1,RR3,RR5,NG,WR2)
0301      DIMENSION BETA2(5),HE(5),DHEDX(5),DSDX1(5),DSDX2(5),VA2(5),
0302      *WU2(5),W2(5),VU2(5),U2(5),X2(5),U(5),YR(5),ZETAR(5),
0303      *RR1(5),RR2(5),RR3(5),RR4(5),RR5(5),RR6(5),YOLD(5),
0304      *AA(5),SR(5),TTE(5),PTF(5),T2(5),P2(5),PRAT2(5),T2S(5),
0305      *DHET(5),RFTAM(5),AMR(5),DBETDX(5),BETA(5),DELR(5),RIS(5),
0306      *DR(5),R(5),WR2(5)
0307      COMMON/TOL/TOL1,TOL2,TOL3,TOL4
0308      COMMON/CSS/CJ,G,Q1
0309      COMMON/GAS/CP,GAM,EMME,ERRE,EXP1,EXP2,VIS2,VIS3
0310      COMMON/IWI/IND,INZ,IWR
0311      INDS=0
0312      INDS1=0
0313      C=2.*G*G*G
0314      Q1=C/VA2(3)**2
0315      DO 274 I=1,5
0316      IF(K(I)-RR3) 270 271 273
0317      270 BETA2(I)=BETA2(3)+(R(I)-RR3)/(RR1-RR3)*DBET(1)
0318      GO TO 274

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0319 27+ BETA2(1)=BETA2(3)
0320 GO TO 274
0321 BETA2(1)=BETA2(3)+(R(I)-RR3)/(RR5-RR3)*DRET(5)
0322 274 CONTINUE
0323 DRETDX(1)=(BETA2(2)-BETA2(1))/(X2(2)-X2(1))
0324 DRETDX(5)=(BETA2(5)-BETA2(4))/(X2(5)-X2(4))
0325 DO 280 I=2,4
0326 M=I-1
0327 N=I+1
0328 280 DRETDX(I)=.5*((BETA2(N)-BETA2(I))/(X2(N)-X2(I))+(BETA2(I)-BETA2
0329 *(M))/(X2(I)-X2(M)))
0330 DO 10 I=1,5
0331 200 TAN1=-2.*TAN(BETA2(I))
0332 PROD=TAN1*DRETDX(I)
0333 SIN1=-2.*SIN(BETA2(I))*2/X2(I)
0334 RI1(I)=PROD+SIN1+DSDX1(I)
0335 SR1(I)=-4.*U(3)*COS(BETA2(I))*STN(BETA2(I))/(UA2(3)*YR(I))
0336 SR2(I)=2.*U(3)*U(1)*COS(BETA2(I))*2/(UA2(3)*2*YR(I)*2)
0337 YOLD(I)=YR(I)
0338 AA(I)=(UA2(3)*YR(I)/COS(BETA2(I))*2/(C*HE(I))
0339 RI3(I)=(C*COS(BETA2(I))*2/(UA2(3)*YR(I))*2)*DHEDX(I)
0340 IF (INDS1-1) 10,250,250
0341 10 CONTINUE
0342 281 IF (IND-1) 201,282,282
0343 282 WRITE(6,121)(RI1(I),I=1,5)
0344 121 FORMAT(/23H CONSTANT INTEGRAND 1-5, 5F8.5)
0345 WRITE(6,122)
0346 122 FORMAT(/60H SLINE INDS1 GRAD S INT2 INT3 INT4 INT
0347 *Y VAL)
0348 201 DO 20 J=1,13
0349 DO 30 I=1,5
0350 AA(I)=AA(I)*(YR(I)/YOLD(I))*2
0351 ANUM=1.-AA(I)
0352 ADEN=1.-AA(I)/(1.-ZETAR(I))
0353 AB=ANUM/ADEN
0354 IF (AB) 130,130,30
0355 130 INDS=1
0356 GO TO 150
0357 30 SR(I)=ALOG(ANUM/ADEN)
0358 DSDX2(1)=(SR(2)-SR(1))/(X2(2)-X2(1))
0359 DSDX2(2)=0.5*(DSDX2(1)+(SR(3)-SR(2))/(X2(3)-X2(2)))
0360 DSDX2(3)=0.5*(DSDX2(2)+(SR(4)-SR(3))/(X2(4)-X2(3)))
0361 DSDX2(4)=0.5*(DSDX2(3)+(SR(5)-SR(4))/(X2(5)-X2(4)))
0362 DSDX2(5)=0.5*(DSDX2(4)+(SR(4)-SR(3))/(X2(4)-X2(3)))
0363 DO 40 I=1,5
0364 SR1(I)=SR1(I)*YOLD(I)/YR(I)
0365 SR2(I)=SR2(I)*(YOLD(I)/YR(I))*2
0366 RI2(I)=SR1(I)-SR2(I)
0367 RI3(I)=RI3(I)*(YOLD(I)/YR(I))*2
0368 IF (NS-1) 31,32,32
0369 31 RI4(I)=DSDX2(I)-(DSDX1(I)+DSDX2(I))*C1*HE(I)
0370 * *(COS(BETA2(I))/YR(I))*2
0371 GO TO 40
0372 32 RI4(I)=-(DSDX1(I)+DSDX2(I))*C1*HE(I)*(COS(BETA2(I))/YR(I))*2
0373 RI5(I)=(DSDX1(I)+DSDX2(I))*SIN(BETA2(I))*2+COS(BETA2(I))*2
0374 * *(CL**2+(DR(I)/2.0)**2)/CL**2-COS(BETA2(I))*2*(2.*CK*RRF*
0375 * DELR(I))/CL**2
0376 RI4(I)=RI4(I)+RI5(I)
0377 40 RI(I)=RI1(I)+RI2(I)+RI3(I)+RI4(I)
0378 SUM1=(RI(1)+RI(2))*(X2(2)-X2(1))/4.
0379 SUM2=(RI(2)+RI(3))*(X2(3)-X2(2))/4.
0380 SUM3=(RI(3)+RI(4))*(X2(4)-X2(3))/4.
0381 SUM4=(RI(4)+RI(5))*(X2(5)-X2(4))/4.
0382 FN1=-(SUM2-SUM1)
0383 FN2=-SUM2
0384 FN4=SUM3
0385 FN5=SUM3+SUM4
0386 DO 50 I=1,5
0387 YOLD(I)=YR(I)
0388 YR(1)=EXP(FN1)
0389 YR(2)=EXP(FN2)
0390 YR(3)=1.0
0391 YR(4)=EXP(FN4)
0392 YR(5)=EXP(FN5)
0393 NCOUNT=0
0394 DO 1001 I=1,5
0395 IF (YR(I).GT.2.0) YR(I)=2.0
0396 IF (YR(I).LT.0.2) YR(I)=0.2
0397 1001 CONTINUE

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0399      DO 110 I=1,5
0400      TEST=ABS(YO1 D(I)-YR(I))
0401      IF (TEST-TOL4) 110,110,119
0402      NCOUNT=NCOUNT+1
0403      IF (NCOUNT-5) 119,140,119
0404      IF (IND-1) 20,120,120
0405      IF (J-3) 80,100,80
0406      IF (J-6) 90,100,90
0407      IF (J-9) 150,100,160
0408      IF (J-12) 20,100,20
0409      DO 60 I=1,5
0410      IF (FORMAT (I4,I7,F10.5,5F8.4)
0411      60 WRITE (6,123) I,INDS1,DSDX2(I),RI2(I),RI3(I),RI4(I),RI(I),YR(I)
0412      20 CONTINUE
0413      DO 70 I=1,5
0414      UA2(I)=YR(I)*UA2(3)
0415      W2(I)=UA2(I)/COS(BETA2(I))
0416      WR2(I)=UA2(I)*KDR(I)/2./CL
0417      W2(I)=SQRT(W2(I)*W2(I)+WR2(I)*WR2(I))
0418      T2(I)=TTE(I)-W2(I)**2/(0.24*WC)
0419      IF (INDS1-1) 251,149,149
0420      251 INDS1=INDS1+1
0421      DO 250 I=1,5
0422      AMR(I)=W2(I)/SQRT(GAM*ERRE*G*T2(I))
0423      250 CONTINUE
0424      DO 190 I=1,5
0425      WU2(I)=UA2(I)*TAN(BETA2(I))
0426      VU2(I)=WU2(I)+U(I)
0427      T2S(I)=TTE(I)-(TTE(I)-T2(I))/(1.-ZETAP(I))
0428      P2(I)=PTF(I)*(T2S(I)/TTE(I))*((GAM/(GAM-1.))
0429      PRAT2(I)=P2(I)/PTE(I)
0430      190 CONTINUE
0431      150 RETURN
0432      END
0433
0434      C
0435      SUBROUTINE FLOWR (PRAT,ZETAP,X,WI,PTF,PTO,TTE,TTO,AS,ZS,RS,AR,ZR,
0436      *RR,M,WCHAN,UA,WPER,CODE,WLRM,R,R,TIPC,A)
0437      DIMENSION PRAT(10),ZETAP(10),X(10),WI(10),PTF(10),TTE(10),
0438      *UA(10),WPER(10),B(20),A(10),R(10)
0439      COMMON/CUR/COSL(10)
0440      COMMON/TOL/TOL1,TOL2,TOL3,TOL4
0441      COMMON/MAC/IN
0442      COMMON/GAS/CP,GAM,EMME,ERRE,EXP1,EXP2,VIS2,VIS3
0443      COMMON/CSS/CJ,G,Q1
0444      COMMON/ARA/RA17,BLEX
0445      COMMON/IWI/IND,INZ,IWR
0446      IN=20
0447      C=BLEX
0448      A(3)=B(1)+B(2)*R(3)+B(3)*R(3)**2+B(4)*R(3)**3+B(5)*R(3)**4
0449      F1=1./(C+1.)
0450      F2=1./(3.*C+1.)
0451      F3=1./(5.*C+1.)
0452      F4=1./(7.*C+1.)
0453      F5=1./(9.*C+1.)
0454      F6=1./(11.*C+1.)
0455      PRATCR=(2./(GAM+1.))*((GAM/(GAM-1.))
0456      PHICR=(2./(GAM+1.))*((1./(GAM-1.))*SQRT(2.*GAM/(GAM+1.))
0457      DO 420 I=1,5
0458      IF (PRATCR-PRAT(I)) 400,402,402
0459      400 XE=1.-PRAT(I)*((GAM-1.)/GAM)
0460      GO TO 404
0461      402 XE=1.-PRATCR*((GAM-1.)/GAM)
0462      404 XE2=XE**2
0463      XE3=XE**3
0464      XE4=XE**4
0465      XFINV=1./(XE-1.)
0466      HNUM=XFINV+F2*XE*F3+XE2*F4+XE3*F5+XE4*F6
0467      HDEN=XEINV+F1+XE*F2+XE2*F3+XE3*F4+XE4*F5
0468      HSTAR=HNUM/HDEN
0469      XT=(HSTAR-1.)/(HSTAR-1.+ZETAP(I))
0470      IF (PRATCR-PRAT(I)) 406,408,408
0471      406 PHI=SQRT(2.*GAM/(GAM-1.))*((PRAT(I))*((2./GAM)-PRAT(I))*
0472      *((GAM+1.)/GAM))
0473      GO TO 410
0474      408 PHI=PHICR
0475      410 A(1)=B(1)+B(2)*R(I)+B(3)*R(I)**2+B(4)*R(I)**3+B(5)*R(I)**4
0476      ARAT=A(1)/A(3)
0477      IF (M-2) 415,412,415
0478      IF (I-5) 415,414,414
0479      414 ARA=ARAT+2.*3.1416*W(5)*TIPC/(7R*AR*FR*(X(5)-X(4)))

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0470 415 IF(IND-1) 420,416,416
0480 416 WRITE(6,416) XI,PHI,ARAT
0481 419 FORMAT(75H XH= F6.4, 6H PHI= F7.5, 7H ARAT= F6.4)
0482 420 WI(1)=(PTE(1)/PI0)/SQRT(TTF(1)/TTO)*ARAT*XI*PHI*CSL(I)
0483 SUM1=(WI(1)+WI(2))*(X(2)-X(1))/2.
0484 SUM2=(WI(2)+WI(3))*(X(3)-X(2))/2.
0485 SUM3=(WI(3)+WI(4))*(X(4)-X(3))/2.
0486 SUM4=(WI(4)+WI(5))*(X(5)-X(4))/2.
0487 WSUM=SUM1+SUM2+SUM3+SUM4
0488 IF(M-1) 428,426,428
0489 426 WREQ=WCHAN/(AS*ZS*RS)
0490 DIFF=ABS(WREQ-WSUM)
0491 GO TO 430
0492 428 WREQ=WCHAN/(AR*ZR*RR)
0493 DIFF=ABS(WREQ-WSUM)
0494 430 TAL=TOL1*WREQ
0495 IF (DIFF-TAL) 432,432,434
0496 432 VA(3)=VA(3)
0497 CODE=20.
0498 GO TO 442
0499 434 IF(WSUM-WREQ) 436,432,438
0500 436 CONTINUE
0501 IF(PRAT(1).LT.PRATOR.AND.PRAT(5).LT.PRATOR) GO TO 470
0502 VA(3)=VA(3)*(1.00+DIFF/WREQ*1.01)
0503 GO TO 442
0504 438 VA(3)=VA(3)*(1.00-DIFF/WREQ*1.01)
0505 442 WPER(1)=0.
0506 WPER(2)=SUM1/WSUM
0507 WPER(3)=(SUM1+SUM2)/WSUM
0508 WPER(4)=(SUM1+SUM2+SUM3)/WSUM
0509 WPER(5)=1.0
0510 IF(IND-1) 450,423,423
0511 423 WRITE(6,422) (WI(I),I=1,5)
0512 422 FORMAT(720H FLOW INTEGRAND 1-5, F10.5)
0513 WRITE(6,424) SUM1,SUM2,SUM3,SUM4,WSUM
0514 424 FORMAT(715H SUMS 1-4, WSUM, SF10.5)
0515 WRITE(6,440) WSUM,WREQ,VA(3)
0516 440 FORMAT(35H REF FLOWS,COMPUTED-REQUIRED,AX VAL,2F10.4,F10.2)
0517 WRITE(6,444) WCHAN,WLBM
0518 444 FORMAT(730H REF FLOW RATE CHANNEL-SQUARE INCHES,FB.5,18H FLOW RATE
0519 *-LRM/SEC,FR.5)
0520 WRITE(6,446) M
0521 446 FORMAT(730H STREAMLINE FLOW FRACTIONS, M=12)
0522 WRITE(6,448) X(2),WPER(2),X(3),WPER(3),X(4),WPER(4)
0523 448 FORMAT(6F10.4)
0524 GO TO 450
0525 470 IN=1
0526 450 RETURN
0527 END
0528 C
0529 SUBROUTINE SLINE (RR,X,DWDX,WPER2,WPER1,HE,U,DHEDX,S,DSDX1,
0530 *ARF,RRF,FC1,FC2,CODE,M,B)
0531 DIMENSION RR(10),X(10),DWDX(10),WI(10),WPER2(10),WPER1(10),HE(10),
0532 *DHEDX(10),S(10),DSDX1(10),U(10),B(20)
0533 COMMON/TOL/TOL1,TOL2,TOL3,TOL4
0534 COMMON/IW1/IND,INZ,IWR
0535 N7=0
0536 SAVE=RR(3)
0537 CODE=1.
0538 DO 700 I=1,4
0539 J=I+1
0540 700 DWDX(I)=(WPER2(J)-WPER2(I))/(X(J)-X(I))
0541 N=0
0542 DO 720 I=2,4
0543 K=I+1
0544 J=I-1
0545 IF (ABS(WPER2(I)-WPER1(I))-TOL2) 716,716,702
0546 702 IF (WPER2(I)-WPER1(I)) 704,716,708
0547 704 XN=X(I)+(WPER1(I)-WPER2(I))/DWDX(J)
0548 IF(M-1) 706,712,706
0549 706 SI=(HE(K)-HE(I))/(X(K)-X(I))
0550 DEL=2.*(SI-DHEDX(I))/(X(K)-X(I))
0551 DHEDX(I)=DHEDX(I)+DEL*(XN-X(I))
0552 HE(I)=HE(I)+DHEDX(I)*(XN-X(I))
0553 SI=(S(K)-S(I))/(X(K)-X(I))
0554 DEL=2.*(SI-DSDX1(I))/(X(K)-X(I))
0555 DSDX1(I)=DSDX1(I)+DEL*(XN-X(I))
0556 S(I)=S(I)+DSDX1(I)*(XN-X(I))
0557 GO TO 712
0558 708 XN=X(I)-(WPER2(I)-WPER1(I))/DWDX(I)

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0559 IF (M-1) 710,712,710
0560 710 SI=(HF(I)-HF(J))/(X(I)-X(J))
0561 DEL=2.*(DHFDX(I)-SI)/(X(I)-X(J))
0562 DHFDX(I)=DHFDX(I)+DEL*(XN-X(I))
0563 HF(I)=HF(I)+DHFDX(I)*(XN-X(I))
0564 SI=(S(I)-S(J))/(X(I)-X(J))
0565 DEL=2.*(DSDX1(I)-SI)/(X(I)-X(J))
0566 DSDX1(I)=DSDX1(I)+DEL*(SN-X(I))
0567 S(I)=S(I)+DSDX1(I)*(XN-X(I))
0568 712 RR(I)=XN*SAVE
0569 GO TO 718
0570 716 N=N+1
0571 IF (N-3) 720,730,720
0572 718 U(I)=U(I)*XN/X(I)
0573 720 CONTINUE
0574 DO 722 I=1,5
0575 722 X(I)=RR(I)/RR(3)
0576 FC1=RR(3)/SAVE
0577 FC2=FC1**2
0578 RRF=RR(3)
0579 ARF=R(1)+R(2)*RRF+B(3)*RRF**2+B(4)*RRF**3+B(5)*RRF**4
0580 IF (IND-1) 732,721,721
0581 721 IF (M-1) 729,732,729
0582 729 WRITE (6,724)
0583 724 FORMAT (/47H SLINE XNEW HENEW DHEDX S-NEW DSDX1)
0584 DO 728 I=1,5
0585 726 FORMAT (I4,F9.4,F9.2,F9.4,F9.6,F9.5)
0586 728 WRITE (6,726) I,X(I),HE(I),DHEDX(I),S(I),DSDX1(I)
0587 GO TO 732
0588 730 CODE=40.
0589 732 RETURN
0590 END
0591 C
0592 SUPROUTINE ALOS1(ZETAS,ZETAPS)
0593 DIMENSION ZETAS(10),ZETAPS(10)
0594 COMMON/AL1/ALFA1(10),U1(10),TTO,RPM,RS(10),SI,TNI,H,D,CI,T1(10),
0595 *P1(10),TO,TEI,ALI,RESP,XX,ANG20,AMS(10),S,TN,C,TE,AL,SO,TNO,
0596 *CO,TEO,U(10),D11,D10,D21,D20,ANG21,ALFAX,T1,TPTO,ALO,AMC
0597 COMMON/AL2/BETA2(10),BETA1(10),BETA0(10),W2(10),TTE(10),U2(10),
0598 *STR,INIR,HR,DZ,CIR,TIPC,SZ,TNR,CR,SOR,TNOR,COR,ALIR,ALR,ALOR
0599 *P2(10),WIP(10),W1(10),TEIR,TER,TEOR,D1IR,D1OR,BETAZ,BETAI,ANM,
0600 *TIR,IR,TOR,STALI(10)
0601 COMMON/GAS/CP,GAM,EMME,ERKE,EXP1,EXP2,VIS2,VIS3
0602 COMMON/CSS/CJ,C,Q1
0603 COMMON/IWI/IND,INZ,IWR
0604 COMMON/AUS/XCL
0605 COMMON/ARE/REE
0606 COMMON/COZ/ICOR,ICOZ,IINC,IAI,ICL,IAN,ICON
0607 COMMON/ARA/BA17,BLEX
0608 COMMON/TR5/TRAS
0609 DO 6001 MACC=1,5,2
0610 TRA1=90.-ALFA1(MACC)*57.29578
0611 TRA2=U1(MACC)*.3048
0612 TRA3=TTO/1.8
0613 TRA4=RPM*.314159/30.*RS(MACC)/12.*.3048
0614 IF(MACC-3) 6002,6003,6004
0615 6002 CALL TRAU2 (TRA1,90.,TRA2,TRA3,EMME,GAM,SI,TNI,H,D,TRAS,CI,TRA4,
0616 *0.,TR16,TRA7,TRA8,TRA9,ZETAS(MACC))
0617 GO TO 6001
0618 6003 CALL TRAU2 (TRA1,90.,TRA2,TRA3,EMME,GAM,S,TN,H,D,TRAS,C,TRA4,
0619 *0.,TR26,TRA7,TRA8,TRA9,ZETAS(MACC))
0620 GO TO 6001
0621 6004 CALL TRAU2 (TRA1,90.,TRA2,TRA3,EMME,GAM,SO,TNO,H,D,TRAS,CO,TRA4,
0622 *0.,TR36,TRA7,TRA8,TRA9,ZETAS(MACC))
0623 6001 CONTINUE
0624 IF(ICOZ.I.T.5) GO TO 2026
0625 DO 2027 MACC=1,5,2
0626 XY=ZETAS(MACC)/(1.-ZETAS(MACC))
0627 ZETAS(MACC)=(((1.+XY)/(1.+XY*P1(MACC)/PTO))**EXP2-1.)/
0628 *(PTO/P1(MACC))**EXP2-1.)
0629 IF(ICOZ.FQ.6) ZETAS(MACC)=(((1.+XY)/(1.+XY*PESP))**EXP2-1.)/
0630 *(1./RESP**EXP2-1.)
0631 2027 CONTINUE
0632 2026 CONTINUE
0633 IF(ICON.NF.3) GO TO 31
0634 30 DO 32 I=1,5,2
0635 32 ZETAPS(I)=ZETAS(I)
0636 31 IF(ICON.NF.2) GO TO 33
0637 IF(ICOR.FQ.4) ZETAPS(1)=TR16
0638 IF(ICOR.FQ.4) ZETAPS(3)=TR2A

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0639      IF(ICOR.EQ.4) ZETAPS(5)=TR36
0640      33 CONTINUE
0641      IF(ICON.NE.1) GO TO 34
0642      DO 35 I=1,5,2
0643      35 ZETAPS(I)=.5*ZETAS(I)
0644      34 CONTINUE
0645      DO 66 K=1,5
0646      66 CONTINUE
0647      RETURN
0648      END
0649
0650      C
0651      SUBROUTINE ALOS2(ZETAR,ZETAPR)
0652      DIMENSION ZETAPS(10),ZETAS(10),ZETAPR(10),ZETAR(10)
0653      COMMON/AL1/ALFA1(10),V1(10),TTO,KPM,RS(10),SI,TNI,H,D,CI,T1(10),
0654      *P1(10),TO,TEI,HLI,RESP,XX,ANGP0,AMS1(10),S,TN,C,TF,AL,SO,TNO,
0655      *CO,TEO,U(10),D11,D10,D21,D20,ANG21,ALFAX,TI,T,PTO,ALU,AMC
0656      COMMON/AL2/BETA2(10),BETA1(10),BETA0(10),W2(10),TTF(10),U2(10),
0657      *SIR,TNR,HR,DZ,CIR,TIPC,SZ,TNR,CR,SOR,TNOR,COR,ALR,ALK,ALOR,
0658      *TIR,TK,TOR,STALI(10)
0659      COMMON/VAR1/RC(10),RSOLD2,RSOLD3,RSOLD4,ASFU,RSFO,RRFO,ARFO,
0660      *RR(10),RROLD2,RROLD3,RROLD4,CV,CK,VA1(10),DALF(10),DBET(10),
0661      *ASF,AMS,R1(20)
0662      COMMON/VAR2/R6(20),ZR,ZS,ARF,R2(20),PR,AMR
0663      COMMON/VAR3/PTE(10),RS1,RS3,RS5,T2(10)
0664      COMMON/VAR4/HW1,RR2,RR3,RR1,RR3,RR5,VA2(10)
0665      COMMON/ANA/BA17,BLEX
0666      COMMON/CAS/CP,GAM,EMME,ERRE,EXP1,EXP2,VIS2,VIS3
0667      COMMON/CSS/CJ,G,Q1
0668      COMMON/IWI/IND,INZ,IWR
0669      COMMON/AUS/XCL
0670      COMMON/ARE/REE
0671      COMMON/COZ/ICOR,ICDZ,IINC,IAI,ICL,IAN,ICON
0672      COMMON/TR5/TRAS
0673      IF(ICON.NE.4) GO TO 6010
0674      DO 6011 MACC=1,5,2
0675      TRAX=90.+BETA2(MACC)*57.29578
0676      TRAX=90.-BETA1(MACC)*57.29578
0677      GIUD=BETA0(MACC)-BETA1(MACC)
0678      IF(IINC.EQ.1.AND.GIUD.GE.0.) TRAX=90.-BETA0(MACC)*57.29578
0679      TRA2=W2(MACC)*.3048
0680      TRA3=TTE(MACC)/1.8
0681      TRA4=U2(MACC)*.3048
0682      IF(MACC-3) 6012,6013,6014
0683      6012 CALL TRA2 (TRA1,TRAX,TRA2,TRA3,EMME,GAM,SIR,TNR,HR,DZ,TRAS,CIR,
0684      *TRA4,TIPC,TR16,TRA7,TRAB,TRA9,ZETAR(MACC))
0685      GO TO 6011
0686      6013 CALL TRA2 (TRA1,TRAX,TRA2,TRA3,EMME,GAM,SZ,TNR,HR,DZ,TRAS,CR,
0687      *TRA4,TIPC,TR26,TRA7,TRAB,YCL,ZETAR(MACC))
0688      GO TO 6011
0689      6014 CALL TRA2 (TRA1,TRAX,TRA2,TRA3,EMME,GAM,SOR,TNOR,HR,DZ,TRAS,COR,
0690      *TRA4,TIPC,TR36,TRA7,TRAB,TRA9,ZETAR(MACC))
0691      6011 CONTINUE
0692      DH1=CP*TT0*(1.-(P2(3)/PTO)**EXP2)
0693      PSI=1./((1.-YCL*DH1)*G*CJ/U2(3)/WU2(3))
0694      ZEZE=ZETAR(3)
0695      DO 6015 MACC=1,5,2
0696      ZETAR(MACC)=ZETAR(MACC)+((1.-ZEZE)*((1.-PSI)*PSI)
0697      6015 CONTINUE
0698      6010 CONTINUE
0699      IF(ICDZ.I.T.5) GO TO 2046
0700      DO 2047 MACC=1,5
0701      XY=ZETAR(MACC)/(1.-ZETAR(MACC))
0702      ZETAR(MACC)=(((1.+XY)/(1.+XY*P2(MACC)/PTE(MACC)))*EXP2-1.)/
0703      *((PTE(MACC)/P2(MACC))*EXP2-1.)
0704      IF(ICDZ.EQ.8) ZETAR(MACC)=(((1.+XY)/(1.+XY*BESP))*EXP2-1.)/
0705      *(1./BESP*EXP2-1.)
0706      2046 CONTINUE
0707      2047 CONTINUE
0708      IF(ICON.NE.3) GO TO 31
0709      30 DO 32 I=1,5,2
0710      32 ZETAPR(I)=ZETAR(I)
0711      31 IF(ICON.NE.2) GO TO 33
0712      IF(ICOR.EQ.4) ZETAPR(1)=TR16
0713      IF(ICOR.EQ.4) ZETAPR(3)=TR26
0714      IF(ICOR.EQ.4) ZETAPR(5)=TR36
0715      33 CONTINUE
0716      IF(ICON.NE.1) GO TO 34
0717      DO 35 I=1,5,2
0718      35 ZETAPR(I)=.5*ZETAR(I)

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0719      34 CONTINUE
0720      ZETAR(2) = ZETAR(1) + (RR(2) - RR1) / (RR3 - RR1) * (ZETAR(3) - ZETAR(1))
0721      ZETAR(4) = ZETAR(3) + (RR(4) - RR3) / (RR5 - RR3) * (ZETAR(5) - ZETAR(3))
0722      ZETAPR(2) = ZETAPR(1) + (RR(2) - RR1) / (RR3 - RR1) * (ZETAPR(3) - ZETAPR(1))
0723      ZETAPR(4) = ZETAPR(3) + (RR(4) - RR3) / (RR5 - RR3) * (ZETAPR(5) - ZETAPR(3))
0724      DO 7001 I=1,5
0725 7001 CONTINUE
0726      RETURN
0727      END
0728 C
0729      FUNCTION VAURA(TH,TE,SP)
0730      TH=THROAT OPENING
0731      TF=TRAILING EDGE THICKNESS
0732      SP=BLADE SPACING
0733      ARG1=TH/SP
0734      TERM1=ATAN(SQRT(1.-(ARG1**2)))/ARG1
0735      TERM2=TERM1*180./3.14159
0736      TERM3=1.-TERM2/90.
0737      TERM4=(4.*TE/SP)*TERM3
0738      ARG2=(TH/SP)+TERM4
0739      VAURA=ATAN(SQRT(1.-(ARG2**2)))/ARG2
0740      RETURN
0741      END
0742 C
0743 C
0744 C
0745      FUNCTION XPO(ANG1,ANG2)
0746      COMMON/TRA/XP01(5,8),XP02(6,8),ALF1(8),ALF01(5),ALF02(6),
0747      *Y(10),Y1(10),Q(6),RX(30),RY(30),IR(30),Z(6),C1(4,8),C2(4,8)
0748      IF(ANG2-80.) 1,2,3
0749      1 CONTINUE
0750      DO 4 I=1,8
0751      DO 5 J=1,4
0752      Q(J)=C1(J,I)
0753      4 Y(I)=YC(ANG2,Q,3)
0754      GO TO 10
0755      2 CONTINUE
0756      DO 6 I=1,8
0757      6 Y(I)=XP01(5,I)
0758      GO TO 10
0759      3 CONTINUE
0760      DO 7 I=1,8
0761      DO 8 J=1,3
0762      Q(J)=C2(J,I)
0763      7 Y(I)=YC(ANG2,Q,2)
0764      10 CONTINUE
0765      DO 11 I=1,7
0766      IF(ANG1.GE.ALF1(I).AND.ANG1.LE.ALF1(I+1)) GO TO 100
0767      IF(ANG1.LT.ALF1(1)) GO TO 101
0768      IF(ANG1.GT.ALF1(8)) GO TO 102
0769      11 CONTINUE
0770      100 CONTINUE
0771      XP0=Y(I)+(Y(I+1)-Y(I))/(ALF1(I+1)-ALF1(I))*(ANG1-ALF1(I))
0772      IF(ANG2.LT.40) XP0=0.09-(0.09-(XP01(1,I)+XP01(1,I+1))/2.)*
0773      *(ANG2-20.)/20.
0774      RETURN
0775      101 XP0=Y(1)
0776      RETURN
0777      102 XP0=Y(8)
0778      RETURN
0779      END
0780 C
0781      FUNCTION CSIM(U1,TO,FMME,GAM)
0782      ERRE=848.*9.80665/FMME
0783      AST=SQRT(2.*GAM/(GAM+1.))*ERRE*TO)
0784      AMACH=U1/AST
0785      IF(AMACH.LE.0.8) CSIM=1.
0786      IF(AMACH.LE.0.8) GO TO 1000
0787      IF(AMACH.LE.1.1) CSIM=1.-0.22/0.3*(AMACH-0.8)
0788      IF(AMACH.LT.1.2.AND.AMACH.GT.1.1) CSIM=0.78+0.15/0.1*(AMACH-1.1)
0789      IF(AMACH.GT.1.2) CSIM=0.92+1.5/.2*(AMACH-1.2)
0790      1000 RETURN
0791      END
0792 C
0793      SUBROUTINE CID(ANG1,T,DEL,CSID,PSID,PSIF,HM,DM)
0794      DIMENSION X(7),Y1(7),Y2(7)
0795      FF=1.-DEL/T/SIN(ANG1)
0796      DATA X/15.,20.,25.,30.,45.,60.,90./
0797      DATA Y1/1.06,1.1,1.17,1.225,1.63,2.1,2.45/
0798      DATA Y2/0.016,0.0215,0.049,0.072,0.156,0.260,0.4 /

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0799      A=ANG1*180./3.1415
0800      DO 1 I=1,6
0801      IF(A.LE.X(I)) Y=1.+0.06*A/15.
0802      IF(A.GE.X(I).AND.A.LE.X(I+1)) Y=+(Y1(I+1)-Y1(I))/(X(I+1)-X(I))*
0803      *(A-X(I))+Y1(I)
0804      IF(A.LE.X(I)) Z=Y2(I)*A/X(I)
0805      IF(A.GE.X(I).AND.A.LE.X(I+1)) Z= (Y2(I+1)-Y2(I))/(X(I+1)-X(I))*
0806      *(A-X(I))+Y2(I)
0807      1 CONTINUE
0808      IF(A.GT.X(7)) Y=1.
0809      IF(A.GT.X(7)) Z=1.
0810      CSID=1.+(Y-1.)*2.*(1.-EF)
0811      PSID=Z*4.*(1.-EF)*(1.-EF)
0812      PSIF=0.025/0.09* HM*HM/DM/DM
0813      RETURN
0814      END
0815      C
0816      FUNCTION CSIW(XPO,CSIP,I,ANG1,AH)
0817      CSIW=XPO*CSIP*T*SIN(ANG1)/AH
0818      RETURN
0819      END
0820      C
0821      FUNCTION CSIR(S,AH,V1,ANG1,UM,XP)
0822      SL=S/AH
0823      IF(SL.LE.0.4) XL=XP*0.65/.4*SL
0824      IF(SL.GT.0.4.AND.SL.LE.0.8) XL=XP*(0.65+0.45/0.4*(SL-.4))
0825      IF(SL.GT.0.8.AND.SL.LE.1.5) XL=XP*(1.1+0.04/0.7*(SL-0.8))
0826      IF(SL.GT.1.5) XL=XP*(1.5+0.6/1.7*(SL-1.5))
0827      ASC=V1*SIN(ANG1)/UM
0828      XRO=0.025+0.015/0.64*ASC*ASC
0829      IF(ASC.LT..2) XRO=.024
0830      IF(ASC.GT..95) XRO=.0475
0831      CSIR=XRO*XL
0832      RETURN
0833      END
0834      C
0835      FUNCTION ALEAK(DELBET,DM,AL,CLE,ALFA1)
0836      C1=0.82-0.075*DELBET
0837      ALEAK=C1*(DM+AL)*CLE/DM/AL/COS(ALFA1)
0838      RETURN
0839      END
0840      C
0841      C
0842      SUBROUTINE CHBFT(X,Y,N,A,M,RX,RH,R)
0843      C
0844      C
0845      C
0846      C
0847      C
0848      C
0849      C
0850      C
0851      C
0852      C
0853      C
0854      C
0855      C
0856      C
0857      C
0858      C
0859      C
0860      C
0861      C
0862      C
0863      C
0864      C
0865      C
0866      C
0867      C
0868      C
0869      C
0870      C
0871      C
0872      C
0873      C
0874      C
0875      C
0876      C
0877      C
0878      C
0879      C
0880      C
0881      C
0882      C
0883      C
0884      C
0885      C
0886      C
0887      C
0888      C
0889      C
0890      C
0891      C
0892      C
0893      C
0894      C
0895      C
0896      C
0897      C
0898      C
0899      C
0900      C
0901      C
0902      C
0903      C
0904      C
0905      C
0906      C
0907      C
0908      C
0909      C
0910      C
0911      C
0912      C
0913      C
0914      C
0915      C
0916      C
0917      C
0918      C
0919      C
0920      C
0921      C
0922      C
0923      C
0924      C
0925      C
0926      C
0927      C
0928      C
0929      C
0930      C
0931      C
0932      C
0933      C
0934      C
0935      C
0936      C
0937      C
0938      C
0939      C
0940      C
0941      C
0942      C
0943      C
0944      C
0945      C
0946      C
0947      C
0948      C
0949      C
0950      C
0951      C
0952      C
0953      C
0954      C
0955      C
0956      C
0957      C
0958      C
0959      C
0960      C
0961      C
0962      C
0963      C
0964      C
0965      C
0966      C
0967      C
0968      C
0969      C
0970      C
0971      C
0972      C
0973      C
0974      C
0975      C
0976      C
0977      C
0978      C
0979      C
0980      C
0981      C
0982      C
0983      C
0984      C
0985      C
0986      C
0987      C
0988      C
0989      C
0990      C
0991      C
0992      C
0993      C
0994      C
0995      C
0996      C
0997      C
0998      C
0999      C
1000      C

```

DESCRIPTION OF PARAMETERS:

X ARRAY OF ABSCISSAE DIMENSIONED REAL*4 X(N)

Y ARRAY OF ORDINATES DIMENSIONED REAL*4 Y(N)

N NUMBER OF SAMPLE POINTS (INTEGER)

A ARRAY OF THE OUTPUTTED POLYNOMIAL COEFFICIENTS

M DIMENSIONED AT LEAST A(M+2) (REAL*4)

RX ORDER OF DESIRED APPROXIMATING POLYNOMIAL

RX WORK ARRAY DIMENSIONED AT LEAST REAL*4 RX(M+2)

RH WORK ARRAY DIMENSIONED AT LEAST REAL*4 RH(M+2)

R INTEGER WORK ARRAY DIMENSIONED AT LEAST R(M+2)

NOTE: DIVIDED DIFFERENCES AND NEWTON'S INTERPOLATING FORMULA IS USED FOR COMPUTING THE POLYNOMIAL COEFFICIENTS.

```

REAL NEXTHI
INTEGER RI,RJ,R(1)
DIMENSION X(1),Y(1),A(1),RX(1),RH(1)
MPLUS1=M+1
MPLUS2=M+2
PREVH=0.0
C
DETERMINE INDEX VECTOR FOR INITIAL REFERENCE SET
R(1)=1
R(MPLUS2)=N
D=(N-1)/MPLUS1
H=D
DO 1 I=2,MPLUS1
R(I)=H+1.0
H=H+D
1 H=-1.0
2
C
SELECT M+2 REFERENCE PAIRS AND SET ALTERNATIVE DEVIATION VECTOR
DO 3 I=1,MPLUS2
RI=R(I)
RX(I)=X(RI)
A(I)=Y(RI)
H=-H
3 RH(I)=H

```

```

0879 C      COMPUTE M+1 LEADING DIVIDED DIFFERENCES
0880      DO 4 J=1,MPLUS1
0881      T1=MPLUS2
0882      A11=A(I1)
0883      RH11=RH(I1)
0884      T=MPLUS1
0885 5      DENOM=RX(I1)-RX(I-J+1)
0886      A1=A(I)
0887      RH1=RH(I)
0888      A(I1)=(A11-A1)/DENOM
0889      RH(I1)=(RH11-RH1)/DENOM
0890      I1=I
0891      A1=A(I)
0892      RH1=RH(I)
0893      I=I-1
0894      IF(I-J) 4,S,S
0895 4      CONTINUE
0896 C      EQUATE (M+1) THE DIFFERENCE TO ZERO TO DETERMINE H
0897      H=-A(MPLUS2)/RH(MPLUS2)
0898 C      WITH H KNOWN, COMBINE THE FUNCTION AND DEVIATION DIFFERENCES
0899      DO 6 I=1,MPLUS2
0900 6      A(I)=A(I)+RH(I)*H
0901 C      COMPUTE POLYNOMIAL COEFFICIENTS
0902      J=M
0903 7      XJ=RX(J)
0904      I=J
0905      A1=A(I)
0906      JPLUS1=J+1
0907      DO 8 I1=JPLUS1,MPLUS1
0908      A11=A(I1)
0909      A(I1)=A1-XJ*A11
0910      A1=A(I1)
0911 8      I=I1
0912      J=J-1
0913      IF(J-1) 9,7,7
0914 9      CONTINUE
0915 C      IF THE REFERENCE DEVIATION IS NOT INCREASING MONOTONICALLY
0916 C      THEN EXIT
0917      HMAX=ABS(H)
0918      IF(HMAX.GT.PREXH) GO TO 29
0919      A(MPLUS2)=-HMAX
0920      RETURN
0921 C      FIND THE INDEX, IMAX, AND VALUE, HIMAX, OF THE LARGEST ABSOLUTE
0922 C      ERROR FOR ALL SAMPLE POINTS
0923 29      A(MPLUS2)=HMAX
0924      PREXH=HMAX
0925      IMAX=R(1)
0926      HIMAX=H
0927      J=1
0928      RJ=R(J)
0929      DO 110 I=1,N
0930      IF(I.EQ.RJ) GO TO 11
0931      XI=X(I)
0932      HI=A(MPLUS1)
0933      K=M
0934 12      HI=HI*XI+A(K)
0935      K=K-1
0936      IF(K-1) 112,12,12
0937 112      HI=Y(I)
0938      ABSHI=ABS(HI)
0939      IF(ABSHI.LE.HMAX) GO TO 11
0940      HMAX=ABSHI
0941      HIMAX=HI
0942      IMAX=I
0943      GO TO 110
0944 11      IF(J.GE.MPLUS2) GO TO 110
0945      J=J+1
0946      RJ=R(J)
0947 110      CONTINUE
0948 C      IF THE MAXIMUM ERROR OCCURS AT A NONREFERENCE POINT, EXCHANGE THIS
0949 C      POINT WITH THE NEAREST REFERENCE POINT HAVING AN ERROR OF THE
0950 C      SAME SIGN AND REPEAT
0951      IF(IMAX.EQ.R(1)) RETURN
0952      DO 14 I=2,MPLUS2
0953      IF(IMAX.LT.R(I)) GO TO 15
0954 14      CONTINUE
0955      I=MPLUS2
0956 15      NEXTHI=H
0957      IF((I-1/2)*N.NE.0) NEXTHI=-H
0958      IF(HIMAX*NEXTHI.GE.0) GO TO 115

```

```

0959      IF(IMAX.GE.R(1)) GO TO 116
0960      J1=MPLUS2
0961      J=M
0962      117 R(J1)=R(J)
0963      J1=J
0964      J=J-1
0965      IF(J-1) 118,117,117
0966      118 R(1)=IMAX
0967      GO TO 2
0968      116 IF(IMAX.LE.R(MPLUS2)) GO TO 120
0969      J=1
0970      DO 121 J1=1,MPLUS2
0971      R(J)=R(J1)
0972      121 J=J1
0973      R(MPLUS2)=IMAX
0974      GO TO 2
0975      115 R(I)=IMAX
0976      GO TO 2
0977      120 R(I-1)=IMAX
0978      GO TO 2
0979      END
0980  C
0981      SUBROUTINE TRAU1
0982      COMMON/TRA/XPO1(5,8),XPO2(6,8),ALF1(8),ALF01(5),ALF02(6),
0983      *Y(10),Y1(10),Q(6),RX(30),RY(30),IR(30),Z(6),C1(4,8),C2(4,8)
0984  C
0985      DO 6 I=1,8
0986      DO 7 J=1,5
0987      7 Y(J)=XPO1(J,I)
0988      DO 8 J=1,6
0989      8 Y1(J)=XPO2(J,I)
0990      CALL CHRFT(ALF01,Y,5,Q,3,RX,RY,IR)
0991      CALL CHRFT(ALF02,Y1,6,Z,3,RX,RY,IR)
0992      DO 12 J=1,4
0993      C1(J,I)=Q(J)
0994      12 C2(J,I)=Z(J)
0995      6 CONTINUE
0996      RETURN
0997      END
0998  C
0999      SUBROUTINE TRAU2 (ANG1,ANGO,V1,TO,EMME,GAM,T,DEZ,HM,DM,CSIP,S,UM,
1000      *CL,RPRO,R2,R3,YCL,RTOT)
1001      CSIP=1
1002      R=XPO(ANG1,ANGO)
1003      P1=CSIM(V1,TO,EMME,GAM)
1004      ANGZ=ANG1*3.1415/180.
1005      CALL CID(ANGZ,T,DEZ,CSID,PSID,PSIF,HM,DM)
1006      R2=CSIW(R,CSIP,T,ANGZ,HM)
1007      R3=CSR(S,HM,V1,ANGZ,UM,CSIP)
1008      RPRO=R*CSIP*R1*CSID+PSIF+PSID
1009      IF(CL.LE.0.) YCL=0.
1010      IF(CL.LE.0.) GO TO 1000
1011      DEL=3.1416-(ANGO+ANG1)*3.1416/180.
1012      ALF1=1.5708-ANGZ
1013      YCL=ALEAK(DEL,DM,HM,CL,ALF1)
1014      1000 RTOT=RPRO+R2+R3
1015  C
1016      RETURN
1017      END
1018      FUNCTION YC(XBAR,Q,M)
1019      DIMENSION Q(6)
1020      YC=0
1021      IF(XBAR.EQ.0.) YC=Q(1)
1022      IF(XBAR.EQ.0.) GO TO 10
1023      M1=M+1
1024      DO 1 I=1,M1
1025      1 YC=YC+Q(I)*XBAR**(I-1)
1026      10 CONTINUE
1027      1000 RETURN
1028      END
1029

```

ASHORT T=00003 IS ON CR00025 USING 00024 BLKS R=0000

```

0001 FTN4,L
0002 PROGRAM SHORT(5)
0003 DIMENSION INAM(3)
0004 DIMENSION NAME(3)
0005
0006 C
0007 COMMON/ABA/BA17,BLEX
0008 COMMON/CUR/COSL(10)
0009 COMMON/TOL/TOL1,TOL2,TOL3,TOL4
0010 COMMON/TR5/TRAS
0011 COMMON/GAS/CP,GAM,EMME,ERRE,EXP1,EXP2,VIS2,VIS3
0012 COMMON/COZ/ICOR,IC0Z,IINC,IAI,ICL,IAN,ICON
0013 COMMON/MAC/IN
0014 COMMON/IWT/IND,INZ,IWR
0015 COMMON/AUS/XCL
0016 COMMON/CSS/CJ,G,Q1
0017 COMMON/VAR1/RC(10),RSOLD2,RSOLD3,RSOLD4,ASFO,RSFO,RRFO,ARFO,
0018 *RR(10),RROLD2,RROLD3,RROLD4,CV,CK,VA1(10),DALF(10),DBET(10),
0019 *ASF,AMS,R1(20)
0020 COMMON/VAR2/B6(20),ZR,ZS,ARF,R2(20),PR,AMR,VU1(10)
0021 COMMON/VAR3/PTE(10),RS1,RS3,RS5,T2(10)
0022 COMMON/VAR4/RR1,BR2,RR3,RR1,RR3,RR5,UA2(10)
0023 COMMON/VAR5/PRAT1(10),RINCI(10),ALFA11(10),BETA11(10),ZETA1(10),
0024 *U2(10),ALFA22(10),BETA22(10)
0025 COMMON/VAR6/PT2(10),TT2(10),PT1(10),DELH(10),ALFA2(10),VU2(10),
0026 *WR2(10),T25(10),T2IS(10)
0027 COMMON/VAR7/TTIS(5),RETAT(5),ETAT(5),ETAI(10),ETAS(10),ETAR(10),
0028 *RSTAR(10),AKIS(10),PSIR(10)
0029 COMMON/VAR8/DR1(10),AMW1(10),AMU2(10),RETET(10),PRAT1T(10),AMR2(
0030 *10),YS(10),X1(10),AREA1(10),ZETAPS(10),WPER1(10),YR(10),X2(10)
0031 COMMON/VAR9/ZETAR(10),ZETAPR(10),AS(10),AR(10),SI(10),SI2(10),
0032 *S1(10),DSDX1(10),WT1(10),HE(10)
0033 COMMON/VAR10/WU1(10),DMEDX(10),DSDX2(10),RI1(10),RI2(10),
0034 *RI3(10),RI4(10),RI(10),SR1(10),SR2(10)
0035 COMMON/VAR11/YOLD(10),AA(10),SR(10),PRAT2(10),WPER2(10),
0036 *DWDX(10),TTIS(10),PRAT3(10),SS(10),ALFA(10)
0037 COMMON/VAR12/BETA(10),DELH(10),WPERD(10),ZETAS(10),ZETAR1(20),
0038 *ZETAR3(20),ZETAR5(20),R1(20),A1(20),T10(20)
0039 COMMON/VAR13/ST1(20),IRR(20),R2(20),A2(20),RINC(20),DR(10),
0040 *BETO(10),STALI(10),AREA2(10),VR1(10)
0041 COMMON/VAR14/WLBM,PRATS,OMEG
0042 COMMON/AL1/ALFA1(10),V1(10),TTO,RPM,RS(10),SI,TNI,H,D,CI,T1(10),
0043 *P1(10),T0,TEI,ALI,BESP,XX,ANG20,AMS1(10),S,TN,C,TE,AL,SO,TNO,
0044 *CO,TEO,U(10),D11,D10,D21,D20,ANG21,ALFAX,T1,TPTQ,ALO,AMC
0045 COMMON/AL2/BETA2(10),BETA1(10),RETAN(10),U2(10),TTE(10),U2(10),
0046 *SIR,TNIR,HR,DZ,CIR,TIPC,SZ,TNR,CR,SOR,TNOR,COR,ALIR,ALR,ALOR,
0047 *P2(10),W1(10),W1(10),TEIR,TER,TEOR,D1IR,D1OR,BETAZ,BETAT,ANH,
0048 *TIR,TR,TOR,STALI(10)
0049 COMMON/ARE/REE
0050 COMMON/TRA/XPO1(5,8),XPO2(6,8),ALF1(8),ALF01(5),ALF02(6),
0051 *Y(10),Y1(10),Q(6),RX(30),RY(30),IR(30),Z(6),C1(4,8),C2(4,8)
0052 DATA INAM /2HSH,2HOR,2HT /
0053 DATA NAME /2HPA,2HRT,2H2 /
0054 CALL TRAU1
0055 XX=1.25
0056 BLEX=0.15
0057 XCL=1.35
0058
0059 C
0060 C
0061 C
0062 C
0063 C
0064 C
0065 C *****OPERATING CONDITIONS*****
0066 PTO=38.22
0067 TTO=626.18
0068 RPM=12000.
0069 PR=2.6
0070 C *****
0071 C
0072 C
0073 C *****INITIAL APPROXIMATIONS*****
0074 AMC=.2247
0075 AMS=.9
0076 AMR=.7
0077 VA1(3)=262.58
0078 VA2(3)=262.58

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0079 C *****
0080 C
0081 C
0082 C *****SPECIAL INPUT DATA*****
0083 TOL1=.01
0084 TOL2=.01
0085 TOL3=.01
0086 TOL4=.01
0087 C
0088 IND=0
0089 INZ=0
0090 IWR=0
0091 ICOR=4
0092 IAI=0
0093 C
0094 IAN=2
0095 ICL=0
0096 IINC=1
0097 ICOZ=6
0098 ICON=3
0099 C
0100 C *****
0101 C
0102 C *****TURBINE GEOMETRY*****
0103 A1(1)=.2126
0104 A1(2)=.22145
0105 A1(3)=.23035
0106 A1(4)=.23925
0107 A1(5)=.24815
0108 A1(6)=.25705
0109 A1(7)=.26595
0110 A1(8)=.27485
0111 A1(9)=.28375
0112 A1(10)=.2926
0113 C
0114 A2(1)=.1912
0115 A2(2)=.20305
0116 A2(3)=.21495
0117 A2(4)=.22685
0118 A2(5)=.23875
0119 A2(6)=.25065
0120 A2(7)=.26255
0121 A2(8)=.27445
0122 A2(9)=.28635
0123 A2(10)=.2983
0124 C
0125 AI=1.088
0126 AI=1.088
0127 ALO=1.088
0128 C
0129 C=1.003
0130 CI=1.003
0131 CO=1.003
0132 C
0133 E=2.8065
0134 ET=2.8065
0135 EO=2.8065
0136 C
0137 T=.2252
0138 TI=.2252
0139 TO=.2252
0140 C
0141 TE=.03
0142 TFI=.03
0143 TEO=.03
0144 C
0145 TN=.0186
0146 TNI=.0186
0147 TNO=.0186
0148 C
0149 ALR=1.088
0150 ALIR=1.088
0151 ALOR=1.088
0152 C
0153 CR=1.003
0154 CIR=1.003
0155 COR=1.003
0156 C
0157 FR=2.45
0158 FIR=2.45

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0159      EDR=2.45
0160      C
0161      TR=.2252
0162      TIR=.2252
0163      TOR=.2252
0164      C
0165      TER=.03
0166      TEIR=.03
0167      TEOR=.03
0168      C
0169      TNR=.0186
0170      TNIR=.0186
0171      TNOR=.0186
0172      C
0173      RC(1)=2.764
0174      RC(5)=3.627
0175      C
0176      RS(1)=2.764
0177      RS(5)=3.627
0178      C
0179      RR(1)=2.693
0180      RR(5)=3.837
0181      C
0182      CV=.885
0183      CK=.0
0184      TIPC=.01
0185      ZS=.31
0186      ZR=.32
0187      C *****
0188      C
0189      C
0190      RC(2)=SQRT(RC(5)*RC(5)/4.+3./4.*RC(1)*RC(1))
0191      RC(3)=SQRT(RC(5)*RC(5)/2.+RC(1)*RC(1)/2.)
0192      RC(4)=SQRT(3./4.*RC(5)*RC(5)+RC(1)*RC(1)/4.)
0193      RS(2)=SQRT(RS(5)*RS(5)/4.+RS(1)*RS(1)/4.*3.)
0194      RS(3)=(RS(1)+RS(5))/2.
0195      RS(4)=SQRT(((RS(5)**2)*.75)+((RS(1)**2)/4.))
0196      RR(2)=SQRT(RR(5)*RR(5)/4.+3./4.*RR(1)*RR(1))
0197      RR(3)=(RR(1)+RR(5))/2.
0198      RR(4)=SQRT(RR(5)*RR(5)*3./4.+RR(1)*RR(1)/4.)
0199      DO 3300 I=1,10
0200      A=I
0201      R1(I)=RS(1)+(A-1.)/9.*(RS(5)-RS(1))
0202      R2(I)=RR(1)+(A-1.)/9.*(RR(5)-RR(1))
0203      3300 CONTINUE
0204      O1=A1(1)
0205      O0=A1(10)
0206      OIR=A2(1)
0207      ORR=A2(10)
0208      DO 3711 I=1,10
0209      IF(RS(3).LE.R1(I)) GO TO 3712
0210      3711 CONTINUE
0211      3712 CONTINUE
0212      I=I-1
0213      O=A1(I)+(A1(I+1)-A1(I))*(RS(3)-R1(I))/(R1(I+1)-R1(I))
0214      DO 3713 I=1,10
0215      IF(RR(3).LE.R2(I)) GO TO 3714
0216      3713 CONTINUE
0217      3714 CONTINUE
0218      I=I-1
0219      OR=A2(I)+(A2(I+1)-A2(I))*(RR(3)-R2(I))/(R2(I+1)-R2(I))
0220      H=RS(5)-RS(1)
0221      D=2.*RS(3)
0222      S=2.*3.1416*RS(3)/ZS
0223      SI=2.*3.1416*RS(1)/ZS
0224      SO=2.*3.1416*RS(5)/ZS
0225      SZ=2.*3.1416*RR(3)/ZR
0226      SIR=2.*3.1416*RS(1)/ZR
0227      SOR=2.*3.1416*RS(5)/ZR
0228      DZ=2.*RR(3)
0229      HR=RR(5)-RR(1)
0230      C
0231      C
0232      C
0233      STATOR OUTLET ANGLES BY VAVRA METHOD
0234      ALFA1(3)=VAVRA(O,TN,S)
0235      ANG21=VAVRA(O1,TN1,SI)
0236      ANG20=VAVRA(O0,TN0,SO)
0237      C
0238      DALF(1)=ANG21-ALFA1(3)
0239      DALF(3)=0.

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0239          DALF(5)=ANGPO-ALFA1(3)
0240      CC
0241      ROTOR OUTLET ANGLES BY VAVRA METHOD
0242      CC
0243          BETA2(3)=-1.*VAVRA(OR,TNR,S7)
0244          BETA1  =-1.*VAVRA(DIR,TNIR,SIR)
0245          BETAZ  =-1.*VAVRA(COR,TNOR,SOR)
0246      CC
0247          DRET(1)=BETA1-BETA2(3)
0248          DRET(3)=0.
0249          DRET(5)=BETAZ-BETA2(3)
0250      10      X1(1)=RS(1)/RS(3)
0251          X2(1)=RR(1)/RR(3)
0252          RROLD2=RR(2)
0253          RROLD3=RR(3)
0254          RROLD4=RR(4)
0255          RSOLD2=RS(2)
0256          RSOLD3=RS(3)
0257          RSOLD4=RS(4)
0258          RS1=RS(1)
0259          RS3=RS(3)
0260          RS5=RS(5)
0261          RR1=RR(1)
0262          RR3=RR(3)
0263          RR5=RR(5)
0264          CALL CHRFT(R1,A1,10,B1,4,T10,ST1,IRR)
0265          CALL CHRFT(R2,A2,10,B2,4,T10,ST1,IRR)
0266          ASF=B1(1)+B1(2)*RS(3)+B1(3)*RS(3)**2+B1(4)*RS(3)**3+B1(5)*RS(3)**4
0267          ARF=B2(1)+B2(2)*RR(3)+B2(3)*RR(3)**2+B2(4)*RR(3)**3+B2(5)*RR(3)**4
0268          ASF=.2526
0269          ARF=.2447
0270          RSF=RS(3)
0271          ASF=ASF
0272          RSFO=RSF
0273          RRF=RR(3)
0274          RRF=RRF
0275          ARFO=ARF
0276      C      INPUT PRINTING
0277      C
0278          WRITE(6,671)
0279      671  FORMAT(1H1,/,60X,12HINPUT PRINTS//40X,50H      R1      A1
0280          *      R2      A2 /)
0281          DO 72 I=1,10
0282          WRITE(6,73) R1(I),A1(I),R2(I),A2(I)
0283      73  FORMAT(40X,F10.3,F10.4,10X,F10.3,F10.4)
0284      72  CONTINUE
0285          WRITE(6,74) ZR,ZR,TIPC,CV,CK
0286      74  FORMAT(/45X,25HNUMBER OF STATOR BLADES = ,F8.0/45X,25HNUMBER OF ROT
0287          *OR BLADES = ,F8.0/45X,25HROTOR TIP CLEARANCE = ,F8.4/45X,25HAXI
0288          *AL DISTANCE L = ,F8.2/45X,25HCURVATURE FACTOR K = ,F8.2/
0289          *//55X,16HBLADING GEOMETRY/)
0290          WRITE(6,75)
0291      75  FORMAT(/30X,70H      C      E      T      TE      TN
0292          *      AL      R /)
0293          WRITE(6,76) CI,EI,TEI,TEI,ALI,RS(1),C,E,T,TE,TN,AL,RS(3),CO,EO,
0294          *TO,TEO,TNO,ALO,RS(5)
0295      76  FORMAT(30X,7F10.4/22X,6HSTATOR,2X,7F10.4/30X,7F10.4/)
0296      77  FORMAT(30X,7F10.4/22X,6HROTOR,2X,7F10.4/30X,7F10.4/)
0297          WRITE(6,77) CIR,EIR,TIP,TEIR,TNIR,ALIR,RR(1),CR,ER,TR,TER,TNR,ALR,
0298          *RR(3),COR,FOR,TOR,TEOR,TNOR,ALOR,RR(5)
0299          WRITE(6,78)
0300      78  FORMAT(/40X,52HALL DIMENSIONS INDICATED IN THIS TABLE ARE IN INCHE
0301          *S/)
0302          WRITE(6,79) ICOR,IAT,IAN,ICOR,IINC,ICL,ICON
0303      79  FORMAT(///,40X,27HCORRELATION SYSTEM,ICOR = ,I5/61X,6HIAI = ,I5/
0304          *61X,6HIAN = ,I5/61X,6HICOR = ,I5/61X,6HINC = ,I5/61X,6HICL = ,I5/6
0305          *1X,6HICON = ,I5)
0306          WRITE(6,81) CP,FMME,GAM,VIS2,VIS3
0307      81  FORMAT(/20X,41HGAS PROPERTIES      CP      MOLECULAR MASS
0308          *GAMM      VISCOSITY (1)      VISCOSITY (2)/38X,10H(RTU/LB F).32X,13
0309          *H(LBM /SEC FT),4X,13H(LBM /SEC FT)/36X,F9.3,5X,F10.3,9X,F7.3,2E15
0310          *.3/)
0311          CALL EXEC(R,NAME)
0312      C
0313      END
0314

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APART2 T=00004 IS ON CR00025 USING 00030 BLKS K=0000

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0001      F1N4.L
0002      PROGRAM PART2(5)
0003      DIMENSION NAME(3)
0004      DIMENSION NAMR(3)
0005      COMMON/ARA/RA17,BLEX
0006      COMMON/CUR/COSL(10)
0007      COMMON/TOL/TOL1,TOL2,TOL3,TOL4
0008      COMMON/TRS/TRAS
0009      COMMON/GAS/CP,GAM,EMME,ERRE,EXP1,EXP2,VIS2,VIS3
0010      COMMON/COZ/ICOR,ICDZ,IINC,IAT,ICL,IAN,ICON
0011      COMMON/MAC/IN
0012      COMMON/IWI/IND,INZ,IWR
0013      COMMON/AUS/XCL
0014      COMMON/CSS/CJ,G,Q1
0015      COMMON/VAR1/RC(10),RSOLD2,RSOLD3,RSOLD4,ASFO,RSFO,RRFO,ARFO,
0016      *RR(10),RROLD2,RROLD3,RROLD4,CV,CK,VA1(10),DALF(10),DBET(10),
0017      *ASF,AMS,R1(20)
0018      COMMON/VAR2/R6(20),ZR,ZS,ARF,R2(20),PR,AMR,VU1(10)
0019      COMMON/VAR3/PTE(10),RS1,RS3,RS5,T2(10)
0020      COMMON/VAR4/RK1,RR2,RR3,RR1,RR3,KR5,VA2(10)
0021      COMMON/VAR5/PKAT1(10),KINCI(10),ALFA11(10),BETA11(10),ZETA1(10),
0022      *V2(10),ALFA22(10),BETA22(10)
0023      COMMON/VAR6/PT2(10),TT2(10),PT1(10),DFLH(10),ALFA2(10),VU2(10),
0024      *WR2(10),T2S(10),T2IS(10)
0025      COMMON/VAR7/TTIS(5),BETAT(5),ETAT(5),ETAI(10),ETAS(10),ETAR(10),
0026      *RSTAR(10),AKIS(10),PSIR(10)
0027      COMMON/VAR8/DR1(10),AMW1(10),AMU2(10),RFTET(10),PRAT1T(10),
0028      *AMR2(10),YS(10),X1(10),AREA1(10),ZETAPS(10),WPER1(10),YR(10),
0029      *X2(10)
0030      COMMON/VAR9/ZETAR(10),ZETAPR(10),AS(10),AR(10),SI1(10),SI2(10),
0031      *S1(10),DSDX1(10),WT1(10),HE(10)
0032      COMMON/VAR10/WU1(10),DHEUX(10),DSDX2(10),RI1(10),RI2(10),
0033      *RI3(10),RI4(10),RI(10),SR1(10),SR2(10)
0034      COMMON/VAR11/YOLD(10),AA(10),SR(10),PRAT2(10),WPER2(10),
0035      *DWDX(10),TTIS(10),PRAT3(10),SS(10),ALFA(10)
0036      COMMON/VAR12/BETA(10),DELR(10),WPERO(10),ZETAS(10),ZETAR1(20),
0037      *ZETAR3(20),ZETARS(20),R1(20),A1(20),T10(20)
0038      COMMON/VAR13/ST1(20),IRK(20),R2(20),A2(20),RINC(20),DR(10),
0039      *BE10(10),STALI(10),AREA2(10),VR1(10)
0040      COMMON/VAR14/WLHM,PRATS,UMEG
0041      COMMON/AL1/ALFA1(10),V1(10),TTO,RPM,RS(10),SI,TNI,H,D,CI,T1(10),
0042      *P1(10),TO,TET,ALI,RESP,XX,ANG20,AMS1(10),S,TN,C,TF,AL,SO,TNO,
0043      *CO,TEO,II(10),D11,D10,D21,D20,ANG21,ALFAX,TI1,PTO,ALO,AMC
0044      COMMON/AL2/BETA2(10),BETA1(10),BETA0(10),W2(10),TTE(10),U2(10),
0045      *SIR,TNIR,HR,DZ,CIR,TIPC,SZ,TNR,CR,SOR,TNOR,COR,ALTR,ALR,ALOR,
0046      *P2(10),WIP(10),W1(10),TEIR,TER,TEOR,D1TR,D1OR,BETAZ,BETAT,ANH,
0047      *TIR,TR,TOR,STALI(10)
0048      COMMON/ARE/REE
0049      COMMON/TRA/XP01(5,8),XP02(6,8),ALF1(8),ALF01(5),ALF02(6),
0050      *Y(10),Y1(10),Q(6),RX(30),RY(30),IR(30),Z(6),C1(4,8),C2(4,8)
0051      DATA NAME /2HPA,2HRT,2H2 /
0052
0053      DATA NAMR/2HPA,2HRT,2H3 /
0054      DO 67 I=1,5
0055      U(I)=RPM*3.14159/30./12.*R8(I)
0056      DR(I)=0.
0057      DELR(I)=0.
0058      ZETAS(I)=.10
0059      ZETAR(I)=.15
0060      ZETAPS(I)=0.05
0061      ZETAPR(I)=0.05
0062      COSL(I)=1.0
0063      YS(I)=1.0
0064      67 YR(I)=1.0
0065      N9=0.
0066      750 NS=0
0067      N9=N9+1
0068      7750 CONTINUE
0069      100 RS(2)=RSOLD2
0070      RS(3)=RSOLD3
0071      DO 530 I=1,5
0072      530 X1(I)=RS(I)/R8(3)
0073      ASF=ASFO
0074      RSF=RSFO
0075      FS1=1.0
0076      FS2=1.0
0077      CALL CHAN (TTO,AMC,PTO,RC,WLHM,WCHAN,WPERO)
0078      NS=0

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0079      R10 DO 801 K=1,15
0080      CALL STATR (ALFA1,X1,TTO,PTO,AMS,T1,P1,U1,VA1,ST1,ST2,YS,S1
0081      *DSDX1,U11,PRAT1,T1IS,SS,DALF,RSF,DELR,CV,CK,ZETAPS,RS,RS1,RS3,
0082      *RSS,ZETAS,DR,ZETA1,AMS1,NS,VR1)
0083      CALL ALOS1(ZETAS,ZETAPS)
0084      DO 120 I=1,5
0085      PTE(I)=PTO
0086      120 TTE(I)=TTO
0087      CALL FLOWR(PRAT1,ZETAPS,X1,WI1,PTI,PTO,TTE,TTO,ASF,ZS,RSF,ASF,
0088      *ZR,RSF,1,WCHAN,VA1,WPER1,CODE,WLBM,B1,RS,TIPC,AREA1)
0089      IF(IN.EQ.1) AMC=AMC-.01
0090      IF(IN.EQ.1) GO TO 7750
0091      IF(CODE=20.) 801,802,801
0092      801 CONTINUE
0093      802 CONTINUE
0094      FC1=1
0095      FC2=FC1**2
0096      ARF=ARF0
0097      RRF=RROLD3
0098      RR(2)=RROLD2
0099      RR(3)=RRF
0100      RR(4)=RROLD4
0101      DO 71 I=1,5
0102      AMS1(I)=V1(I)/SQRT(GAM*ERRE*GT1(I))
0103      X2(I)=RR(I)/RR(3)
0104      71 CONTINUE
0105      CALL ROT01 (U11,VA1,RPM,U,BETA1,HE,TTE,PTI,X2,P1,T1,W1,WU1,X1,
0106      *RS,ZETAR,ZETAPR,RR,DHEDX,DSDX1,S1,U2,OHFG,RR1,RR2,RR3,FS1,FS2,
0107      *ZETAR,R6,RS1,RS3,RSS,BETO,STALII,RINCI,VR1)
0108      CODE=1
0109      IMACC=0
0110      201 DO 200 K=1,14
0111      CALL ROT02 (BETA2,HE,DHEDX,DSDX1,DSDX2,VA2,WU2,W2,U12,U2,X2,U2,
0112      *YR,ZETAR,R1,R12,R13,R14,R1,SR1,SR2,AA,SR,TTE,PTI,T2,P2,PRAT2,
0113      *T2S,INDS,DR1,RRF,DELR,CV,CK,DR,RR,RR1,RR3,RRS,NS,WR2)
0114      CALL ALOS2(ZETAR,ZETAPR)
0115      IF (INDS=1) 310,320,310
0116      320 WRITE (6,36) ((AA(I),I=1,5)
0117      WRITE (6,36) ((AA(I),I=1,5)
0118      36 FORMAT(35H ENTROPY INDETERMINATE,PRINT AA 1-5,SE12.4/,25X,10HZETAR
0119      *1-5,SE12.4/25X,10H VA2 1-5,SE12.4/)
0120      IND=1
0121      310 CALL FLOWR(PRAT2,ZETAPR,X2,WI1,PTI,PTO,TTE,TTO,ASF,ZS,RSF,ARF,
0122      *ZR,RRF,2,WCHAN,VA2,WPER2,CODE,WLBM,B2,RR,TIPC,AREA2)
0123
0124      IF(IN.EQ.1) AMC=AMC-.01
0125      IF(IN.EQ.1) GO TO 7750
0126      200 CONTINUE
0127      130 CONTINUE
0128      IMACC=IMACC+1
0129      IF(IMACC.GE.10) GO TO 220
0130      4322 FORMAT(/20H LOOP IN SLINE ROT//SE10.3)
0131      IF(CODE=40.) 201,220,201
0132      5000 CONTINUE
0133      DO 221 I=1,5
0134      DELR(I)=RS(I)-(RC(I)+RR(I))/2.
0135      DR(I)=RC(I)-RR(I)
0136      221 COSL(I)=SQRT(CV*CV/(DR(I)**2+CV*CV))
0137      NS=1
0138      880 DO 881 K=1,15
0139      CALL ALOS1(ZETAS,ZETAPS)
0140      CALL STATR (ALFA1,X1,TTO,PTO,AMS,T1,P1,U1,VA1,ST1,ST2,YS,S1
0141      *DSDX1,U11,PRAT1,T1IS,SS,DALF,RSF,DELR,CV,CK,ZETAPS,RS,RS1,RS3,
0142      *RSS,ZETAS,DR,ZETA1,AMS1,NS,VR1)
0143      DO 860 I=1,5
0144      PTE(I)=PTO
0145      860 TTE(I)=TTO
0146      CALL FLOWR(PRAT1,ZETAPS,X1,WI1,PTI,PTO,TTE,TTO,ASF,ZS,RSF,ASF,
0147      *ZR,RSF,1,WCHAN,VA1,WPER1,CODE,WLBM,B1,RS,TIPC,AREA1)
0148      IF(IN.EQ.1) AMC=AMC-.01
0149      IF(IN.EQ.1) GO TO 7750
0150      IF(CODE=20.) 881,882,881
0151      881 CONTINUE
0152      882 CONTINUE
0153      861 CALL ROT01 (U11,VA1,RPM,U,BETA1,HE,TTE,PTI,X2,P1,T1,W1,WU1,X1,
0154      *RS,ZETAR,ZETAPR,RR,DHEDX,DSDX1,S1,U2,OHFG,RR1,RR2,RR3,FS1,FS2,
0155      *ZETAR,R6,RS1,RS3,RSS,BETO,STALII,RINCI,VR1)
0156      CODE=1
0157      894 DO 896 K=1,10
0158      CALL ALOS2 (ZETAR,ZETAPR)

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0159      CALL ROTOP (BETA2,HE,DHFDX,DSDX1,DSDX2,VA2,WU2,W2,VU2,V2,X2,U2,
0160      *YR,ZETAR,R11,X12,R13,W14,R1,SD1,SR2,AA,AF,TTE,PTF,T2,P2,PRAT2,
0161      *T2S,INDS,DRET,RRF,DFLR,CV,CK,DR,RR,RR1,RR3,RR5,NS,WR2)
0162      IF (INDS-1) 895,320,895
0163      895 CALL FLOWR (PRAT2,ZETAPR,X2,W11,PTF,PTO,TTE,TT0,ASF,ZS,RSF,ARF,ZR,
0164      *RKF,2,WCHAN,VA2,WPR2,CODE,WLEN,R2,RR,TIPC,AREA2)
0165      IF (IN.EQ.1) AMC=AMC-.01
0166      IF (IN.EQ.1) GO TO 7750
0167      IF (CODE-20.) 896,897,896
0168      896 CONTINUE
0169      897 CONTINUE
0170      225 DO 227 I=1,5
0171      227 PRAT3(I)=PTO/P2(I)
0172      IND=0
0173      PRAT5=(PRAT3(1)+2.*(PRAT3(2)+PRAT3(3)+PRAT3(4))+PRAT3(5))/8.
0174      WRITE(1,245) PRAT5
0175      265 FORMAT(IX,'COMPUTED PRESSURE RATIO=',F6.3)
0176      DIFF=ABS(PR-PRAT5)
0177      TAL=10L3*PR
0178      IF (TAL-DIFF) 920,910,910
0179      910 N11=0
0180      GO TO 223
0181      920 CONTINUE
0182      710 IF (PR-PRAT5) 712,712,714
0183      712 AMC=AMC-DIFF/18.
0184      GO TO 750
0185      714 AMC=AMC+DIFF/18.
0186      GO TO 750
0187      223 CONTINUE
0188      CALL EXEC(8,NAMR)
0189      END

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APART3 T=00004 IS ON CR00025 USING 00042 BLKS K=0000

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0001 FTN4,L
0002 PROGRAM PART3(5)
0003 DIMENSION NAME(3)
0004 DIMENSION NAMR(3)
0005 COMMON/ABA/RA17,BLEX
0006 COMMON/CUR/COSL(10)
0007 COMMON/TOI/TOL1,TOL2,TOL3,TOL4
0008 COMMON/TRS/TRAS
0009 COMMON/GAS/CP,GAM,FMME,ERRE,EXP1,EXP2,VIS2,VIS3
0010 COMMON/COZ/ICOR,ICDZ,IINC,IAI,ICL,IAN,ICON
0011 COMMON/MAC/IN
0012 COMMON/IWI/IND,INZ,IWR
0013 COMMON/AUS/XCL
0014 COMMON/CSS/CJ,G,Q1
0015 COMMON/VAR1/RC(10),RSOLD2,RSOLD3,RSOLD4,ASFO,RSFO,RRFO,ARFO,
0016 *RR(10),RROLD2,RROLD3,RROLD4,CV,CK,VA1(10),DALF(10),DBET(10),
0017 *ASF,AMS,R1(20)
0018 COMMON/VAR2/R6(20),ZR,ZS,ARF,R2(20),PR,AMR,VU1(10)
0019 COMMON/VAR3/PTE(10),RS1,RS3,RS5,T2(10)
0020 COMMON/VAR4/RR1,RR2,RR3,RR4,RR5,VA2(10)
0021 COMMON/VAR5/PRA1(10),KINCI(10),ALFA1(10),BETA1(10),ZETA1(10),
0022 *V2(10),ALFA2(10),BETA2(10)
0023 COMMON/VAR6/PT2(10),TT2(10),PT1(10),DELH(10),ALFA2(10),VU2(10),
0024 *WR2(10),T25(10),T2IS(10)
0025 COMMON/VAR7/TTIS(5),BETAT(5),ETAT(5),ETAI(10),ETAS(10),ETAR(10),
0026 *RSTAR(10),AKIS(10),PSTR(10)
0027 COMMON/VAR8/DR1(10),AMW1(10),AMV2(10),BFTET(10),PRAT1(10),
0028 *AMR2(10),YS(10),X1(10),AREA1(10),ZETAPS(10),WPER1(10),YR(10),
0029 *X2(10)
0030 COMMON/VAR9/ZETAR(10),ZETAPR(10),AS(10),AR(10),SI1(10),SI2(10),
0031 *S1(10),DSDX1(10),WI1(10),HE(10)
0032 COMMON/VAR10/WU1(10),DHEUX(10),DSDX2(10),RI1(10),RI2(10),
0033 *RI3(10),RI4(10),RI(10),SR1(10),SR2(10)
0034 COMMON/VAR11/YULD(10),AA(10),SR(10),PRAT2(10),WPER2(10),
0035 *DWDX(10),TIS(10),PRAT3(10),SS(10),ALFA(10)
0036 COMMON/VAR12/BETA1(10),DELH(10),WPERO(10),ZETAS(10),ZETAR(20),
0037 *ZETAR3(20),ZETAR5(20),R1(20),A1(20),T1(20)
0038 COMMON/VAR13/ST1(20),IRR(20),R2(20),A2(20),RINC(20),DR(10),
0039 *RETO(10),STALII(10),AREA2(10),VR1(10)
0040 COMMON/VAR14/WLBM,PRATS,OMEG
0041 COMMON/AL1/ALFA1(10),V1(10),TTO,RPM,RS(10),SI,TNI,H,D,CI,T1(10),
0042 *P1(10),TO,TEI,ALI,BESP,XX,ANG20,AMS1(10),S,TN,C,TE,AL,SO,TNO,
0043 *CO,TEO,U(10),D11,D10,D21,D20,ANG21,ALFAX,TI,T,PTO,ALO,AMC
0044 COMMON/AL2/BETA2(10),BETA1(10),BETA0(10),W2(10),TTE(10),U2(10),
0045 *SIR,TNIR,HR,DZ,CIR,TIPC,SZ,TNR,CR,SOR,TNOR,COR,ALIE,ALR,ALOR,
0046 *P2(10),W02(10),W1(10),TEIR,TER,TEOR,D1R,D1OR,BETAZ,BETAI,ANA,
0047 *TIR,TR,TOR,STALI(10)
0048 COMMON/ARE/REE
0049 COMMON/TRA/XPO1(5,8),XPO2(6,8),ALF1(8),ALFO1(5),ALFO2(6),
0050 *Y(10),Y1(10),Q(6),RX(30),RY(30),IR(30),Z(6),C1(4,8),C2(4,8)
0051 DATA NAME /2HPA,2HRT,2HZ /
0052
0053 DATA NAMR/2HPA,2HRT,2H3 /
0054
0055 999 FORMAT(1H1)
0056 WRITE(6,999)
0057 WRITE(6,401)
0058 401 FORMAT(//27X,' SET PAGE RPM TOTAL/STATIC INLET
0059 *TOTAL INLET TOTAL')
0060 WRITE(6,402)
0061 402 FORMAT(//27X,67HNUMBER NUMBER PRESSURE RATIO PRESSU
0062 *RE TEMPERATURE)
0063 403 FORMAT(72X, 5H(PSI), 7X,8H(DEG. R)/)
0064 J=1
0065 IS=1
0066 WRITE(6,405)J,IS,RPM,PR,PTO,TTO
0067 405 FORMAT(27X,I3,I8,F11.1,F14.3,F15.2/)
0068 WRITE(6,404)
0069 404 FORMAT(//57X21H STATOR EXIT SOLUTION//)
0070 WRITE(6,406)
0071 406 FORMAT(1X,'STREAM RADIAL X=R/RM RADIAL BLADE Y=VA
0072 */VAM BLADE LOSS ZETA* FLOW RATE')
0073 WRITE(6,407)
0074 407 FORMAT(1X,109H LINE POSITION SHIFT OPENING
0075 * EFFICIENCY COEFFICIENT CONTINUITY FRACTION /)
0076 WRITE(6,411)
0077 411 FORMAT(12X,4H(IN),13X,4H(IN),5X,4H(IN))
0078 DO 408 I=1,5

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0079 PRAT1(I)=1./PRAT1(I)
0080 ALFA11(I)=ALFA1(I)*S7.3
0081 RETA11(I)=RETA1(I)*S7.3
0082 ALFA2(I)=ATAN(UU2(I)/UA2(I))
0083 U2(I)=UA2(I)/COS(ALFA2(I))
0084 U2(I)=SQRT(U2(I)*U2(I)+WR2(I)*WR2(I))
0085 ALFA22(I)=ALFA2(I)*S7.3
0086 RETA22(I)=RETA2(I)*S7.3
0087 DELH(I)=(U(I)*UU1(I)-U2(I)*UU2(I))/(G*CJ)
0088 TT2(I)=TTO-DELH(I)/CP
0089 PT2(I)=P2(I)*(TT2(I)/T2(I))**EXP1
0090 PT1(I)=P1(I)*(TTO/T1(I))**EXP1
0091 TPIS(I)=TTO*(P2(I)/PTO)**EXP2
0092 T2S(I)=TTE(I)*(P2(I)/PTE(I))**EXP2
0093 TTIS(I)=TTO*(PT2(I)/PTO)**EXP2
0094 RETAT(I)=PTO/PT2(I)
0095 ETAT(I)=(TTO-TT2(I))/(TTO-TTIS(I))
0096 ETAT(I)=(TTO-TT2(I))/(TTO-T2S(I))
0097 ETAS(I)=(TTO-T1(I))/(TTO-T1S(I))
0098 ETAR(I)=(TTE(I)-T2(I))/(TTE(I)-T2S(I))
0099 RSTAR(I)=(T1S(I)-TPIS(I))/(TTO-T2S(I))
0100 AKIS(I)=2.*G*CJ*CP*(TTO-T2S(I))/U(I)**2
0101 PSJK(I)=SQRT(ETAR(I))
0102 DR1(I)=RC(I)-RS(I)
0103 AMW1(I)=W1(I)/SQRT(GAM*ERRE*G*T1(I))
0104 AMS1(I)=U1(I)/SQRT(GAM*ERRE*G*T1(I))
0105 AMU2(I)=U2(I)/SQRT(GAM*ERRE*G*T2(I))
0106 AMR2(I)=W2(I)/SQRT(GAM*ERRE*G*T2(I))
0107 RETET(I)=PTE(I)/P2(I)
0108 PRAT1(I)=PTO/PT1(I)
0109 408 WRITE(6,409) 1,RS(I),X1(I),DR1(I),AREA1(I),YS(I),ETAS(I),ZETA1(I),
0110 *ZETAPS(I),WPER1(I)
0111 DELH(10)=0.
0112 DO 240 I=1,4
0113 L=I+1
0114 240 DELH(10)=DELH(10)+.5*(WPER2(L)-WPER2(I))*(DELH(L)+DELH(I))
0115 HP=DELH(10)*CJ*WLRH/S50.
0116 AMOM=HP*S50./OMEG
0117 THETA=SQRT(TTO/S18.4)
0118 DELTA=PTO/14.7
0119 HP1=HP/(THETA*DELTA)
0120 AMOM1=AMOM/DELTA
0121 RPM1=RPM/THETA
0122 WLBH1=WLBH*THETA/DELTA
0123 ETAS=(ETAT(1)+ETAT(5)+2.*(ETAT(2)+ETAT(3)+ETAT(4)))/8.
0124 RETAG=(RETAT(1)+RETAT(5)+2.*(RETAT(2)+RETAT(3)+RETAT(4)))/8.
0125 ETAG=(ETAT(1)+ETAT(5)+2.*(ETAT(2)+ETAT(3)+ETAT(4)))/8.
0126 AKISS=(AKIS(1)+AKIS(5)+2.*(AKIS(2)+AKIS(3)+AKIS(4)))/8.
0127 RSTAR5=(RSTAR(1)+RSTAR(5)+2.*(RSTAR(2)+RSTAR(3)+RSTAR(4)))/8.
0128 409 FORMAT(1X,14,F12.3,F10.3,F9.4,F9.4,F11.4,F11.4,F14.4,F14.4)
0129 WRITE(6,412)
0130 412 FORMAT(///22X,23HABSOLUTE VELOCITY (FPS),27X,23HRELATIVE VELOCITY
0131 *(FPS)/)
0132 413 FORMAT(1X,6HSTREAM,2X,2(SOH AXIAL RADIAL TANGENTIAL OVER
0133 *ALL),7H WHEEL)
0134 WRITE(6,413)
0135 WRITE(6,414)
0136 414 FORMAT(1X,6H LINE 2(SOHCOMPONENT COMPONENT COMPONENT VE
0137 *LOCITY),8HVELOCITY//)
0138 DO 415 I=1,5
0139 415 WRITE(6,416) I,VA1(I),VR1(I),VU1(I),V1(I),VA1(I),VR1(I),WU1(I),W1(
0140 *I),U(I)
0141 416 FORMAT(15,2X,2(F8.2,3F12.2,6X),F8.2)
0142 WRITE(6,418)
0143 418 FORMAT(///7X,113H MACH NUMBER PRESSURE FLOW ANGLE
0144 * TEMPERATURE PRESSURE PRESSURE)
0145 WRITE(6,419)
0146 419 FORMAT( 7X,113H (DEG. R) (PSI) (DEG) RATIO //)
0147 *
0148 WRITE(6,492)
0149 492 FORMAT( 7H STREAM)
0150 WRITE(6,420)
0151 420 FORMAT(7H LINE,2(24H ABSOLUTE RELATIVE),2(24H TOTAL
0152 * STATIC),24H TOT/TOT TOT/STA //)
0153 DO 422 I=1,5
0154 422 WRITE(6,421) 1,AMS1(I),AMW1(I),ALFA11(I),RETA11(I),TTO,T1(I),PT1(I)
0155 *P1(I),PRAT1(I),PRAT1(I)
0156 421 FORMAT(14,3X,2F10.2,4X,2F10.2,4X,2F10.2,4X,2F10.3,4X,F11.4,F10.4)
0157 WRITE(6,999)
0158 WRITE(6,401)

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0159      WRITE(6,402)
0160      WRITE(6,403)
0161 452 FORMAT(//57X,21H ROTOR EXIT SOLUTION///)
0162      IS=2
0163      WRITE(6,405) J,IS,RPM,PR,PTO,TTO
0164      WRITE(6,452)
0165      WRITE(6,406)
0166      WRITE(6,407)
0167      DO 423 I=1,5
0168      WRITE(6,409) I,RR(I),X2(I),DR(I),AREA2(I),YR(I),ETAR(I),ZETAR(I),
0169      *ZETAPR(I),WPER2(I)
0170      WRITE(6,412)
0171      WRITE(6,413)
0172      WRITE(6,414)
0173      DO 424 I=1,5
0174 424 WRITE(6,416) I,VA2(I),WR2(I),VU2(I),V2(I),VA2(I),WR2(I),WU2(I),W2(I)
0175      * ,U2(I)
0176      WRITE(6,418)
0177      WRITE(6,419)
0178      WRITE(6,422)
0179      WRITE(6,420)
0180      DO 425 I=1,5
0181 425 WRITE(6,421) I,AMV2(I),AMR2(I),ALFA22(I),BETA22(I),TT2(I),T2(I),
0182      *PT2(I),P2(I),BETAT(I),PRAT3(I)
0183      WRITE(6,491)
0184 491 FORMAT(//)
0185      WRITE(6,426)
0186 426 FORMAT(7H STREAM, 41H EQUIVALENT EQUIVALENT EQUIV/STATIC)
0187 427 FORMAT(7H LINE, 38H TEMPERATURE INLET PRESSURE)
0188 428 FORMAT( 7X, 38H (DEG. R) (PSI) RATIO)
0189 429 FORMAT( 7X, 22H (DEG. R) (PSI) RATIO)
0190      WRITE(6,427)
0191      WRITE(6,428)
0192      WRITE(6,429)
0193      DO 430 I=1,5
0194 430 WRITE(6,431) I,TTE(I),PTE(I),BETET(I)
0195 431 FORMAT(14,F13.2,F15.3,F11.1)
0196      WRITE(6,999)
0197      WRITE(6,401)
0198      WRITE(6,402)
0199      WRITE(6,403)
0200      IS=3
0201      WRITE(6,405) J,IS,RPM,PR,PTO,TTO
0202      WRITE(6,441)
0203 441 FORMAT(//45X,31H OVERALL TURBINE CHARACTERISTICS///)
0204      WRITE(6,442)
0205 442 FORMAT(102H STREAM PRESSURE RATIO EFFICIENCY
0206      * HEAD BLADE/JET THEORETICAL )
0207      WRITE(6,443)
0208 443 FORMAT(102H LINE TOT/STA TOT/TOT TOT/STA TOT/TOT
0209      * COEFFICIENT SPEED RATIO DEGREE OF REACTION /)
0210      DO 444 I=1,5
0211      BLAJE=1./SQRT(AKIS(I))
0212 444 WRITE(6,445) I,PRAT3(I),BETAT(I),ETAI(I),ETAT(I),AKIS(I),BLAJE,RST
0213      *AR(I)
0214 445 FORMAT(15,F14.4,F11.4,F11.4,F13.4,F12.4,F15.4,F16.4)
0215      WRITE(6,446)
0216 446 FORMAT(//53X,24H MASS AVERAGED QUANTITIES///)
0217 447 FORMAT(52X,13H HORSE POWER =,F10.2,3X,4H(HP))
0218 448 FORMAT(52X,13H MOMENT =,F10.2,3X,7H(FT-LB))
0219 449 FORMAT(52X,13H FLOW RATE =,F10.2,3X,8H(LB/SEC)///)
0220 461 FORMAT(43X,22H REFERRED RPM =,F10.2)
0221 462 FORMAT(43X,22H REFERRED HORSE POWER =,F10.2,3X,4H(HP))
0222 463 FORMAT(43X,22H REFERRED MOMENT =,F10.2,3X,7H(FT-LB))
0223 464 FORMAT(43X,22H REFERRED FLOW RATE =,F10.2,3X,8H(LB/SEC)///)
0224 465 FORMAT(40X,25H TOTAL/STATIC EFFICIENCY =,F10.4)
0225 466 FORMAT(40X,25H TOTAL/TOTAL EFFICIENCY =,F10.4)
0226 467 FORMAT(36X,29H TOTAL/STATIC PRESSURE RATIO =,F10.4)
0227 468 FORMAT(36X,29H TOTAL/TOTAL PRESSURE RATIO =,F10.4//)
0228 469 FORMAT(34X,31H HEAD COEFFICIENT =,F10.4)
0229 471 FORMAT(34X,31H THEORETICAL DEGREE OF REACTION =,F10.4)
0230 472 FORMAT(34X,31H BLADE/TFT SPEED RATIO =,F10.4)
0231 473 FORMAT(34X,31H MACH NUMBER AT STATION 0 =,F10.4)
0232      WRITE(6,447) HP
0233      WRITE(6,448) AMOM
0234      WRITE(6,449) WLBH
0235      WRITE(6,461) RPM1
0236      WRITE(6,462) HP1
0237      WRITE(6,463) AMOM1
0238      WRITE(6,464) WLBH1

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0239      WRITE(6,465) ETAS
0240      WRITE(6,466) ETA6
0241      WRITE(6,467) PRATS
0242      WRITE(6,468) BETA6
0243      WRITE(6,469) AKISS
0244      RIHJFS=1./SQRT(AKISS)
0245      WRITE(6,472) BLAJFS
0246      WRITE(6,471) RSTAR5
0247      WRITE(6,473) AMC
0248      IF(INZ-1) 400,930,930
0249      930 IF(N11-1) 400,400,400
0250      400 CONTINUE
0251      END

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