

**Axial Flow Compressor Design
Computer Programs Incorporating
Full Radial Equilibrium**

**Part I—Flow Path and Radial Distribution of
Energy Specified (Program II)**

by

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ABSTRACT

A compressor aerodynamic design program was developed to account for complete radial equilibrium of flow and to evaluate losses on the basis of blade element loss prediction methods. Radial distribution of energy is specified as a polynomial variation of whirl velocity at the exit of each rotor blade row; rotor tip loadings are specified as are limiting values of rotor hub relative exit angles, stator hub Mach numbers, stator hub loadings, and the compressor flow path. The blockage factor is specified as the unblocked fraction of annulus area at the hub and casing of each axial station. The program user specifies a desired overall mass-averaged pressure ratio and provides data for a maximum number of stages, not to exceed twelve.

AXIAL FLOW COMPRESSOR DESIGN COMPUTER PROGRAMS
INCORPORATING FULL RADIAL EQUILIBRIUM. PART I—FLOW PATH AND
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SUMMARY

The technical objectives of the contract included generating a computer programmed compressor aerodynamic design system which accounts for full radial equilibrium of the flow, including streamline curvature and radial gradients in total enthalpy and entropy. The resulting design-point computation is iterative, with efficiencies determined through the use of correlated blade element profile loss data and the loss associated with a normal shock in the blade passages, where appropriate. The computer program is written with "buffer" storage capacity for up to ten sets of profile loss parameter data, each set including hub, mean, and tip data for diffusion factor values between 0 and 1.0. These profile loss data sets are elected by the program user for any given design calculation from a master file of up to 999 profile loss parameter sets. In this program, energy addition is determined through specification of the functional form of whirl velocity distribution at each rotor exit, and through specification of limiting values on four aerodynamic parameters for each stage. These aerodynamic parameters are:

1. Rotor tip diffusion factor
2. Stator hub diffusion factor
3. Stator hub Mach number
4. Rotor hub relative exit angle

In addition, the compressor flow path is specified.

The program accepts design input data for a specified maximum number of stages and, barring any error messages from the calculation, computes aerodynamic performance until either the maximum number of stages is reached or the specified overall pressure ratio is attained. The design computations may be based on 5, 7, 9, or 11 streamlines, at the user's option. Hub and tip blockages are input separately, at each axial station, as the unblocked fraction of local geometric annulus area. The program user has the capability of specifying the total mass flow at each axial calculation station. Any changes in mass flow are distributed proportionally among all streamtubes involved in the design computation.

The computation and the corresponding program logic are developed in detail in Appendix A (System of Equations and Computations) and Appendix C (Program Flow Charts). The Fortran IV Source Deck listing of the computer program is shown in Appendix B.

Input format and the preparation of required input data are presented in Appendix D, along with the data set describing a sample design problem. Appendix E illustrates the format of program output, through presentation of the computed results for the sample design problem.

INTRODUCTION

As a part of Contract NAS3-7277 for the NASA-Lewis Research Center, four axial flow computer programs were developed. The first of these programs was based on the assumption of simple radial equilibrium of static pressure and constant efficiency radially. In this program, limits on hub and tip ramp angles, axial velocity ratio across blade rows, rotor hub and stator tip loadings, rotor exit relative flow angle, and stator hub Mach number are specified; the velocity diagram and stage-by-stage performance are calculated. This program is reported in Reference 1.

The second program accounts for complete radial equilibrium of flow. Losses are evaluated on the basis of blade element loss prediction methods. Radial distribution of energy is specified as a polynomial variation of whirl velocities at the exit of each rotor blade row; rotor tip loadings are specified as are limiting values of rotor hub relative exit angles, stator hub Mach numbers, stator hub loadings, and the compressor flow path. This computer program is reported herein and will be designated as "Axial Flow Compressor Design Program II."

A third design program was also developed under this contract and will be reported at a later date. Program III differs from Program II in that the radial distribution of total pressure is specified rather than the whirl velocity distribution, and there is the option of specifying the flow path or specifying the axial velocity ratios and calculating the resulting flow path.

SYMBOLS

Note: The primary symbols are illustrated schematically in Figure 1.

a	sonic velocity, ft/sec
A, B, C, D, E	constants in whirl velocity polynomial
b	axial spacing of computational stations, in.
c_p	specific heat at constant pressure, BTU/lb _m -R°

D	diffusion factor; total derivative
F	blade force on gas, lb_f/lb_m
F, G, K, W	constants, variously defined in Equations (A-38) through (A-40) and in Equations (A-44) through (A-46)
g_c	universal gravitational constant, $32.174 \text{ ft-lb}_m/\text{lb}_f\text{-sec}^2$
H	enthalpy, BTU/lb_m
J	conversion factor, $778 \text{ ft-lb}_f/\text{BTU}$
L	overall compressor axial length, in.
M	Mach number
m	molecular weight, lb_m/mole
n	axial station index
N	number of axial stations
P	pressure, $\text{lb}_f/\text{in.}^2$ abs
Q	heat transfer rate, $\text{BTU}/\text{lb}_m\text{-sec}$
R	radius, in.
R_c	total pressure ratio
R_i	i^{th} rotor
$\mathcal{R}$	gas constant, $\text{ft-lb}_f/\text{lb}_m\text{-R}^\circ$
S	entropy, $\text{BTU}/\text{lb}_m\text{-R}^\circ$
S_i	i^{th} stator
t	time, sec
T	temperature, $^\circ\text{R}$
U	wheel speed, ft/sec
V	fluid velocity, ft/sec

w	mass flow rate, lb_m/sec
x	fraction of blade span
Z	axial coordinate, in.

Greek

α	ramp angle, degrees
β	air angle, measured from engine axis, degrees
γ	ratio of specific heats
δ	blockage factor expressed as unblocked fraction of annulus area
Δ	change; final value minus initial value
η	adiabatic efficiency
θ	circumferential coordinate, radians
ν	Prandtl-Meyer angle, degrees
ρ	density, lb_m/ft^3
σ	solidity
ϕ	air turning angle, degrees
ω	angular speed, radians/second
$\bar{\omega}$	blade total pressure loss coefficient

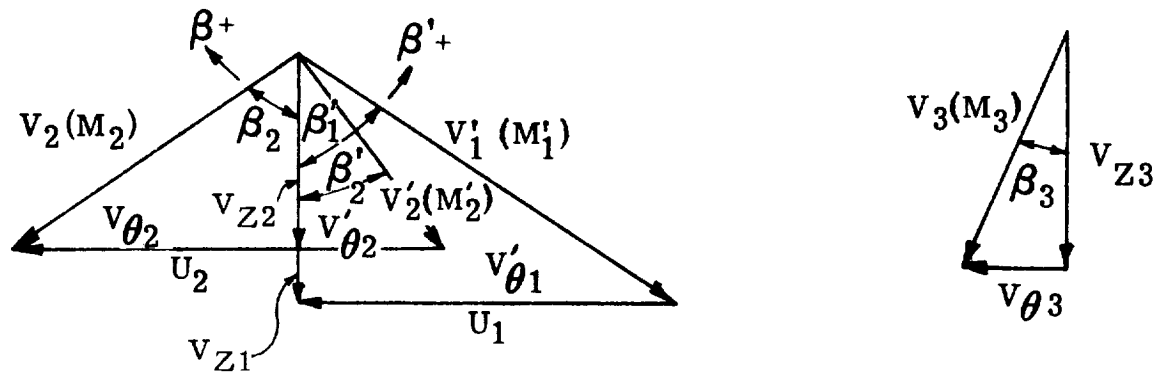
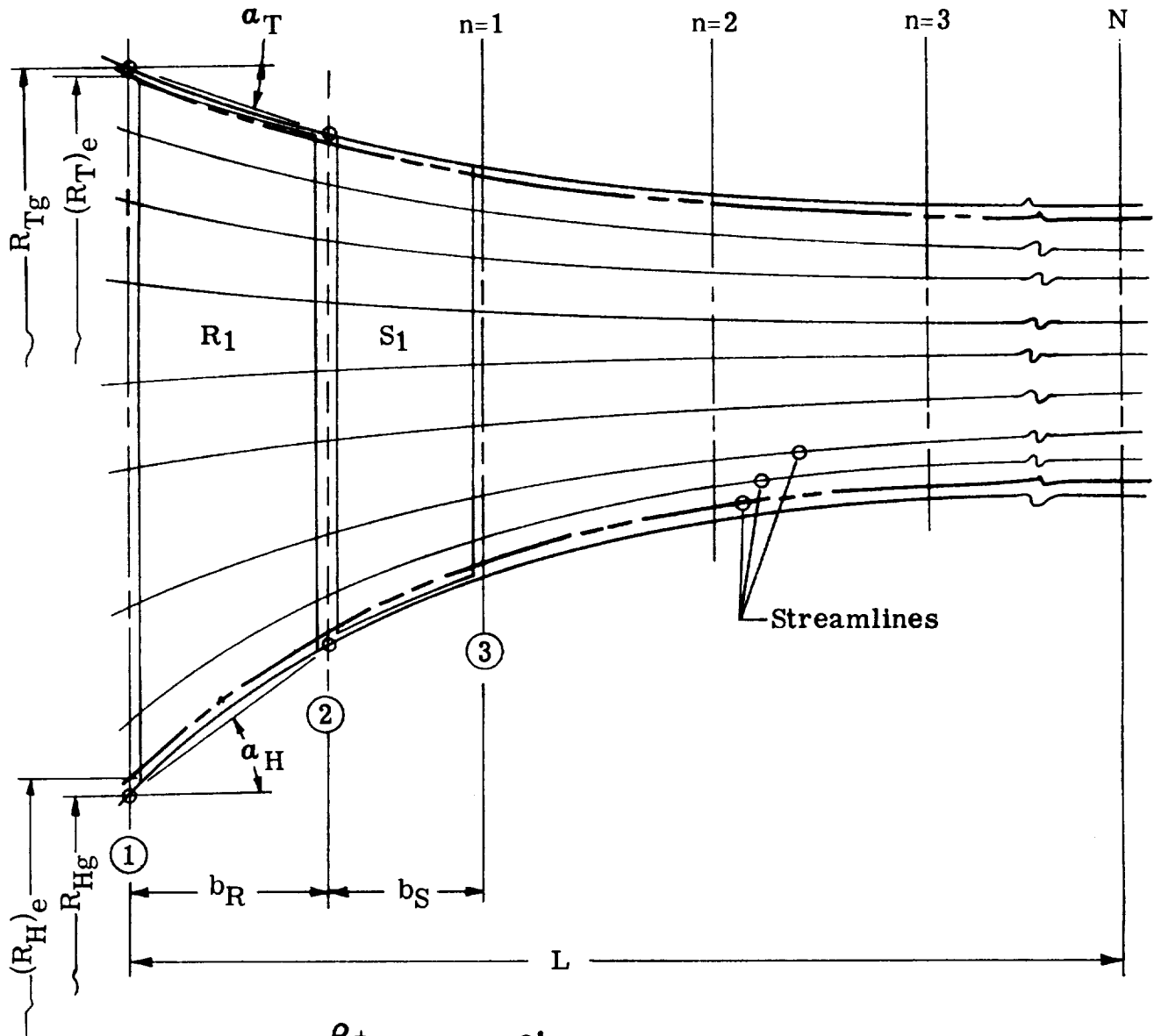
Subscripts

1	rotor entrance station
2	rotor exit station
3	stator exit station
e	effective value (of hub or tip radius)
g	geometric value (of hub or tip radius)

H	hub section
i	ideal
j	designates value of variable at reference streamline
L	limiting value
max	maximum value
p	profile
R	rotor; radial component
S	stator
s	shock
ss	supersonic
T	tip section
t	total
θ	whirl component
Z	axial component

Superscript

'	relative value of a variable
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Velocity diagram along a streamline

4575-1

Figure 1. Schematic presentation of symbols.

TECHNICAL DISCUSSION

The computer program, bearing Allison identification N-35, accounts for full radial equilibrium including radial gradients in total enthalpy and entropy. Specific heat is treated as a function of temperature with the exception of the computation of shock loss, where c_p is assumed constant; elsewhere in the calculation, all integrations involving c_p in the integrand are performed for variable c_p . The program will not calculate supersonic axial flows; a check is made at the mean streamline of each axial station and the computation is terminated whenever an axial Mach number greater than 1.0 is encountered in three consecutive passes of the calculation.

The program requires description of the flow path geometry, including location of all axial stations, plus hub and tip blockages at all stations. The computation of adiabatic efficiencies uses blade profile loss parameter data input as a function of diffusion factor for hub, mean, and tip sections. This profile loss data is interpolated and extrapolated to any point along the blade length by means of a second degree curve fit. Shock loss is computed at each streamline position by means of the shock model of Reference 2, using the ratio of supersonic turning to total turning input as a function of blade span for each blade row.

As mentioned in the summary, the program draws its input-specified profile loss data sets from a master file or library of up to 999 loss-data sets. This master file appears as permanent data and is located at the rear of the program deck; this library of loss data sets is the only information stored as permanent data. Up to ten of the profile loss-data sets may be selected for use in any one compressor design calculation. Each loss-data set consists of 20 values of profile loss parameter $(\bar{w}_p \cos \beta'_2) / 2 \sigma$ for each of the hub (10% span), mean (50% span), and tip (90% span) sections. These 60 values of loss parameter appear on 5 cards; each card consists of 12 fields of 6 columns each. The values of loss parameter for the hub section are entered first; next the values for the mean and tip sections. At each blade section, values are entered corresponding to increasing values of diffusion factor. The program automatically assigns the 20 loss-parameter values at any blade section to the 20 diffusion factor values 0, 0.1, 0.15, 0.20, 0.25, . . . , 1.0.

Aerodynamic design of each stage is governed by specified limiting values for each of four aerodynamic design parameters. These parameters are:

1. Rotor tip diffusion factor
2. Stator hub diffusion factor

3. Stator hub Mach number

4. Rotor hub exit relative flow angle

The program provides two alternative logic paths ensuring that the input-specified limiting values of these parameters are not violated in any stage. The program user may elect to: (1) drive the calculation to satisfaction of the most restrictive of its aerodynamic limits at each stage or (2) adjust the calculation at each stage so that all aerodynamic design parameters for that stage are less than or equal to their specified limiting values.

PROGRAM DESCRIPTION

The basic equations of motion which govern the three-dimensional flow of an inviscid compressible gas through a turbomachine have been derived in many reports such as Reference 3.

The pertinent equations for steady axisymmetric flow in cylindrical coordinates are:

Continuity Equation

$$\frac{1}{R} \frac{\partial(\rho R V_R)}{\partial R} + \frac{\partial(\rho V_Z)}{\partial Z} = 0 \quad (1)$$

Radial Equation of Motion

$$g_c J \frac{\partial H_t}{\partial R} = g_c F_R + g_c J T \frac{\partial S}{\partial R} + \frac{V_\theta}{R} \frac{\partial(R V_\theta)}{\partial R} + V_Z \left(\frac{\partial V_Z}{\partial R} - \frac{\partial V_R}{\partial Z} \right) \quad (2)$$

Circumferential Equation of Motion

$$0 = g_c F_\theta - \frac{1}{R} \left[V_R \frac{\partial(R V_\theta)}{\partial R} + V_Z \frac{\partial(R V_\theta)}{\partial Z} \right] \quad (3)$$

Axial Equation of Motion

$$g_c J \frac{\partial H_t}{\partial Z} = g_c F_Z + g_c J T \frac{\partial S}{\partial Z} + \frac{V_\theta}{R} \frac{\partial(R V_\theta)}{\partial Z} - V_R \left[\frac{\partial V_Z}{\partial R} - \frac{\partial V_R}{\partial Z} \right] \quad (4)$$

Energy Equation

$$\frac{D H_t}{D t} = Q + \frac{\omega}{g_c J} \frac{D(R V_\theta)}{D t} \quad (5)$$

Gradient of Entropy

$$\frac{DS}{Dt} = \frac{Q}{T} \quad (6)$$

Condition of Integrability

$$\frac{\partial}{\partial R} \left(\frac{F_Z}{R F_\theta} \right) = \frac{\partial}{\partial Z} \left(\frac{F_R}{R F_\theta} \right) \quad (7)$$

Equations (1) through (7) relate eight unknowns in F_R , F_θ , F_Z , V_R , V_θ , V_Z , S , and H_t .

The compressor design analysis considered for this study considers full radial equilibrium and radial gradients in total enthalpy and entropy. The simplifying assumptions are:

1. Only stations between blade rows are to be considered; therefore, F_R , F_θ , and F_Z are zero.
2. Heat transfer is zero therefore Q is zero.
3. Consideration need be given only to the radial equation of motion.

With these assumptions, Equations (3), (4), (6), and (7) are eliminated. Equation (1) is then rewritten for convenience as

$$w = 2\pi \int_{R_H}^{R_T} \rho V_Z R dR \quad (8)$$

and Equation (2) is written as

$$\begin{aligned} V_Z^2 - V_{Z_j}^2 = 2g_c J \int_{T_{t_j}}^{T_t} c_p(T) dT - (V_\theta^2 - V_{\theta_j}^2) - 2 \int_{R_j}^R \frac{V_\theta^2}{R} dR \\ - 2g_c J \int_{R_j}^R T \frac{\partial S}{\partial R} dR + 2 \int_{R_j}^R V_Z \left(\frac{\partial V_R}{\partial Z} \right)_R dR, \quad (9) \end{aligned}$$

where the subscript j here refers to the reference streamline used in the integration. The energy equation becomes

$$g_c J (\Delta H_t) = \omega \Delta (RV_\theta) \quad (10)$$

The method of solution of this set of equations in this application involves specification of the flow path geometry and an indirect specification of energy addition in each stage. Energy addition for a stage is established through a given functional form for rotor exit whirl velocity and given limiting values for the aerodynamic design parameters of each stage. Adiabatic efficiencies are computed through use of input profile loss data and the shock loss across a normal shock in the blade passage (Reference 2).

With blade inlet conditions known, exit velocity conditions are then computed iteratively through Equations (8) and (9).

The primary objective of this computer program is to calculate design parameter and performance in accordance with full radial equilibrium and with efficiencies determined from input blade element profile loss data, while ensuring that the specified limiting values of the four aerodynamic stage design parameters are not violated in any stage. During iterative solutions of Equations (8) and (9), efficiency and energy addition are revised as required to achieve this objective. Energy addition is determined by establishing a rotor exit whirl velocity level consistent with the limiting values of stage design parameters.

The detailed procedure to accomplish the objectives of this program and the development of the program logic to automate this design performance analysis are discussed in the following subsection. A detailed summary of the calculations is given in Appendix A.

DEVELOPMENT OF PROGRAM LOGIC

The given functional form for whirl velocity at the rotor exit and the specified limiting values for the four aerodynamic design parameters combine to control the energy addition in any given stage. The limiting values of the aerodynamic parameters may each be used to solve for a corresponding limiting value of rotor exit whirl velocity at the streamline where the parameter is specified. One of these four values of whirl velocity is most restrictive on stage design and is used in conjunction with the specified form for whirl velocity to establish stage energy addition.

The methods of rewriting the expressions for the limiting values of stage aerodynamic parameters to solve for rotor exit values of V_θ are developed in Appendix A.

1. The expression for the rotor tip diffusion factor is

$$D_{R_T} = 1.0 - \frac{V_{2T}'}{V_{1T}'} + \frac{U_{1T} - V_{\theta 1T} - U_{2T} + V_{\theta 2T}}{2\sigma_{R_T} V_{1T}'}$$

which rearranges to

$$V_{\theta 2T}^2 + G V_{\theta 2T} + W = 0 \quad (11)$$

where

$$G = \left[\frac{-2(U_{2T} + KF)}{1.0 - K^2} \right]$$

$$W = \left[\frac{V_{Z2T}^2 + U_{2T}^2 + V_{R2T}^2 - F^2}{1.0 - K^2} \right]$$

$$K = \frac{1}{2\sigma_{R_T}}$$

$$F = \left[(1.0 - D_{R_T}) V_{1T}' + \frac{U_{1T} - V_{\theta 1T} - U_{2T}}{2\sigma_{R_T}} \right]$$

Therefore,

$$V_{\theta 2T} = \frac{-G \pm \sqrt{G^2 - 4W}}{2} \quad (12)$$

where the calculation is restricted to positive, real roots. When the limiting value of rotor tip diffusion factor is used to evaluate F, the chosen solution of Equation (12) represents a critical value of rotor tip exit whirl velocity, satisfying the limiting value specified for rotor tip diffusion factor.

2. The expression for the stator hub diffusion factor is

$$D_{S_H} = 1.0 - \frac{V_{3H}}{V_{2H}} + \frac{V_{\theta 2H} - V_{\theta 3H}}{2\sigma_{S_H} V_{2H}} \quad (13)$$

which rearranges to

$$V_{\theta 2H}^2 + G V_{\theta 2H} + W = 0$$

where

$$G = \frac{-2KF}{F^2 - 1.0}$$

$$W = \frac{K^2 - V_{Z2H}^2 - V_{R2H}^2}{F^2 - 1.0}$$

$$K = \frac{\left[V_{Z3H}^2 + V_{\theta 3H}^2 + V_{R3H}^2 \right]^{1/2} + \frac{V_{\theta 3H}}{2\sigma S_H}}{1.0 - DS_H}$$

$$F = \frac{1}{2\sigma S_H (DS_H - 1.0)}$$

Hence,

$$V_{\theta 2H} = \frac{-G \pm \sqrt{G^2 - 4W}}{2} \quad (14)$$

where the calculation is again restricted to positive, real roots. Using the limiting value of DS_H to evaluate K and F , the resulting solution of Equation (14) represents a critical value of $V_{\theta 2H}$, based on the specified limit for DS_H in the given stage.

3. The expression for the stator hub Mach number is

$$MS_H = \frac{V_{2H}}{a_{S_H}}$$

where

$$a_{S_H} = \sqrt{\gamma \cdot g_c \cdot \mathcal{R} \cdot TS_H}$$

This rearranges to

$$V_{\theta 2H} = \left[M_{S_H}^2 a_{S_H}^2 - (V_{Z2H}^2 + V_{R2H}^2) \right]^{1/2} \quad (15)$$

If the limiting value of stator hub entrance Mach number is used in Equation (15), there results the corresponding critical value of $V_{\theta 2H}$.

4. The relative exit flow angle at the rotor hub is expressed as

$$\beta'_{2H} = \tan^{-1} \left[\frac{V'_{\theta 2H}}{(V_{Z2H}^2 + V_{R2H}^2)^{1/2}} \right]$$

it follows that

$$V'_{\theta 2H} = (V_{Z2H}^2 + V_{R2H}^2)^{1/2} \tan(\beta'_{2H}) \quad (16)$$

and

$$V_{\theta 2H} = U_{2H} - V'_{\theta 2H} \quad (17)$$

The limiting value of β'_{2H} may be used to solve for the corresponding critical value of $V_{\theta 2H}$.

Now, the absolute tangential velocity at the rotor exit is defined by the functional relationship:

$$V_{\theta 2} = \frac{A}{R_2^2} + \frac{B}{R_2} + C + DR_2 + ER_2^2 \quad (18)$$

where A, B, C, D, and E are constant coefficients. To use this expression for the radial evaluation of tangential velocity, some arbitrary method of determining the coefficients must be adopted, since any one of the four stage aerodynamic parameters provides a value of $V_{\theta 2}$ at only one radius and, therefore, can be used to evaluate only one of the five coefficients. It was decided to set values for the usually less prominent coefficients A, C, D, and E and to compute values for B, based on each of the four critical values of $V_{\theta 2}$, which arise from the limiting values of the aerodynamic parameters. This decision to compute values of B was influenced by the fact that assigning a value of zero to A, C, D, and E results in a free-vortex velocity distribution.

As already indicated, the program fixes the energy addition in a stage of the design through computation of four critical values of $V_{\theta 2}$, each corresponding to the given limiting value of an aerodynamic stage design parameter. Using these values of $V_{\theta 2}$, each at its appropriate radius, four values of the coefficient B are established using the relationship

$$B = RV_{\theta 2} - \left\{ \frac{A}{R_2} + CR_2 + DR_2^2 + ER_2^3 \right\} \quad (19)$$

The lowest value of B among the four values thus determined corresponds to the stage design parameter which is critical at the time in the design computation when this value of B is computed and selected. This selected value of B then defines the rotor exit whirl velocity distribution for its stage and hence establishes the stage energy addition at that point in the design computation.

The computer program satisfies the stage aerodynamic design parameters in either of two optional ways. The user may elect to: (1) reduce the program-stored value of the whirl velocity "B" coefficient for any stage whenever necessary to avoid exceeding the minimum of the four "critical" values of B computed for that stage in a given pass of the design computation or (2) use the minimum of the four values of B computed, for each pass in each stage of the designed compressor. The latter or "drive" option ensures that each stage of the final compressor design will satisfy the critical one of the four specified design parameters limiting values. The "no-drive" option ensures only that no stage of a design will exceed any of its specified limits for the aerodynamic design parameters.

The radial profile of axial velocity at an axial station is obtained by substituting Equation (18) into the radial equilibrium equation, (9), and integrating the resulting expression from a reference streamline j to any other streamline. The term $V_{Z_j}^2$ serves as the constant of integration and must be

selected to satisfy continuity; V_{Z_j} is established by trial and error at each axial station, for each pass of the design computation.

The program begins a design computation by reading in the specified data on which the design is to be based, including: (1) the coefficients describing c_p variation with temperature, (2) the loss data sets selected from the master file, and (3) data basically describing the machine to be designed, including relative error tolerances to be used in the iterative computations, and the design data for each of the maximum number of stages. The stage data includes:

- Limiting values for the aerodynamic parameters
- Specific loss data sets to be used for rotor and stator

- Flow increments in rotor and stator
- Polynomial coefficients describing exit whirl velocity distributions for rotor and stator
- Blade solidity distributions
- Distributions of the ratio of supersonic turning to total turning
- Specification of flow path

The program considers ten axial stations at any one point in its iterative design computations. The first five axial stations of the flow path represent the inlet, and the program computes three exit stations behind the last stage being designed. Hence, the program initially considers only the first stage, with the inlet ducting and the program-computed exit ducting making up the remaining eight axial stations initially considered.

The program begins its computation by evaluating T_t , P_t , and $c_p(T)$ in the inlet. Setting V_R and V_θ in the inlet to zero, and assuming dR/dZ and d^2R/dZ^2 both zero at the front of the machine, the program then sets mass flow rate throughout the inlet equal to the flow rate at the first station. Using flow increment data specified for each input blade row, total flow rate at each station of the entire input flow path is then computed.

Having established the number of streamtubes and the midstream index streamline to be used in axial velocity computations, the program next establishes a simple radial equilibrium solution of the flow equations for the initial ten stations; the whirl velocity distribution at the exit of the rotor is initially established using the input value for the B coefficient of the corresponding polynomial. At this point, the program establishes the full radial equilibrium solution to the flow equations for the ten stations initially considered. Streamline curvature effects and radial gradients in total enthalpy and entropy are included.

Next, the stage aerodynamic limits for the stage(s) among the ten axial stations currently considered are checked and any necessary iteration on the design of these stage(s) is performed, accounting for full radial equilibrium. This iteration may be accomplished with either the "drive" option or "no-drive" requested by the program user. Continuity is satisfied at every pass and convergence is established on efficiency.

When convergence is fully established, the desired pressure ratio input for this design is compared with the cumulative pressure ratio at the exit of the last stage in the current converged design. If the desired pressure ratio has not been met, and if the specified maximum number of stages allows, another stage is added to the design at this point. Two stations from the front of the design flow path are deleted, fully converged, at this point and the exit ducting is re-established in the "new" ten-station design flow path.

When a new stage is added, the current values of slopes, curvatures and axial velocities from the immediately preceding stage are used in the first pass on the new stage, and the design is redone (i. e., convergence is re-established) for all ten stations currently considered by the computer. The check of cumulative pressure ratio is made, and another stage added as before if needed and if available. The design computation may stop at numerous points and produce one of a number of error messages if difficulty is encountered for physical or numerical reasons. The stopping points and corresponding error messages are shown in the program flow charts and in the source deck listing, Appendices C and B, respectively.

PROGRAM RESTRICTIONS

It has been pointed out already that use of the limiting values of the aerodynamic stage design parameters DR_T , DS_H , and MS_H , to establish corresponding critical values of the "B" coefficient in the whirl velocity polynomial, is subject to restrictions on the choice of roots in establishing $V_{\theta 2}$ values at hub or tip.

A further restriction applies to the specification of limiting values for rotor tip diffusion factor and stator hub diffusion factor in a stage. If the maximum value of diffusion factor as defined below is exceeded in either case, both the corresponding roots for $V_{\theta 2}$ are complex, and physical meaning is lost. The program has error messages imbedded in the logic so that this condition may be readily determined.

The maximum level of rotor tip diffusion factor for the inlet flow conditions, tip speed, axial velocity ratio, and solidity can be easily established. The diffusion factor is

$$DR = 1 - \frac{V_2'}{V_1'} + \frac{V_{\theta 1}' - V_{\theta 2}'}{2 \sigma V_1'} \quad (20)$$

or

$$DR = 1 - \frac{V_{Z2}}{|\cos \beta_2'| V_1'} + \frac{(U_1 - V_{\theta 1}') - V_{Z2} \tan \beta_2'}{2 \sigma V_1'} \quad (21)$$

Since with established inlet conditions and V_{Z2} the rotor diffusion factor is dependent only on $V_{\theta 2}'$ or β_2' , Equation (21) can be solved for its maximum value. Differentiating, with β_2' considered to be in the first or fourth quadrant,

$$\frac{d(D_R)}{d\beta_2'} = - \frac{V_{Z_2}}{\cos^2 \beta_2' V_1'} \sin \beta_2' - \frac{V_{Z_2}}{2\sigma V_1'} \frac{1}{\cos^2 \beta_2'} \quad (22)$$

Setting the right hand side to zero and solving for β_2' , it is found that

$$(\beta_2')_{D_R \max} = \arcsin \left(-\frac{1}{2\sigma} \right) \quad (23)$$

and that D_R is at its maximum value. Substitution of Equation (23) into Equation (21) yields

$$D_{R \max} = 1 - \frac{V_{Z_2}}{\left(\frac{\sqrt{4\sigma^2 - 1}}{2\sigma} \right) V_1'} + \frac{(U_1 - V_{\theta_1}) + \frac{V_{Z_2}}{\sqrt{4\sigma^2 - 1}}}{2\sigma V_1'} \quad (24)$$

Similarly, the maximum level of stator hub diffusion factor for given flow conditions and solidity may be established. The stator diffusion factor is

$$D_S = 1.0 - \frac{V_3}{V_2} + \frac{V_{\theta_2} - V_{\theta_3}}{2\sigma V_2} \quad (25)$$

or

$$= 1.0 - \frac{V_3 |\cos \beta_2|}{V_{Z_2}} + \frac{|\cos \beta_2| \{V_{Z_2} \tan \beta_2 - V_{\theta_3}\}}{2\sigma V_{Z_2}} \quad (26)$$

Considering β_2 to lie in the first or fourth quadrant, it is possible to establish the following derivative:

$$\frac{dD_S}{d\beta_2} = \sin \beta_2 \left[\frac{V_3}{V_{Z_2}} + \frac{V_{\theta_3}}{2\sigma V_{Z_2}} \right] + \frac{1}{2\sigma} \left[\frac{1 - \sin^2 \beta_2}{\cos \beta_2} \right] \quad (27)$$

It follows that

$$(\beta_2)_{D_S \max} = \arcsin \left\{ \frac{-1}{2\sigma \left[\frac{V_3}{V_{Z_2}} + \frac{V_{\theta_3}}{2\sigma V_{Z_2}} \right]} \right\} \quad (28)$$

Substituting Equation (28) into Equation (26) results in the expression

$$D_{S \max} = 1.0 - \frac{\cos(\beta_2) D_{S \max}}{V_{Z_2}} \left\{ V_3 + \frac{1}{2\sigma} \left[\frac{V_{Z_2}}{2\sigma \left(\frac{V_3}{V_{Z_2}} + \frac{V_{\theta_3}}{2\sigma V_{Z_2}} \right)} + V_{\theta_3} \right] \right\} \quad (29)$$

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APPENDIX A

SYSTEM OF EQUATIONS AND COMPUTATIONS

The system of equations and computations presented in this appendix constitute an iterative design system for computing performance of multistage axial-flow compressors. It has been pointed out that the computation considers only stations between blade rows, in addition to inlet and exit stations. Full radial equilibrium of the flow is computed, including radial gradients of total enthalpy and entropy. Flow is assumed axisymmetric and the gas is considered ideal, with c_p taken as a function of temperature.

The computer-programmed design system will handle a maximum of 12 stages, with the design of individual stages limited by input-specified maximum values of four aerodynamic parameters in each stage. These parameters are: rotor tip diffusion factor, stator hub diffusion factor, stator hub inlet Mach number, and rotor hub exit relative flow angle. As described under Development of Program Logic and in Appendix D, the program user may elect to design all stages such that, in each stage, the converged design satisfies the most critical of the four aerodynamic limits. Alternatively, the program user may elect to design with only the assurance that no aerodynamic limits are violated anywhere in a converged design.

In summary, the following information is given:

- Specific heat at constant pressure, as a function of temperature
- Molecular weight of the gas
- Maximum number of stages in the planned design
- Minimum mass-averaged overall pressure ratio
- Total mass flow rate
- Number of streamlines to be considered in the design computation (5, 7, 9, 11)
- Fraction of the total flow passing between the hub and each successive streamline

Furthermore, in the inlet ducting and at the compressor entrance, the following items are given:

- Inlet total pressure
- Inlet total temperature
- Axial location of all inlet stations
- Hub radius and blockage at each axial station
- Tip radius and blockage at each axial station
- Radial variation of inlet guide vane loss coefficient (input by streamline)
- Radial variation of inlet guide vane exit whirl velocity
- Tip speed at the inlet of the first rotor

For each of the maximum number of stages in the design, the following items are given:

- Annulus geometry and blockages at hub and tip
- Radial distribution of solidity (rotor, stator)
- Initial radial distribution of rotor exit whirl velocity
- Radial distribution of stator exit whirl velocity
- Profile loss parameter correlations at hub, mean, tip (rotor, stator)
- Radial distribution of the ratio of supersonic turning to total turning (rotor, stator)
- Limiting values for rotor tip and stator hub diffusion factors
- Limiting value of stator hub inlet Mach number
- Limiting value of rotor hub exit relative flow angle

The basic equations employed in this design system are displayed in the description of computations presented here. The equations are presented in cylindrical coordinates, assuming axisymmetry and neglecting body forces. The solution is necessarily an iterative one, proceeding to the satisfaction of several error tolerances specified as input and described in Appendix D.

CONTINUITY EQUATION

$$w = 2 \pi \int_{R_{H_e}}^{R_{T_e}} \rho V_Z R dR \quad (A-1)$$

From geometric input dimensions and blockage, aerodynamic hub and tip radii are determined at each axial station. From the definitions

$$\delta_H = \frac{R_T^2 - R_{H_e}^2}{R_T^2 - R_H^2} = \text{hub blockage factor} \quad (A-2)$$

$$\delta_T = \frac{R_{T_e}^2 - R_H^2}{R_T^2 - R_H^2} = \text{tip blockage factor} \quad (A-3)$$

where blockage factor is the decimal portion of geometric area not blocked, there results the expressions

$$R_{H_e} = \left[\delta_H R_H^2 + (1 - \delta_H) R_T^2 \right]^{1/2} \quad (A-4)$$

$$R_{T_e} = \left[\delta_T R_T^2 + (1 - \delta_T) R_H^2 \right]^{1/2} \quad (A-5)$$

The annulus is subdivided into (j-1) streamtubes, where j is input as the number of streamlines considered in the design. The fraction of the total mass flow passing between the hub and each of the j streamlines is given as input and

$$\text{DELM (j)} = 2\pi \int_{R_{H_e}}^{R_j} \rho V_Z R dR \quad (\text{A-6})$$

ENERGY EQUATION

$$H_{t_2} - H_{t_1} = \frac{1}{g_c J} \left[U_2^2 + V_{\theta_2}^2 - U_1^2 - V_{\theta_1}^2 \right] \quad (\text{A-7})$$

T_{t_2} is determined by an iterative solution of the equation

$$H_{t_2} - H_{t_1} = \int_{T_{t_1}}^{T_{t_2}} c_p(T) dT \quad (\text{A-8})$$

solving for the upper limit of the integral.

The exit total pressure for the rotor at any streamline is determined using exit total temperature and efficiency. The adiabatic efficiency is then redetermined by calculating an isentropic temperature rise from an iterative solution of

$$P_{t_2} = P_{t_1} e^{\frac{J}{R} \left[\int_{T_{t_1}}^{T_{t_2}} c_p(T) \frac{dT}{T} \right]} \quad (\text{A-9})$$

and solving Equation (A-8) for $H_{t_2, i}$. Efficiency is then found from

$$\eta = \frac{H_{t_2, i} - H_{t_1}}{H_{t_2} - H_{t_1}} \quad (\text{A-10})$$

RADIAL EQUILIBRIUM EQUATION

$$V_Z^2 - V_{Zj}^2 = 2g_c J \int_{T_{tj}}^{T_t} c_p(T) dT - \left(V_\theta^2 - V_{\theta j}^2 \right) - 2 \int_{R_j}^R \frac{V_\theta^2}{R} dR \quad (A-11)$$

$$-2g_c J \int_{R_j}^R T \frac{\partial S}{\partial R} dR + 2 \int_{R_j}^R V_Z \left(\frac{\partial V_R}{\partial Z} \right)_R dR$$

The entropy gradient term of the radial equilibrium equation is evaluated from the following expression

$$2g_c J \int_{R_j}^R T \frac{\partial S}{\partial R} dR = 2g_c J \int_{R_1}^{R_2} T \frac{\partial}{\partial R} \left[\int_{T_{t1}}^{T_{t2}} c_p(T) \frac{dT}{T} - \frac{R}{J} \ln \frac{P_{t2}}{P_{t1}} \right] dR \quad (A-12)$$

The streamline curvature term is evaluated from

$$2 \int_{R_j}^R V_Z \left(\frac{\partial V_R}{\partial Z} \right)_R dR = 2 \int_{R_j}^R V_Z \left(\frac{\partial V_R}{\partial Z} \right)_\psi dR - 2 \left[\frac{V_R^2 - V_{Rj}^2}{2} \right] \quad (A-13)$$

where the subscript ψ designates a derivative taken along a streamline.

EQUATION OF STATE

$$\rho = \frac{P}{R T} \quad (A-14)$$

STATIC-TO-TOTAL AND RELATIVE-TO-ABSOLUTE CONVERSIONS

From the definition of total enthalpy, the relationship

$$H_t - H = \frac{V^2}{2g_c J} \quad (A-15)$$

is established.

Static temperature is evaluated iteratively from

$$H_t - H = \int_T^{T_t} c_p(T) dT \quad (A-16)$$

and static pressure is calculated from

$$P = P_t e^{\left[\frac{J}{R} \int_{T_t}^T \frac{c_p(T) dT}{T} \right]} \quad (A-17)$$

Relative total enthalpies are determined from

$$H'_t - H_t = \frac{1}{2g_c J} [V'^2 - V^2] \quad (A-18)$$

Relative total temperature is found iteratively from

$$H'_t - H = \int_T^{T'_t} c_p(T) dT \quad (A-19)$$

and relative total pressure is evaluated using the expression

$$P'_t = P e^{\left[\frac{J}{R} \int_T^{T'_t} \frac{c_p(T) dT}{T} \right]} \quad (A-20)$$

LOSS CALCULATION

The total pressure loss coefficient is defined for rotors as

$$\bar{\omega}'_t = \frac{P'_{t2,i} - P'_{t2}}{P'_{t1} - P_1} \quad (A-21)$$

and for stators as

$$\bar{\omega}_t = \frac{P_{t2} - P_{t3}}{P_{t2} - P_2} \quad (A-22)$$

The total loss coefficient is taken as the sum of profile and shock loss coefficients

$$\bar{\omega}_t = \bar{\omega}_p + \bar{\omega}_s \quad (A-23)$$

The shock loss coefficient is calculated on the basis of the normal-shock-in-passage model presented in Reference 2 (See References in report). In this computation, the specific heat of the gas is evaluated at local temperature but is not treated rigorously as a variable. For each stage in a design calculation, the computer program receives as input a radial distribution of the ratio of supersonic turning to total turning for both rotor and stator. Supersonic turning is computed as

$$\phi_{ss} = \left(\beta'_1 - \beta'_2 \right) \frac{\phi_{ss}}{\phi_{total}} \quad (A-24)$$

For stators, the absolute air angles are substituted. If the relative inlet Mach number is equal to or greater than 1.0, the inlet Prandtl-Meyer angle is calculated from

$$v_1 = \sqrt{\frac{\gamma+1}{\gamma-1}} \tan^{-1} \sqrt{\frac{\gamma-1}{\gamma+1} (M_1'^2 - 1)} - \tan^{-1} \sqrt{M_1'^2 - 1} \quad (A-25)$$

The Prandtl-Meyer angle at the intersection of the assumed normal shock with the suction surface is calculated from

$$v_{ss} = v_1 + \phi_{ss} \quad (A-26)$$

The Mach number at this location is then determined from an iterative solution of the expression

$$v_{ss} = \sqrt{\frac{\gamma+1}{\gamma-1}} \tan^{-1} \sqrt{\frac{\gamma-1}{\gamma+1} (M_{ss}'^2 - 1)} - \tan^{-1} \sqrt{M_{ss}'^2 - 1} \quad (A-27)$$

The effective shock upstream Mach number, from which the pressure ratio across the shock is computed, is

$$M_e' = \frac{1}{2} \left(M_1' + M_{ss}' \right) \quad (A-28)$$

Using the normal shock relationship, Equation (99), Reference 4 (in report),

$$\left(\frac{P_{t2}'}{P_{t1}'} \right)_{\text{normal shock}} = \left[\frac{(\gamma + 1) M_e'^2}{(\gamma - 1) M_e'^2 + 2} \right]^{\gamma/\gamma - 1} \left[\frac{\gamma + 1}{2\gamma M_e'^2 - (\gamma - 1)} \right]^{1/\gamma - 1} \quad (\text{A-29})$$

the shock total pressure ratio is determined. The shock loss coefficient is then evaluated as

$$\bar{\omega}_s = \frac{1 - \left(\frac{P_{t2}'}{P_{t1}'} \right)_{\text{normal shock}}}{1 - \left(\frac{P_1}{P_{t1}'} \right)} \quad (\text{A-30})$$

where

$$\frac{P_1}{P_{t1}'} = \left[1 + \frac{\gamma - 1}{2} M_1'^2 \right]^{-\gamma/\gamma - 1} \quad (\text{A-31})$$

Now, if the inlet relative Mach number is less than 1.0, the effective upstream shock Mach number is calculated as

$$M_e' = M_1' \times \frac{1}{2} \times (1 + M_{ss}') \quad (\text{A-32})$$

where M_{ss}' is a function of ϕ_{ss} determined by iterative solution of the equation

$$\phi_{ss} = \sqrt{\frac{\gamma + 1}{\gamma - 1}} \times \tan^{-1} \sqrt{\frac{\gamma - 1}{\gamma + 1} (M_{ss}'^2 - 1)} - \tan^{-1} \sqrt{M_{ss}'^2 - 1} \quad (\text{A-33})$$

If M_e' is greater than 1.0, $\bar{\omega}_s$ is evaluated using Equations (A-29), (A-31),

and (A-30) as before. If M_e' is less than 1.0, $\bar{\omega}_s$ is assumed equal to 0.

The profile loss coefficient is determined from blade element loss data, input as profile loss parameter $\frac{\bar{\omega}_p \cos \beta'_2}{2\sigma}$ correlated as a function of diffusion

factor for hub, mean and tip sections as described earlier and in Appendix D. The hub and tip loss data sets are associated with 10% span and 90% span, respectively. Blade diffusion factor is calculated as

$$D_R = 1.0 - \frac{V_2'}{V_1'} + \frac{V_{\theta 1}' - V_{\theta 2}'}{2\sigma V_1'} \quad (\text{For rotors}) \quad (\text{A-34})$$

and

$$D_S = 1.0 - \frac{V_3}{V_2} + \frac{V_{\theta 2} - V_{\theta 3}}{2\sigma V_2} \quad (\text{For stators}) \quad (\text{A-35})$$

where solidity, σ , is determined at the average radius associated with a stream surface in the blade passage.

When the diffusion factor is established for the flow along a given streamline in a given blade row, the average percent span for that streamline in the passage is used to establish a profile loss parameter value associated with the given streamline. The loss parameter is established using a parabolic curve fit along the blade span, using the mean section loss parameter value and the hub or tip section value, as appropriate. Both loss parameter values are taken at the diffusion factor level computed for the subject streamline. The parabolic fit takes the form

$$\left[\frac{\bar{\omega}_p \cos \beta_2'}{2\sigma} \right]_x = \left[\frac{\bar{\omega}_p \cos \beta_2'}{2\sigma} \right]_{0.5} + 6.25 (x - 0.5)^2 \left[\left(\frac{\bar{\omega}_p \cos \beta_2'}{2\sigma} \right)_{0.9, 0.1} - \left(\frac{\bar{\omega}_p \cos \beta_2'}{2\sigma} \right)_{0.5} \right] \quad (\text{A-36})$$

The profile loss coefficient is then computed directly, using solidity and stream-plane relative exit flow angle at the subject streamline.

The total loss coefficient is used to establish an actual exit total pressure using Equation (A-21) or Equation (A-22), as appropriate. This exit total pressure is used to re-establish adiabatic efficiency through the use of Equations (A-9), (A-8) and (A-10), as described earlier.

ENERGY ADDITION—Determined by Stage Aerodynamic Design Parameters

As described earlier, and in Appendix D, the computer program user may elect to design each compressor stage to satisfy the critical one of the four limiting values specified for its aerodynamic design parameters, or the user may elect to design only with the assurance that all converged stage designs will not violate any of the prescribed aerodynamic limits. Satisfaction of the critical one of four aerodynamic limits in each converged stage design occurs in the so-called "drive" option, where the rotor exit whirl velocity distribution (B coefficient in whirl polynomial) is adjusted to satisfy the critical aerodynamic limit at each re-assessment of loading in each stage during design computations. By contrast, the "no-drive" program option merely decreases the B coefficient of the rotor exit whirl velocity polynomial sufficiently to avoid a violation of an aerodynamic limit each time such a violation is encountered during re-assessment of loading. It is possible and likely that during design computations prior to convergence in any given stage, the whirl velocity distribution in this program option will be reduced to a level such that none of the four design-limiting criteria are equalled in the converged design when the no-drive option is used.

Summarizing, each of the four design criteria is used to establish a corresponding distribution of whirl velocity; that is, each aerodynamic limit may be used to determine a value of the B coefficient in the rotor exit whirl velocity polynomial at a given point in the design computations. In the "drive" program option, the lowest of these four values of B is chosen and used to define the rotor exit whirl velocity distribution at that point in the calculation. In the "no-drive" program option, the B value is changed to equal the lowest of the four computed values only if B is currently larger than the lowest of the four values computed from the stage aerodynamic design limits.

Expressions for the B coefficient in terms of aerodynamic parameters are developed as follows.

1. B coefficient in terms of rotor tip diffusion factor

The diffusion factor at the rotor tip is given by

$$D_{RT} = 1.0 - \frac{V'_{2T}}{V'_{1T}} + \frac{V'_{\theta 1T} - V'_{\theta 2T}}{2\sigma_{RT} V'_{1T}} \quad (A-37)$$

or

$$D_{RT} = 1.0 - \frac{V'_{2T}}{V'_{1T}} + \frac{U_{1T} - V_{\theta 1T} - U_{2T} + V_{\theta 2T}}{2\sigma_{RT} V'_{1T}}$$

This may be rearranged as

$$V'_{2T} = \frac{V_{\theta 2T}}{2\sigma_{RT}} + \left[(1.0 - D_{RT}) V'_{1T} + \frac{U_{1T} - V_{\theta 1T} - U_{2T}}{2\sigma_{RT}} \right]$$

or as

$$V'_{2T} = K V_{\theta 2T} + F \quad (A-38)$$

where

$$K = \frac{1}{2\sigma_{RT}}$$

and

$$F = \left[(1.0 - D_{RT}) V'_{1T} + \frac{U_{1T} - V_{\theta 1T} - U_{2T}}{2\sigma_{RT}} \right]$$

now

$$V'_{2T} = \left[(U_{2T} - V_{\theta 2T})^2 + V_{R2T}^2 + V_{Z2T}^2 \right]^{1/2} \quad (A-39)$$

Squaring and equating (A-38) and (A-39) results in

$$\begin{aligned} U_{2T}^2 - 2U_{2T} V_{\theta 2T} + V_{\theta 2T}^2 + V_{R2T}^2 \\ + V_{Z2T}^2 = K^2 V_{\theta 2T}^2 + 2KF V_{\theta 2T} + F^2 \end{aligned}$$

which reduces to

$$V_{\theta 2T}^2 + \left[\frac{-2 (U_{2T} + KF)}{1.0 - K^2} \right] V_{\theta 2T} + \left[\frac{V_{Z2T}^2 + U_{2T}^2 + V_{R2T}^2 - F^2}{1.0 - K^2} \right] = 0$$

or

$$V_{\theta 2T}^2 + G V_{\theta 2T} + W = 0 \quad (A-40)$$

where

$$G = \left[\frac{-2 (U_{2T} + KF)}{1.0 - K^2} \right]$$

and

$$W = \left[\frac{V_{Z2T}^2 + U_{2T}^2 + V_{R2T}^2 - F^2}{1.0 - K^2} \right]$$

The absolute tangential velocity at the rotor tip may be obtained by solving Equation (A-40).

$$V_{\theta 2T} = \frac{-G \pm \sqrt{G^2 - 4W}}{2} \quad (A-41)$$

The calculation is restricted to positive real roots. The coefficient B is given by

$$B = R_{2T} V_{\theta 2T} - C R_{2T} - D R_{2T}^2 - E R_{2T}^3 - \frac{A}{R_{2T}} \quad (A-42)$$

2. B coefficient in terms of stator hub diffusion factor

The stator hub diffusion factor is expressed as

$$D_{SH} = 1.0 - \frac{V_{3H}}{V_{2H}} + \frac{V_{\theta 2H} - V_{\theta 3H}}{2\sigma_{SH} V_{2H}} \quad (A-43)$$

This equation may be arranged as

$$V_{2H} = -K + F V_{\theta 2H} \quad (A-44)$$

where

$$K = \frac{\left[V_{Z_{3H}}^2 + V_{\theta_{3H}}^2 + V_{R_{3H}}^2 \right]^{1/2} + \frac{V_{\theta_{3H}}}{2\sigma_{SH}}}{1.0 - D_{SH}}$$

and

$$F = \frac{1}{2\sigma_{SH} (D_{SH} - 1.0)}$$

Now, expressing V_{2H} in terms of its components and squaring Equation (A-44), there results

$$V_{\theta_{2H}}^2 + V_{\theta_{2H}} G + W = 0 \quad (A-45)$$

where

$$G = \frac{-2KF}{F^2 - 1.0}$$

$$W = \frac{K^2 - V_{Z_{2H}}^2 - V_{R_{2H}}^2}{F^2 - 1.0}$$

Hence,

$$V_{\theta_{2H}} = \frac{-G \pm \sqrt{G^2 - 4W}}{2} \quad (A-46)$$

where the calculation is again restricted to positive, real roots. Using the limiting value of D_{SH} to evaluate K and F, the resulting solution of

Equation (A-46) represents a critical value of $V_{\theta_{2H}}$. The corresponding B coefficient is expressed as in Equation (A-42).

3. B coefficient in terms of stator hub Mach number

The sonic velocity at a stator hub is

$$a_{S_H} = \sqrt{\gamma g_c \mathcal{R} T_{2_H}} \quad (A-47)$$

and

$$\frac{V_{2_H}}{a_{S_H}} \equiv M_{S_H} \quad (A-48)$$

This may be written as

$$M_{S_H} = \frac{\left[V_{\theta 2_H}^2 + V_{R 2_H}^2 + V_{Z 2_H}^2 \right]^{1/2}}{a_{S_H}} \quad (A-49)$$

Squaring and rearranging results in

$$V_{\theta 2_H} = \left[M_{S_H}^2 a_{S_H}^2 - \left(V_{Z 2_H}^2 + V_{R 2_H}^2 \right) \right]^{1/2} \quad (A-50)$$

Note that where the quantity shown in parentheses here is negative, the limiting value of M_{S_H} cannot be satisfied by adjusting $V_{\theta 2_H}$. The program produces an error message when this condition is encountered. As before, the B coefficient is given by Equation (A-42).

4. B coefficient in terms of rotor hub exit relative flow angle

The relative exit flow angle at the hub is

$$\beta'_{2_H} = \tan^{-1} \left[\frac{V'_{\theta 2_H}}{\left(V_{Z 2_H}^2 + V_{R 2_H}^2 \right)^{1/2}} \right] \quad (A-51)$$

Thus,

$$V'_{\theta 2_H} = \left(V_{Z 2_H}^2 + V_{R 2_H}^2 \right)^{1/2} \tan \left(\beta'_{2_H} \right)$$

and

$$V_{\theta_{2H}} = U_{2H} - \left(V_{Z_{2H}}^2 + V_{R_{2H}}^2 \right)^{1/2} \tan \left(\beta'_{2H} \right) \quad (A-52)$$

When the limiting value of β'_{2H} is employed to evaluate $V_{\theta_{2H, L}}$, the corresponding limiting value of the B coefficient is obtained from Equation (A-42).

APPENDIX B

FORTRAN IV SOURCE DECK LISTING

INDEX

<u>Subroutine</u>	<u>Page</u>
MAIN	B- 1
ANEXIT	B-18
B2CAL	B-19
B2CAL1	B-21
B2CAL2	B-22
B2CAL3	B-23
CAXIAL	B-25
COPY	B-30
DATA	B-31
DATAL	B-32
DRIVE	B-33
ENTALP	B-35
ERROR	B-36
GAM	B-41
INEST	B-42
INLET	B-44
INTEG	B-46
LOSE	B-48
LOSS	B-50
MOVE	B-56
OUTLET	B-58
OUTPUT	B-60
PRFIT2	B-71
RDERIV	B-74
ROTOU	B-75
RSTART	B-78
SHOCK	B-79
SLINE	B-80
STAOUT	B-81
STREAM	B-84
THERM1	B-87
THERM2	B-88
THERM3	B-89
THERMP	B-90
XDERIV	B-91

12/15/67

SUBROUTINE MAIN
INTEGER BLADE

C	***** PROGRAM COMMENTS *****	MAIN	2
		MAIN	3
		MAIN	4
C	*** THIS CALCULATION WILL YIELD THE STAGE LOADING AND DESIGN	MAIN	5
C	POINT PERFORMANCE OF AN AXIAL FLOW COMPRESSOR WHICH MEETS	MAIN	6
C	THE FOLLOWING CONDITIONS...	MAIN	7
C	1. A MINIMUM PRESSURE RATIO.	MAIN	8
C	2. A MAXIMUM NUMBER OF STAGES.	MAIN	9
C	3. A MAXIMUM ASPECT RATIO FOR EACH BLADE ROW.	MAIN	10
C	4. STAGE EFFICIENCY PROFILE WHICH MATCHES THE LOSS	MAIN	11
C	TABLES.	MAIN	12
C	5. MAXIMUM ABSOLUTE MACH NUMBER AT THE STATOR ENTRANCE	MAIN	13
C	AT THE HUB.	MAIN	14
C	6. MAXIMUM STATOR HUB D-FACTOR.	MAIN	15
C	7. MAXIMUM RELATIVE FLOW ANGLE OUT OF THE ROTOR HUB.	MAIN	16
C	8. MAXIMUM ROTOR TIP D-FACTOR (OPTIONAL).	MAIN	17
C	*** OTHER INPUT PARAMETERS INCLUDE...	MAIN	18
C	• HUB AND TIP BLOCKAGE FACTORS AT EACH AXIAL STATION.	MAIN	19
C	• SPECIFIC HEAT AS A FUNCTION OF TEMPERATURE.	MAIN	20
C	• BLADE ELEMENT LOSS DATA.	MAIN	21
C	• SOLIDITY, WHIRL VELOCITY AND ESTIMATED EFFICIENCY AS	MAIN	22
C	A FUNCTION OF RADIUS.	MAIN	23
C	• DESIGN SPEED AND AIRFLOW.	MAIN	24
C	• ANNULUS GEOMETRY.	MAIN	25
C	• INLET GUIDE VANE LOSS COEFFICIENT.	MAIN	26
C	***** OUTLINE OF THE CALCULATION PROCEDURE *****	MAIN	27
C	*** THE CALCULATION BEGINS BY SOLVING THE SIMPLE RADIAL	MAIN	28
C	EQUILIBRIUM (SRE) FLOW EQUATION AT THE INLET OF THE	MAIN	29
C	MACHINE.	MAIN	30
C	*** THEN THE FLOW THROUGH THE INLET, FIRST ROTOR AND	MAIN	31
C	STATOR, AND THE PROGRAM PREPARED EXIT IS ANALYZED	MAIN	32
C	WITH THE INPUT LOADING AND A CONSTANT EFFICIENCY	MAIN	33
C	PROFILE (CURVATURE EFFECTS INCLUDED).	MAIN	34
C	*** NOW THE LOADING IS ALTERED TO MEET ONE OF LIMITS D,	MAIN	35
C	6,7, AND E.	MAIN	36
C	*** NOW THE LOSS IS DETERMINED FROM THE INPUT MAPS AND THE	MAIN	37
C	CORRESPONDING EFFICIENCY IS CALCULATED. IF THE INPUT	MAIN	38
C	EFFICIENCIES DO NOT MATCH THE CALCULATED EFFICIENCIES THE	MAIN	39
C	INPUT EFFICIENCIES ARE RE-SET AND THE CALCULATION REPEATED	MAIN	40
C	FROM THE POINT WHERE CURVATURE EFFECTS WERE INTRODUCED.	MAIN	41
C	THIS PROCEDURE IS REPEATED UNTIL THE INPUT AND CALCULATED	MAIN	42
C	EFFICIENCIES CONVERGE.	MAIN	43
C	*** IF CUMULATIVE MASS AVERAGE PRESSURE RATIO IS BELOW THE	MAIN	44
C	REQUIRED MINIMUM AN ADDITIONAL STAGE IS ADDED TO THE	MAIN	45
C	COMPRESSOR. THE CALCULATION IS DEvised TO CONSIDER ONLY	MAIN	46
		MAIN	47
		MAIN	48
		MAIN	49
		MAIN	50
		MAIN	51
		MAIN	52
		MAIN	53
		MAIN	54
		MAIN	55
		MAIN	56

12/15/67

MAIN. - EFN SOURCE STATEMENT - IFN(S) -

C	THE LAST 10 AXIAL STATIONS AT A TIME.	MAIN	57
		MAIN	58
		MAIN	59
		MAIN	60
		MAIN	61
		MAIN	62
		MAIN	63
C	***** PROGRAM VARIABLES *****	MAIN	64
		MAIN	65
		MAIN	66
C	***** DIMENSIONED VARIABLES *****	MAIN	67
		MAIN	68
C	ALPHA - USED FOR THE ABSOLUTE FLOW ANGLE	MAIN	69
		MAIN	70
C	ATAR - ROTOR EFFICIENCY (AND STAGE EFFICIENCY DEPENDING	MAIN	71
C	ON THE INDEX) EQUIVALENCED TO ATAS.	MAIN	72
		MAIN	73
C	ATAS - STAGE EFFICIENCY (SEE ATAR).	MAIN	74
		MAIN	75
C	B2 - CONTAINS THE VALUE OF THE COEFFICIENT OF 1.0/R	MAIN	76
C	IN THE WHIRL VELOCITY INPUT EQUATION.	MAIN	77
		MAIN	78
		MAIN	79
C	BETA - RELATIVE FLOW ANGLE	MAIN	80
		MAIN	81
C	BH - BLOCKAGE FACTOR AT THE HUB.	MAIN	82
		MAIN	83
C	BLADE - BLADE TYPE (INTEGER).	MAIN	84
		MAIN	85
C	BT - BLOCKAGE FACTOR AT THE TIP.	MAIN	86
		MAIN	87
C	CD - SCRATCH VECTOR USED IN STREAM AND CAXIAL.	MAIN	88
		MAIN	89
C	CP - SPECIFIC HEAT AT CONSTANT PRESSURE.	MAIN	90
		MAIN	91
C	CPCD - COEFFICIENTS OF SPECIFIC HEAT AT CONSTANT	MAIN	92
C	PRESSURE AS A FUNCTION OF TOTAL TEMPERATURE.	MAIN	93
		MAIN	94
C	CR - RADIAL COMPONENT OF VELOCITY.	MAIN	95
		MAIN	96
C	CSLOPE - DERIVATIVE OF AXIAL VELOCITY WITH RESPECT TO	MAIN	97
C	AXIAL LENGTH.	MAIN	98
		MAIN	99
C	CU2 - TANGENTIAL OR WHIRL VELOCITY SQUARED.	MAIN	100
		MAIN	101
C	CU - TANGENTIAL COMPONENT OF VELOCITY.	MAIN	102
		MAIN	103
C	CUCU - CONTAIN COEFFICIENTS OF WHIRL VELOCITY EQUATION.	MAIN	104
		MAIN	105
C	CX - AXIAL COMPONENT OF VELOCITY - I.E. AXIAL VELOCITY.	MAIN	106
		MAIN	107
C	CXM - AXIAL VELOCITY NORMALIZED TO THE MEAN LINE AXIAL	MAIN	108
C	VELOCITY (ALSO USED AS A SCRATCH VECTOR).	MAIN	109
		MAIN	110
C	CXNEW - AXIAL VELOCITY CALCULATED FROM THE CURVATURE	MAIN	111
C	EQUATION.	MAIN	112

12/15/67

MAIN. - EFN SOURCE STATEMENT - IFN(S) -

C	CXS	- AXIAL VELOCITY FROM THE CONTINUITY EQUATION.	MAIN 113
C	DA	- VALUE OF INTEGRAL FROM J TO J+1.	MAIN 114
C	DELM	- FRACTION MASS FLOW BETWEEN HUB AND J-TH STREAM-	MAIN 115
C		LINE. MUST BE STRICTLY MONOTONIC IN J.	MAIN 116
C	DEPV	- SCRATCH VECTOR.	MAIN 117
C	DF	- INDEPENDENT VALUES OF D-FACTOR USED WITH FOUNO	MAIN 118
C		TO DETERMINE LOSS COEFFICIENTS.	MAIN 119
C	DFACT	- D-FACTORS.	MAIN 120
C	DFL	- D-FACTOR LIMIT.	MAIN 121
C	DFLOW	- ON READ-IN DFLOW CONTAINS THE INCREMENTAL MASS	MAIN 122
C		FLOW RATE PER BLADE ROW. IT IS EQUIVALENCED TO	MAIN 123
C		FLOW AND WILL LATER CONTAIN THE MASS FLOW RATE	MAIN 124
C		PER STATION.	MAIN 125
C	EMACH	- CONTAINS THE AVERAGED MACH NUMBER USED TO	MAIN 126
C		CALCULATE THE SHOCK LOSS. IN OUTPUT IT	MAIN 127
C		CONTAINS A*/S.	MAIN 128
C	FLOW	- MASS FLOW RATE (SEE DFLOW).	MAIN 129
C	FOUND	- LOSS COEFFICIENTS FOR VARIOUS D-FACTORS, BLADE	MAIN 130
C		TYPES AND 10,50 AND 90 PER CENT BLADE HEIGHTS.	MAIN 131
C	FRDEL	- SCRATCH	MAIN 132
C	GAMMA	- RATIO OF SPECIFIC HEAT.	MAIN 133
C	HMN	- ON THE ROTOR INDEX THIS VECTOR CONTAINS THE HUB	MAIN 134
C		ABSOLUTE MACH NUMBER LIMIT. ON THE STATOR INDEX	MAIN 135
C		IT CONTAINS THE RELATIVE FLOW ANGLE LIMIT.	MAIN 136
C	MACH	- ABSOLUTE AND RELATIVE MACH NUMBERS.	MAIN 137
C	OBAR	- LOSS COEFFICIENT.	MAIN 138
C	PG	- TOTAL PRESSURE	MAIN 139
C	R	- STREAMLINE RADII.	MAIN 140
C	RCLKVE	- THE SECOND DERIVATIVE OF RADIUS WITH RESPECT TO	MAIN 141
C		AXIAL LENGTH.	MAIN 142
C	RH	- HUB RADIUS.	MAIN 143
C	RHO	- STATIC DENSITY.	MAIN 144
C	RINT	- INTEGRAL FROM J TO JM.	MAIN 145
			MAIN 146
			MAIN 147
			MAIN 148
			MAIN 149
			MAIN 150
			MAIN 151
			MAIN 152
			MAIN 153
			MAIN 154
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12/15/67

MAIN.	- EFN	SOURCE STATEMENT	- IFN(5)	-
C		ROSTAG - STAGNATION DENSITY.	MAIN	169
C		RS - SHROUD RADIUS.	MAIN	170
C		RSLOPE - FIRST DERIVATIVE OF RADIUS WITH RESPECT TO	MAIN	171
C		AXIAL LENGTH.	MAIN	172
C		RTRAIL - NEW STREAMLINE RADIUS.	MAIN	173
C		SGCO - COEFFICIENTS OF SOLIDITY POLYNOMIAL.	MAIN	174
C		SCLO - SOLIDITY.	MAIN	175
C		SSCO - COEFFICIENTS OF THE RATIO OF SUPERSONIC TO TOTAL	MAIN	176
C		TURNING.	MAIN	177
C		TERM1 - SCRATCH VECTOR.	MAIN	178
C		TERMA - SCRATCH VECTOR.	MAIN	179
C		TERMB - SCRATCH VECTOR.	MAIN	180
C		TERMC - SCRATCH VECTOR.	MAIN	181
C		TITLE - RUN TITLE (ALPHANUMERIC IDENTIFICATION OF A	MAIN	182
C		DATA SET).	MAIN	183
C		TO - TOTAL TEMPERATURE.	MAIN	184
C		TSTAT - STATIC TEMPERATURE.	MAIN	185
C		U - WHEEL SPEED.	MAIN	186
C		W - LOSS FACTORS ACROSS THE INLET GUIDE VANE.	MAIN	187
C		X - AXIAL COORDINATE.	MAIN	188
			MAIN	189
			MAIN	190
			MAIN	191
			MAIN	192
			MAIN	193
			MAIN	194
			MAIN	195
			MAIN	196
			MAIN	197
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			MAIN	223
			MAIN	224

12/15/67

MAIN. - EFN SOURCE STATEMENT - IFN(S) -

C	A3C3A0 - SEE A1CA0.	MAIN 225
C	A4C4A0 - SEE A1CA0.	MAIN 226
C	A5C5A0 - SEE A1CA0.	MAIN 227
C	CM - MEAN STREAMLINE NORMALIZED AXIAL VELOCITY AND A SCRATCH CELL.	MAIN 228
C	CMEAN - MEAN AXIAL VELOCITY FROM CONTINUITY.	MAIN 229
C	CMEANP - MEAN AXIAL VELOCITY FROM PREVIOUS PASS.	MAIN 230
C	CM2 - MEAN AXIAL VELOCITY SQUARED.	MAIN 231
C	CCINTG - INTEGRAL OF CP DT FROM 0.0 TO STANDARD TEMPERATURE	MAIN 232
C	CPI2 - COEFFICIENT OF THE INTEGRAL OF CP DT USED IN SUBROUTINE THERM2.	MAIN 233
C	CPI3 - SAME AS CPI2.	MAIN 234
C	CPI4 - SAME AS CPI2.	MAIN 235
C	CPI5 - SAME AS CPI2.	MAIN 236
C	CPI6 - SAME AS CPI2.	MAIN 237
C	CPC2 - COEFFICIENT OF THE INTEGRAL OF CP/T DT USED IN SUBROUTINE THERM3.	MAIN 238
C	CPO3 - SAME AS CPO2.	MAIN 239
C	CPC4 - SAME AS CPO2.	MAIN 240
C	CPC5 - SAME AS CPO2.	MAIN 241
C	DAMP - WEIGHTING FACTOR FOR ITERATION OF AXIAL VELOCITY	MAIN 242
C	DD - SCRATCH CELL.	MAIN 243
C	DIFCM - RELATIVE ERROR IN MEAN AXIAL VELOCITY ITERATION.	MAIN 244
C	DIFF - RELATIVE ERROR SCRATCH CELL.	MAIN 245
C	DIFF3 - RELATIVE ERROR SCRATCH CELL.	MAIN 246
C	DT - TEMPERATURE RISE ALONG A STREAMLINE AND ALSO USED AS A SCRATCH CELL.	MAIN 247
C	DUMMY - SCRATCH CELL.	MAIN 248
C	G - UNIVERSAL GAS CONSTANT = 1545.44.	MAIN 249
C	GASK - GAS CONSTANT.	MAIN 250

12/15/67

MAIN. - EFM SOURCE STATEMENT - IFM(S) -

C			MAIN 281
C	GJ	= 2 TIMES GRAVITATIONAL CONSTANT TIMES JOULES	MAIN 282
C		CONSTANT = 50070.466.	MAIN 283
C	GR	= 2. TIMES GRAVITATIONAL CONSTANT TIMES GAS CONSTANT	MAIN 284
C	GR2	= GR/2.	MAIN 285
C	JULE	= JOULES CONSTANT = 778.12.	MAIN 286
C	MAFR	= MASS AVERAGED PRESSURE RATIO.	MAIN 287
C	MOLEWT	= MOLECULAR WEIGHT OF THE WORKING FLUID.	MAIN 288
C	QLEARN	= LOSS CALCULATED FROM PRESSURES.	MAIN 289
C	PGCU	= INLET TOTAL PRESSURE.	MAIN 290
C	Q	= SCRATCH CELL.	MAIN 291
C	RATP	= RATIO OF TOTAL TEMPERATURE TO TOTAL TEMPERATURE	MAIN 301
C		REFERENCE RAISED TO THE GAMMA/(GAMMA-1) TIMES	MAIN 302
C		RATIO OF TOTAL PRESSURE REFERENCE TO TOTAL	MAIN 303
C		TEMPERATURE. NOTE.. THE REFERENCE QUANTITIES ARE	MAIN 304
C		NOT INCLUDED SINCE DIFFERENTIATION REMOVES THEM.	MAIN 305
C	RPM	= REVOLUTIONS PER MINUTE.	MAIN 306
C	SAVE	= SCRATCH CELL USED TO HOLD A NUMBER FOR SHORT TIME.	MAIN 307
C	SAVEN	= SAME AS SAVE.	MAIN 308
C	SCCU	= SCRATCH CELL.	MAIN 310
C	SUM	= SCRATCH CELL.	MAIN 311
C	TERM	= SCRATCH CELL.	MAIN 312
C	TESTDS	= USED IN CHECKING THE STATOR HUB D-FACTOR LIMIT.	MAIN 313
C	TCP	= THE ITERATION ON SPECIFIC HEAT HOLDS THE	MAIN 314
C		PREVIOUS VALUE OF SPECIFIC HEAT.	MAIN 315
C	TDCD	= INLET TOTAL TEMPERATURE.	MAIN 316
C	TCLAT	= TOLERANCE ON EFFICIENCY.	MAIN 317
C	TCLDP	= TOLERANCE ON THE TOTAL TEMPERATURE RISE AND	MAIN 318
C		SPECIFIC HEAT.	MAIN 319
C	TCLDX	= TOLERANCE ON THE AXIAL VELOCITY AND RELATED	MAIN 320
C		VARIABLES.	MAIN 321
C	TCLR	= MASS FLOW RATE TOLERANCE.	MAIN 322
			MAIN 323
			MAIN 324
			MAIN 325
			MAIN 326
			MAIN 327
			MAIN 328
			MAIN 329
			MAIN 330
			MAIN 331
			MAIN 332
			MAIN 333
			MAIN 334
			MAIN 335
			MAIN 336

12/15/67

MAIN. - EFN SOURCE STATEMENT - IFN(S) -

C	TOTINT	- TOTAL INTEGRAL.	MAIN 337
C	TOTPR	- CURRENT CUMULATIVE TOTAL MASS AVERAGE PRESSURE	MAIN 338
C		RATIO.	MAIN 339
			MAIN 340
C	V	- USUALLY ABSOLUTE VELOCITY.	MAIN 341
			MAIN 342
C	VMI	- USUALLY ABSOLUTE VELOCITY.	MAIN 343
			MAIN 344
			MAIN 345
			MAIN 346
			MAIN 347
			MAIN 348
C	***** INTEGER VARIABLES *****		MAIN 349
			MAIN 350
C	BLADE	- INDICATES WHICH LOSS DATA TO USE FOR THE BLADE	MAIN 351
C		AT STATION I.	MAIN 352
			MAIN 353
C	COUNT	- ITERATION COUNTER.	MAIN 354
			MAIN 355
C	I	- STATION INDEX.	MAIN 356
			MAIN 357
C	IB	- FIRST STATION AT WHICH CALCULATION IS TAKING	MAIN 358
C		PLACE.	MAIN 359
			MAIN 360
C	IB1	- SECOND STATION AT WHICH CALCULATION IS TAKING	MAIN 361
C		PLACE.	MAIN 362
			MAIN 363
C	IDUMP	- RESERVED FOR FUTURE APPLICATION.	MAIN 364
			MAIN 365
C	IFIRST	- INDEX OF FIRST ROTOR EXIT AT WHICH CALCULATION	MAIN 366
C		IS CONTINUING.	MAIN 367
			MAIN 368
C	IG	- NUMBER OF LOSS DATA SETS IN THE PERMANENT DATA.	MAIN 369
			MAIN 370
C	II	- SCRATCH INDEX.	MAIN 371
			MAIN 372
C	IKK	- INDEX TO INDICATE WHICH LOSS DATA SET TO USE.	MAIN 373
			MAIN 374
C	ICUTTR	- OUTPUT TRIGGER....	MAIN 375
			MAIN 376
C		1 = ALL STREAMLINE POSITIONS.	MAIN 377
C		2 = ODD STREAMLINE POSITIONS.	MAIN 378
C		3 = HUB, MEAN AND TIP STREAMLINE POSITIONS.	MAIN 379
C		4 = HUB AND TIP STREAMLINE POSITIONS.	MAIN 380
			MAIN 381
C	IPASS	- PASS THROUGH ITERATION PROCEDURE.	MAIN 382
C		1 = SIMPLE RADIAL EQUILIBRIUM	MAIN 383
C		2 = CURVATURE EFFECTS	MAIN 384
C		3 = CURVATURE EFFECTS WITH ALTERED EFFICIENCY	MAIN 385
C		PROFILE	MAIN 386
			MAIN 387
C	IS	- SCRATCH INDEX.	MAIN 388
			MAIN 389
C	ISAVE	- USED TO SAVE AND RESTORE AN INDEX FOR A	MAIN 390
C		PARTICULAR CALCULATION.	MAIN 391
			MAIN 392

12/15/67

	MAIN.	- EFN	SOURCE STATEMENT	- IFN(S) -	
C	IT	-	SCRATCH INDEX.		MAIN 393
C	J	-	STREAMLINE INDEX.		MAIN 394
C	JIN	-	J - 1.		MAIN 395
C	JJ	-	SCRATCH INDEX AND LOOP COUNT.		MAIN 396
C	JM	-	MID-STREAMLINE INDEX.		MAIN 397
C	JM1	-	JM - 1.		MAIN 398
C	K	-	SCRATCH INDEX.		MAIN 399
C	KK	-	SCRATCH INDEX.		MAIN 400
C	K1	-	SCRATCH INDEX.		MAIN 401
C	L	-	SCRATCH VECTOR INDEX.		MAIN 402
C	LC1	-	ITERATION COUNTER.		MAIN 403
C	LC2	-	ITERATION COUNTER.		MAIN 404
C	LC3	-	ITERATION COUNTER.		MAIN 405
C	LC4	-	ITERATION COUNTER.		MAIN 406
C	LC5	-	ITERATION COUNTER.		MAIN 407
C	LC6	-	ITERATION COUNTER.		MAIN 408
C	LIMIT	-	ZERO MEANS FORCE THE CALCULATION TO MEET ONE OF		MAIN 409
C			THE LIMITS AT EACH STAGE.		MAIN 410
C	LOOP	-	ITERATION COUNTER.		MAIN 411
C	LOOP1	-	ITERATION COUNTER		MAIN 412
C	LSTAGE	-	INDEX OF LAST STATOR EXIT.		MAIN 413
C	MSTAGE	-	MAXIMUM NUMBER OF STAGES.		MAIN 414
C	N	-	SCRATCH INDEX.		MAIN 415
C	NLINES	-	NUMBER OF STREAMLINES AT WHICH CALCULATION IS		MAIN 416
C			TO TAKE PLACE.		MAIN 417
C	NTUBES	-	NUMBER OF STREAMTUBES.		MAIN 418
C	NX	-	INDEX OF LAST STATION AT WHICH CALCULATION IS		MAIN 419
C			TAKING PLACE.		MAIN 420
C	NX1	-	(NX - 1) INDEX OF NEXT TO LAST STATION, ETC.		MAIN 421
					MAIN 422
					MAIN 423
					MAIN 424
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					MAIN 427
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12/15/67

MAIN. - EFN SOURCE STATEMENT - IFN(S) -

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C          ***** LOGICAL VARIABLE *****
C          IERROR - INDICATES THAT SOME VARIABLE HAS NOT MET THE
C                   TOLERANCES IF TRUE.
C          YES - INDICATES CONVERGENCE OF AXIAL VELOCITIES.

REAL MACH, MAPR, MOLEWT, JOULE
DIMENSION ATAS(29,11), FLOW(32)
LOGICAL IERROR, YES
COMMON /MATRIX/ ALPHA(10,11), ATAR(29,11), B2(29),
X BETA(10,11), BH(32), BLADE(29), BT(32),
X CC(10,11), CP(32,11), CPCO(6), CR(32,11),
X CSLOPE(10,11), CU2(11), CU(32,11), CUCC(29,5),
X CX(32,11), CXM(10,11), CXNEW(10,11), CXRATG(29),
X CXS(10,11), DA(10), DELM(11), DEPV(10,11),
X DF(20), DFACT(29,11), DFL(29), DFLOW(32),
X EMACH(29,11), FOUNC(20,3,10), FROEL(10,11), GAMMA(32,11),
X HMN(29), HUB(32), IKK(10), MACH(29,11),
X OBAR(29,11), PU(32,11), K(32,11), RCURVE(10,11),
X RH(32), RHU(32,11), RINT(11), ROSTAG(11),
X RS(32), RSLOPE(10,11), RTRAIL(11), SCCO(29,5),
X SOLID(29,11), SSCO(29,5), TERM1(10,11), TERMA(11),
X TERMB(11), TERMC(11), TIP(32), TITLE(12),
X TO(32,11), TSTAT(11), U(32,11), W(11),
X X(32)
COMMON /SCALER/ A, AA, A10A0, A202A0, A303A0, A404A0,
X A505A0, B, BB, CC, CM, CMEAN, CMEANP, CUINTG,
X CPI2, CPI3, CPI4, CPI5, CPI6, CPD2, CPD3, CPD4,
X CPD5, DAMP, DCP, DD, DIFCM, DT, DUMMY, ERAS1,
X G, GASK, GJ, GR, GR2, JOULE, MAPR, MOLEWT,
X PCCO, C, RPM, TCP, TERMO, TESTBH, TESTDS, TESTMS,
X TOCO, TOL, TOLAT, TOLB2, TOLMIN, TOLMS, TOLTIP, TOLCP,
X TOLCX, TOLR, TOTINT, TOTPR, V, VMI
COMMON /INTEGR/ I, IB, IB1, IDUMP, IERROR, IFIRST,
X IG, ICUTTR, IPASS, IS, IT, J, JIN, JJ,
X JM, JM1, K, K1, KK, L, LIMIT, LSTAGE,
X MSTAGE, NLINES, NTUBES, NX, NX1, YES
EQUIVALENCE (ATAR(1,1), ATAS(1,1)), (FLOW(1), DFLOW(1))

1 CONTINUE

C          *** READ THE JOB TITLE, NECESSARY FOR JOB DESCRIPTION
10 READ (5,11) (TITLE(I), I=1,12)
   READ (5,5) (CPCO(I), I=1,6)

C          *** CALCULATE THE COEFFICIENTS NEEDED IN THE VARIOUS
C                   OPERATIONS INVOLVING CP
CPC2=CPCO(3)/2.
CPC3=CPCO(4)/3.
CPC4=CPCO(5)/4.

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12/15/67

MAIN. - EFN SOURCE STATEMENT - IFN(S) -

CPC5=CPC(6)/5.	MAIN 505
A10A0=CPC(2)/CPCU(1)	MAIN 506
A202A0=CPC2/CPCU(1)	MAIN 507
A303A0=CPC3/CPCU(1)	MAIN 508
A404A0=CPC4/CPCU(1)	MAIN 509
A505A0=CPC5/CPCU(1)	MAIN 510
COINITG= THERM3(518.686)	MAIN 511
CPI2=CPC(2)/2.	MAIN 512
CPI3=CPC(3)/3.	MAIN 513
CPI4=CPC(4)/4.	MAIN 514
CPI5=CPC(5)/5.	MAIN 515
CPI6=CPC(6)/6.	MAIN 516
11 FORMAT (12A6)	MAIN 517
KK=1	MAIN 518
C *** INPUT INDEX TO INDICATE WHICH LOSS DATA SETS TO USE	MAIN 519
READ (5,910) (IKK(J),J=1,10)	MAIN 520
K1= IKK(1)	MAIN 521
C *** REWIND MASTER TAPE OF LOSS DATA	MAIN 522
935 REWIND 2	MAIN 523
DO 950 L=1, 10	MAIN 524
C *** READ LOSS DATA FROM MASTER TAPE	MAIN 525
READ (2) ((CX(K,J),K=1,20),J=1,3)	MAIN 526
C *** IS THIS SET DESIRED	MAIN 527
IF (K1.LT.1.OR.K1.GT.10) CALL ERROR(1)	MAIN 528
937 IF (K1.NE..1) GO TO 950	MAIN 529
DO 945 J=1, 3	MAIN 530
DO 945 K=1, 20	MAIN 531
C *** STORE LOSS DATA FROM MASTER TAPE INTO PROPER ALLOCATION	MAIN 532
C TO BE USED IN LOSS SUBROUTINE	MAIN 533
945 FOUND(K,J,KK)= CX(K,J)	MAIN 534
IF (KK.EQ.10) GO TO 960	MAIN 535
KK=KK+1	MAIN 536
KI=IKK(KK)	MAIN 537
IF (K1.EQ.0) GO TO 960	MAIN 538
950 CONTINUE	MAIN 539
GO TO 935	MAIN 540
960 REWIND 2	MAIN 541
KK= KK-1	MAIN 542
910 FORMAT (24I3)	MAIN 543
C *** READ THE SCALAR QUANTITIES	MAIN 544
READ (5,15) MSTAGE,NLINES,IOUTTR,IDUMP,CPNEW,LIMIT,	MAIN 545
X FLOW(1),MULEWT,TCCO,PCCU,ITPR,TOLCX,TOLR,TOLCP,RPM,DAMP	MAIN 546
X ,TOLMIN,TOLB2,TCLAT,TOLMS,TCLTIP,ATAR(1,1),ATAR(1,2),ATAR(1,3)	MAIN 547
	MAIN 548
	MAIN 549
	MAIN 550
	MAIN 551
	MAIN 552
	MAIN 553
	MAIN 554
	MAIN 555
	MAIN 556
	MAIN 557
	MAIN 558
	MAIN 559
	MAIN 560

12/15/67

MAIN. - EFN SOURCE STATEMENT - IFN(S) -

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*** ERROR WILL SET THE TEMPERATURE OR PRESSURE TO THE ABSOLUTE VALUE OF SAME AND WILL GO TO A NEW DATA SET IF ONE OF THE VALUES IS ZERO
IF (POCO.LE.0.0.OR.TOCO.LE.0.0) CALL ERROR(10)
*** THE NUMBER OF STREAMLINES MUST BE 5,7,9 OR 11, ERROR WILL TERMINATE EXECUTION
IF (NLINES.LT.5.OR.NLINES.GT.11.OR.MOD(NLINES,2).EQ.0)
X CALL ERROR(6)
*** ERROR RESETS THE NUMBER OF STAGES TO BE CONSIDERED TO 12. NOTE...NEXT DATA SET MAY NOT EXECUTE PROPERLY
IF (MSTAGE.GT.12) CALL ERROR(7)
15 FORMAT (6I5,4F10.5/7F10.5/7F10.5)
NX=2*MSTAGE + 8
*** READ THE INLET GEOMETRY AND BOUNDARY LAYER BLOCKAGE FACTORS
READ (5,35) (X(I),RH(I),EH(I),RS(I),BT(I),I=1,NX)
*** READ THE FRACTION MASS FLOW BETWEEN THE HUB AND THE J-TH STREAMLINE. THESE NUMBERS MUST INCREASE MONOTONICALLY
READ (5,20) (DELM(I),I=1,NLINES)
NTUBES= NLINES-1
DO 3 I=1,NTUBES
IF (DELM(I).GE.DELM(I+1)) CALL ERROR (34)
3 CONTINUE
*** READ THE LOSS FACTORS ACROSS THE INLET GUIDE VANE FOR THE J-TH STREAMLINE
8 READ (5,20) (W(I),I=1,NLINES)
READ (5,35) (CUCC(5,J),J=1,5)
5 FORMAT (3E20.8)
20 FORMAT (7F10.5)
35 FORMAT (5F10.5)
*** WRITE OUT MACHINE DESCRIPTION
CALL DATE(DA)
WRITE (6,39) (TITLE(I),I=1,12),(DA(I),I=1,2)
36 WRITE (6,40) MSTAGE,TOTPR,NLINES,POCO,FLOW(1),TOCO,MULEWT,RPM,
X TOLCX, TCLB2, TCLAT, TOLMS, TOLR,
X (DELM(I),I=1,NLINES)
WRITE (6,41) NLINES, (W(I),I=1,NLINES)
*** WRITE OUT INLET GEOMETRY
39 FORMAT (1H124X14A6)
40 FORMAT (1H028X63F****-*** ADVANCED MULTISTAGE AXIAL-FLOW COMPRES
XSUR ***-***** //38X43F***-*** ANALYSIS AT DESIGN CONDITIONS **--**

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12/15/67

MAIN. - EFN SOURCE STATEMENT - IFN(S) -

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X ///47X26H----I N P U T D A T A---- /// 9X35H THE MACHINE IS TO HAMAIN 617
XVE NO MORE THAN 13,7H STAGES15X25HA TOTAL PRESSURE RATIO OF F7.3, MAIN 618
X11H IS DESIRED //9X35H CALCULATIONS ARE TO BE PERFORMED AT 13, MAIN 619
X12H STREAMLINES 10X27H THE INLET TOTAL PRESSURE IS F9.2, MAIN 620
X 13H LBS/SQ. INCH // 9X 27H THE MAIN 621
XE INLET MASS FLOW RATE IS F7.2, 7H LB/SEC 19X30H THE INLET TOTAL TEMAIN 622
XMPERATURE IS F7.2, 7H DEG. R//9X32H MOLECULAR WEIGHT OF THE FLUID IS MAIN 623
X F7.2, 21X 16H THE TIP SPEED IS F7.1, 9H FT./SEC. // 9X 27H AXIAL VELUMAIN 624
XCITY TOLERANCE IS F7.4, 26X 26H B COEFFICIENT TOLERANCE IS F7.4 // MAIN 625
X 9X 27H THE EFFICIENCY TOLERANCE IS F7.4, 26X 24H MACH NUMBER TOLERAMAIN 626
XNCE IS F7.4, // 9X 24H THE CONTINUITY TOLERANCE F7.4 /// 9X 29H THE MAIN 627
XFRACTION OF THE TOTAL MASS FLOW BETWEEN THE HUB AND THE J-TH STREAMAIN 628
XMLINE IS. // 9X 11F7.3 ) MAIN 629
MAIN 630
41 FORMAT (//9X46H THE INLET GUIDE VANE LOSS COEFFICIENTS FOR THE 13, MAIN 631
X 34H STREAMLINES ARE (FROM HUB TO TIP) // 9X 11F7.4 /// MAIN 632
MAIN 633
42 FORMAT ( 5X 85H THE RATIO OF THE AREAS OF THE LAST 3 STATIONS TO 1HMAIN 634
XE AREA OF THE LAST STATOR EXIT ARE F7.4, 2(1H.F7.4), 2H .) MAIN 635
MAIN 636
45 FORMAT (1F1///45X28H----FLOWPATH DESCRIPTION----///23X7H STATION5XMAIN 637
X9H AXIAL11X3H HUB6X12H HUB BLOCKAGE7X3H TIP7X12H TIP BLOCKAGE / 25X MAIN 638
X 3H NO.5X1CH COORDINATE 6X6H RADIUS8X6H FACTOR 8X6H RADIUS 8X6H FACTOR/ MAIN 639
X 33X 8H (INCHES) 7X 8H (INCHES) 20X 8H (INCHES) /// MAIN 640
MAIN 641
46 FORMAT (20X17, 5F14.3) MAIN 642
MAIN 643
WRITE (6,56) MAIN 644
MAIN 645
56 FORMAT (1H0//18X84H**NOTE** ALL POLYNOMIALS (EXCEPT FOR THE SPECIFIMAIN 646
XC HEAT POLYNOMIAL) ARE OF THE FORM - /40X38HP(R) = A/R**2 + B/R + MAIN 647
XC + D*R + E*R**2 /// 23X73H THE POLYNOMIAL FOR THE WHIRL VELOCITY AMAIN 648
XT THE EXIT OF THE INLET GUIDE VANE / ) MAIN 649
MAIN 650
WRITE (6,57) (CUCO(5,J),J=1,5) MAIN 651
MAIN 652
57 FORMAT ( 5X 3HA =E15.6,3X 3HB =E15.6,3X 3HC =E15.6,3X 3HD =E15.6, MAIN 653
X 3X 3HE =E15.6 // ) MAIN 654
MAIN 655
WRITE (6,58) CPGC MAIN 656
MAIN 657
58 FORMAT (1H033X53H THE SPECIFIC HEAT POLYNOMIAL IS IN THE FOLLOWING MAIN 658
XFORM // 3X 4HCP = E12.5,3H + E12.5,5H*T + E12.5,8H*T**2 + E12.5, MAIN 659
X 8H*T**3 + E12.5,8H*T**4 + E12.5,5H*T**5 // ) MAIN 660
MAIN 661
WRITE (6,42) ATAR(1,1), ATAR(1,2), ATAR(1,3) MAIN 662
WRITE (6,45) MAIN 663
DO 37 J=1,NX MAIN 664
37 WRITE (6,46) J,X(J),RH(J),BH(J),RS(J),BT(J) MAIN 665
N=2*NSTAGE + 4 MAIN 666
MAIN 667
C *** READ THE STAGE DATA MAIN 668
MAIN 669
DO 60 I=5,N,2 MAIN 670
READ (5,25) DFL(I+1), HMN(I+1), HMN(I+2), DFL(I+2), MAIN 671
X BLADE(I+1), BLADE(I+2),DFLOW(I+1),DFLOW(I+2), MAIN 672

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12/15/67

MAIN. - EFN SOURCE STATEMENT - IFN(S) -

X (CUCO(I+1,J),J=1,5),	MAIN 673
X (SSCO(I+1,J),J=1,5),	MAIN 674
X (SUCCO(I+1,J),J=1,5),	MAIN 675
X (CUCO(I+2,J),J=1,5),	MAIN 676
X (SSCO(I+2,J),J=1,5),	MAIN 677
X (SUCCO(I+2,J),J=1,5)	MAIN 678
60 CONTINUE	MAIN 679
	MAIN 680
25 FORMAT (4F10.4/2I5,2F10.4/(5E10.4))	MAIN 681
	MAIN 682
C *** CHECK THE BLOCKAGE FACTORS	MAIN 683
	MAIN 684
NN=N+1	MAIN 685
DO 61 I=1,NN	MAIN 686
	MAIN 687
C *** ERROR SETS THE BLOCKAGE FACTOR TO 1.0	MAIN 688
	MAIN 689
IF (BT(I).LE.0.) CALL ERROR(25)	MAIN 690
IF (BH(I).LE.0.0) CALL ERROR(21)	MAIN 691
61 CONTINUE	MAIN 692
DO 70 I=5,N	MAIN 693
B2(I+1)=CLCO(I+1,2)	MAIN 694
70 CONTINUE	MAIN 695
NX=N+4	MAIN 696
DO 89 I=1,KK	MAIN 697
89 WRITE (6,90) I,(DF(J),(FOUND(J,K,I),K=1,3),J=1,20)	MAIN 698
90 FORMAT (1H1////////43X 25H... LOSS DATA SET NUMBER13,5H ...////	MAIN 699
X 9X 8HD-FACTOR 10X 13HAT 10 PERCENT 10X 13HAT 50 PERCENT 10X	MAIN 700
X 13HAT 90 PERCENT 5X 21H(OF BLADE HEIGHT FROM / 92X 13HTHE GEOMETR	MAIN 701
XIC HUB)/ 20(F17.3,F18.4,2F23.4/))	MAIN 702
	MAIN 703
C *** CALCULATE THE GAS CONSTANT	MAIN 704
	MAIN 705
GASK= G/MCLEWT	MAIN 706
DCP= GASK / JOULE	MAIN 707
GR= 64.348*GASK	MAIN 708
GR2= GR*.5	MAIN 709
	MAIN 710
C *** CALCULATE THE TOTAL TEMPERATURE, TOTAL PRESSURE, AND	MAIN 711
C SPECIFIC HEAT IN THE INLET	MAIN 712
DO 95 I=1,NX	MAIN 713
TIP(I)= RS(I)	MAIN 714
HUB(I)= RH(I)	MAIN 715
95 CONTINUE	MAIN 716
RPM= RPM/RS(5)	MAIN 717
I=1	MAIN 718
J=1	MAIN 719
TO(1,1)= TOCO	MAIN 720
CALL THERMP	MAIN 721
DO 101 J=1,NLINES	MAIN 722
DO 99 I=1,5	MAIN 723
TC(I,J)= TOCO	MAIN 724
PU(I,J)= PUCCO	MAIN 725
CP(I,J)= CP(1,1)	MAIN 726
99 GAMMA(I,J)= GAMMA(1,1)	MAIN 727
	MAIN 728

12/15/67

C	*** SET THE RADIAL AND WHIRL VELOCITIES TO ZERO	MAIN 729
	DO 100 I=1,NX	MAIN 730
	CU(I,J)= 0.	MAIN 731
100	CR(I,J)= 0.	MAIN 732
	ATAR(6,J)= 0.9	MAIN 733
	ATAR(7,J)= 0.89	MAIN 734
		MAIN 735
C	*** DR/DX AND D2R/DX2 AND D(CX)/DX ARE ASSUMED ZERO AT	MAIN 736
C	THE INLET TO THE MACHINE	MAIN 737
		MAIN 738
	RSLOPE(1,J)= 0.	MAIN 739
	RCURVE(1,J)= 0.	MAIN 740
101	CSLOPE(1,J)= 0.	MAIN 741
	NX=NX-3	MAIN 742
	DO 105 I=6,NX	MAIN 743
	IF (DFL(I).LE.0.(CR.DFL(I).GE.0.9) CALL ERROR(28)	MAIN 744
105	IF (BLADE(I).LT.1.(CR.BLADE(I).GT.NK) CALL ERROR(17)	MAIN 745
		MAIN 746
		MAIN 747
C	*** CONVERT THE RELATIVE FLOW ANGLES TO RADIAN	MAIN 748
		MAIN 749
	DO 106 I=7,NX,2	MAIN 750
106	FMN(I)= FMN(I)/57.2957795	MAIN 751
		MAIN 752
C	*** SET THE MASS FLOW RATE THROUGH THE INLET TO THE VALUE	MAIN 753
C	AT THE FIRST STATION	MAIN 754
		MAIN 755
	FLOW(2)= FLOW(1)	MAIN 756
	FLOW(3)= FLOW(1)	MAIN 757
	FLOW(4)= FLOW(1)	MAIN 758
	FLOW(5)=FLOW(1)	MAIN 759
		MAIN 760
C	*** CALCULATE THE TOTAL FLOW RATE AT EACH STATION	MAIN 761
		MAIN 762
	DO 110 I=5,N	MAIN 763
110	FLOW(I+1)= FLOW(I)+DFLOW(I+1)	MAIN 764
		MAIN 765
C	*** SET THE FLOW RATE AT THE LAST 3 STATIONS EQUAL TO THE	MAIN 766
C	FLOW RATE AT THE LAST STATOR EXIT	MAIN 767
		MAIN 768
	FLOW(N+2)= FLOW(N+1)	MAIN 769
	FLOW(N+3)= FLOW(N+1)	MAIN 770
	FLOW(N+4)= FLOW(N+1)	MAIN 771
		MAIN 772
C	*** CALCULATE THE NUMBER OF STREAMTUBES	MAIN 773
		MAIN 774
	NTUBES= NLINES-1	MAIN 775
	JM1= NLINES/2	MAIN 776
		MAIN 777
C	*** CHECK AND CALCULATE THE OUTPUT TRIGGER..	MAIN 778
C	1 = ALL STREAMLINES	MAIN 779
C	2 = EVERY OTHER ONE	MAIN 780
C	3 = MEAN, HUB, AND TIP	MAIN 781
C	4 = HUB AND TIP	MAIN 782
		MAIN 783
	IF (IOUTTR.LT.1.(CR.IOUTTR.GT.4) CALL ERROR(20)	MAIN 784

12/15/67

MAIN. - EFN SOURCE STATEMENT - IFN(S) -		
	IF (IOUTTR.LT.3) GO TO 113	MAIN 735
	IF (IOUTTR.EQ.4) GO TO 112	MAIN 736
	IOUTTR=JM1	MAIN 737
	GO TO 113	MAIN 738
112	IOUTTR=NTUBES	MAIN 739
113	IFIRST=6	MAIN 740
C	*** CALCULATE THE MID-STREAMLINE INDEX	MAIN 751
	JM= JM1+1	MAIN 742
C	*** INITIALIZE THE INDICES (THE FIRST ROTOR INLET	MAIN 743
C	IS AT STATION NUMBER 5)	MAIN 744
	L= 1	MAIN 745
	IB= 1	MAIN 746
	IPASS=1	MAIN 747
	IB1= 2	MAIN 748
	LSTAGE=7	MAIN 749
	NX1=9	MAIN 750
	NX=10	MAIN 751
C	*** CALCULATE THE SIMPLE RADIAL EQUILIBRIUM SOLUTION	MAIN 752
C	OF THE FLOW EQUATIONS IN THE INLET	MAIN 753
	CALL INLET	MAIN 754
	I= 6	MAIN 755
115	IPASS= 1	MAIN 756
120	CONTINUE	MAIN 757
	LC6=0	MAIN 758
	CALL ROTOUT	MAIN 759
	I= I+1	MAIN 760
130	CALL STAGOUT	MAIN 761
C	*** CALCULATE CONDITIONS AT THE OUTLET	MAIN 762
	CALL OUTLET	MAIN 763
C	*** PRINT OUTPUT AT THIS POINT, TRANSFER TO A NEW DATA SET	MAIN 764
140	IF (LC6.GT.50) CALL ERROR(19)	MAIN 765
C	*** CALCULATE THE AXIAL VELOCITIES INCLUDING CURVATURE EFFECTS	MAIN 766
142	CALL CAXIAL	MAIN 767
	LC5=0	MAIN 768
	IPASS= 2	MAIN 769
	L= 1	MAIN 770
C	*** CHECK THE LIMITS AND ITERATE WITH CURVATURE EFFECTS ON	MAIN 771
C	THE LAST STAGE ONLY	MAIN 772
	I=LSTAGE-1	MAIN 773
	CALL ROTOUT	MAIN 774
	I=LSTAGE	MAIN 775
	CALL STAGOUT	MAIN 776

12/15/67

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      MAIN.      - EFN      SOURCE STATEMENT - IFM(S) -

141 IERROR=.FALSE.
    LC5=LC5+1
C      *** PRINT OUTPUT AT THIS POINT, TRANSFER TO A NEW DATA SET
      IF (LC5.GT.50) CALL ERROR(18)
      DO 145 II=IFIRST,LSTAGE,2
        I=II
C      *** CHECK THE ROTOR
      CALL ROTCUT
      SAVE= CUCU(I,2)
      IF (LIMIT.NE.0) GO TO 144
      CALL DRIVE
      IF (ABS((SAVE-CUCU(I,2))/SAVE).LT.TOLB2) GO TO 144
      CALL PRFIT2
      CALL STREAM
      GO TO 141
144 CUCU(I,2)= SAVE
    I=II+1
C      *** CHECK THE STATOR
      CALL STAGHT
145 CONTINUE
      IF (IERROR) GO TO 141
      CALL LOSS
146 LC6=LC6+1
    I=LSTAGE-1
C      *** IPASS WILL BE EQUAL TO 3 IF THE LOSSES DO NOT CORRELATE
C      WITH THE EFFICIENCIES
      IF (IPASS.EQ.3) GO TO 140
      CALL CAXIAL
C      *** CALCULATE THE MASS AVERAGED PRESSURE RATIO
      DO 155 J=1,NLINES
        TERMB(J)= TO(LSTAGE,J)
C      *** SOLVES FOR TERMB(J) IN GASK*ALOG(PU(LSTAGE,J)/PO(1,1) =
C      INTEGRAL FROM TO(1,1) TO TERMB(J) OF (CP/T) DT
      CALL THERM2(PO(LSTAGE,J)/PO(1,1),TERMB(J),TO(1,1))
      TERMB(J)=TERMB(J)/TO(1,1)
155 DEPV(9,J)= RHC(LSTAGE,J)*CX(LSTAGE,J)*R(LSTAGE,J)
      I=LSTAGE
      L=9
      CALL INTEG(DEPV,2)
      SUM= RINT(NLINES)-RINT(1)
      L=8
      DO 157 J=1,NLINES
157 DEPV(8,J)= (TERMB(J)-1.)*DEPV(9,J)
      CALL INTEG(DEPV,2)

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MAIN 841
 MAIN 842
 MAIN 843
 MAIN 844
 MAIN 845
 MAIN 846
 MAIN 847
 MAIN 848
 MAIN 849
 MAIN 850
 MAIN 851
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 MAIN 885
 MAIN 886
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 MAIN 893
 MAIN 894
 MAIN 895
 MAIN 896

11/15/67

MAIN. - EFN SOURCE STATEMENT - IFN(S) -

	V= RINT(NLINES)-RINT(1)	MAIN 897
	MAPR=EXP(JOULE*(THERM3((V/SUM+1.0)*TO(1,1))-THERM3(TO(1,1)))/GASK)	MAIN 898
		MAIN 899
C	*** IF THE MASS AVERAGED PRESSURE EXCEEDS THE PRESSURE	MAIN 900
C	RATIO DESIRED THE CALCULATION IS COMPLETE	MAIN 901
		MAIN 902
	IF (MAPR.GE.TOTPR) GO TO 175	MAIN 903
		MAIN 904
C	*** SINCE THE MASS AVERAGE PRESSURE RATIO HAS NOT BEEN MET WE	MAIN 905
C	CHECK TO SEE IF ANOTHER STAGE MAY BE ADDED. IF NOT THE	MAIN 906
C	FLOW PARAMETERS WILL BE PRINTED	MAIN 907
		MAIN 908
	IF ((LSTAGE-5)/2.GE.MSTAGE) GO TO 170	MAIN 909
		MAIN 910
C	*** INITIALIZE THE CALCULATION TO ADD ONE MORE STAGE	MAIN 911
		MAIN 912
	IFIRST=MAXO(IFIRST,LSTAGE-3)	MAIN 913
	I= LSTAGE + 1	MAIN 914
	IB= IB+2	MAIN 915
	IB1= IB1+2	MAIN 916
	IX= IX+2	MAIN 917
	IX1= IX1+2	MAIN 918
	LSTAGE=LSTAGE+2	MAIN 919
		MAIN 920
C	*** SINCE THE CALCULATION AND CHECKING IS TO BE CONTINUED	MAIN 921
C	UPSTREAM FOR NO MORE THAN 3 WHOLE STAGES, IT IS ASSUMED	MAIN 922
C	THAT DR/DX, D2R/DX2 AND D(CX)/DX AT STAGES PREVIOUS TO	MAIN 923
C	THESE WILL NOT BE AFFECTED BY THE ADDITION OF ONE MORE	MAIN 924
C	STAGE. THEREFORE THE VALUES CALCULATED FOR THE PREVIOUS	MAIN 925
C	CONFIGURATION ARE TO BE SAVED FOR USE IN THE NEW	MAIN 926
C	CONFIGURATION	MAIN 927
		MAIN 928
	DO 160 J=1,NLINES	MAIN 929
	RSLOPE(1,J)=RSLOPE(3,J)	MAIN 930
	RCURVE(1,J)=RCURVE(3,J)	MAIN 931
160	CSLOPE(1,J)=CSLOPE(3,J)	MAIN 932
	GO TO 115	MAIN 933
		MAIN 934
C	*** PRINT MESSAGE TO INDICATE THAT THE DESIRED PRESSURE RATIO	MAIN 935
C	HAS NOT BEEN MET	MAIN 936
		MAIN 937
	170 CALL ERROR(9)	MAIN 938
	175 CALL OUTPUT	MAIN 939
		MAIN 940
C	*** RETURN FOR A NEW DATA SET	MAIN 941
		MAIN 942
	IF (1.GE.0) GO TO 1	MAIN 943
	RETURN	MAIN 944
	END	MAIN 945

12/15/67

ANXIT. - EFN SOURCE STATEMENT - IFN(S) -

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SUBROUTINE AN EXIT
C      *** THIS SUBROUTINE ADDS AN EXIT TO THE MACHINE BASED ON
C      A HORIZONTAL TIP AND THE HUB CALCULATED FROM THE RATIO
C      OF THE AREA OF THE STATION TO THE AREA OF THE LAST
C      STATOR EXIT.
REAL MACH, MAPR, MOLENT, JOULE
DIMENSION ATAS(29,11), FLOW(32)
LOGICAL IERROR, YES
COMMON /MATRIX/ ALPHA(10,11), ATAR(29,11), B2(29),
X BETA(10,11), BH(32), BLADE(29), BT(32),
X CG(10,11), CP(32,11), CPCU(6), CR(32,11),
X CSLCPE(10,11), CU2(11), CU(32,11), CUCU(29,5),
X CX(32,11), CXM(10,11), CXNEW(10,11), CXRATO(29),
X CXS(10,11), CA(10), DELM(11), DEPV(10,11),
X DF(20), DFACT(29,11), DFL(29), DFLOW(32),
X EMACH(29,11), FLUND(20,3,10), FRDEL(10,11), GAMMA(32,11),
X HMN(29), HUB(32), IKK(10), MACH(29,11),
X OBAR(29,11), PL(32,11), R(32,11), RCURVE(10,11),
X RH(32), RHC(32,11), RINT(11), ROSTAG(11),
X RS(32), RSLCPE(10,11), KTRAIL(11), SLCU(29,5),
X SOLID(29,11), SSCC(29,5), TERM1(10,11), TERMA(11),
X TERMB(11), TERMC(11), TIP(32), TITLE(12),
X TO(32,11), TSTAT(11), U(32,11), W(11),
X X(32)
COMMON /SCALER/ A, AA, A10A0, A202A0, A303A0, A404A0,
X A505A0, B, BB, CC, CM, CMEAN, CMEANP, COUNTG,
X CPI2, CPI3, CPI4, CPI5, CPI6, CPO2, CPO3, CPO4,
X CPO5, CAMP, DCP, DC, DIFCM, DT, DUMMY, ERAS1,
X G, GASK, GJ, GR, GR2, JOULE, MAPR, MOLENT,
X POCO, Q, RPM, TCP, TERMD, TESTGH, TESTDS, TESTMS,
X TOCG, TOL, TOLAT, TOLB2, TOLMIN, TOLMS, TOLTIP, TOLCP,
X TOLCX, TOLR, TOTINT, TOTPR, V, VMI
COMMON /INTEGR/ I, IB, IB1, IDUMP, IERROR, IFIRST,
X IG, IOUTTR, IPASS, IS, IT, J, JIN, JJ,
X JM, JM1, K, KI, KK, L, LIMIT, LSTAGE,
X MSTAGE, NLINES, NTUBES, NX, NX1, YES
EQUIVALENC: (ATAR(1,1), ATAS(1,1)), (FLOW(1), DFLOW(1))
AA= RS(LSTAGE)**2
BB= RH(LSTAGE)**2
DO 10 JK=1,3
JL=LSTAGE+JK
RS(JL)= RS(LSTAGE)
RH(JL)= SQRT(AA + (BB-AA)*ATAR(1,JK))
10 CONTINUE
RETURN
END

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12/15/67

SUBROUTINE B2CAL

*** CALCULATE THE B-COEFFICIENT OF WHIRL VELOCITY AT THE ROTOR
EXIT FOR THE ROTOR TIP D-FACTOR

REAL MACH, MAPR, MOLEWT, JOULE
DIMENSION ATAS(25,11), FLOW(32)
LOGICAL IERRGR, YES

COMMON /MATRIX/ ALPHA(10,11), ATAR(29,11), B2(29),
X BETA(10,11), BH(32), BLADE(29), BT(32),
X CO(10,11), CP(32,11), CPO(6), CR(32,11),
X CSLOPE(10,11), CU2(11), CU(32,11), CUCU(29,5),
X CX(32,11), CXM(10,11), CXNEW(10,11), CXRAT(29),
X CXS(10,11), DA(10), DELM(11), DEPV(10,11),
X DF(20), DFACT(29,11), DFL(29), DFLW(32),
X EMACH(29,11), FOUNO(20,3,10), FRDEL(10,11), GAMMA(32,11),
X HMN(29), HUB(32), IKK(10), MACH(29,11),
X DEAR(29,11), PC(32,11), R(32,11), RCURVE(10,11),
X RH(32), RHO(32,11), RINT(11), RSTAG(11),
X RS(32), RSLOPE(10,11), RTRAIL(11), SDCO(29,5),
X SOLID(29,11), SSCO(29,5), TERMI(10,11), TERMA(11),
X TERMB(11), TERMC(11), TIP(32), TITLE(12),
X TU(32,11), TSTAT(11), U(32,11), W(11),
X X(32)
COMMON /SCALER/ A, AA, A10A0, A202A0, A303A0, A404A0,
X A505A0, E, BB, CC, CM, CMEAN, CMEANP, COINTG,
X CPI2, CPI3, CPI4, CPI5, CPI6, CPU2, CPO3, CPO4,
X CPO5, DAMP, DCP, DG, DIFCM, DT, DUMMY, ERAS1,
X G, GASK, GJ, GR, GR2, JOULE, MAPR, MOLEWT,
X POCO, Q, RPM, TCP, TERMD, TESTBH, TESTOS, TESTMS,
X TOCO, TOL, TOLAT, TOLB2, TCLMIN, TOLMS, TCLTIP, TOLCP,
X TOLCX, TOLR, TETINT, TOTPR, V, VMI
COMMON /INTEGR/ I, IB, IB1, IDUMP, IERROR, IFIRST,
X IG, ICUTTR, IPASS, IS, IT, J, JIN, JJ,
X JM, JM1, K, K1, KK, L, LIMIT, LSTAGE,
X MSTAGE, NLINES, NTUBES, NX, NX1, YES
EQUIVALENCE (ATAR(1,1), ATAS(1,1)), (FLOW(1), DFLW(1))

AA=(R(I,NLINES)+R(I-1,NLINES))*0.5
V=SQRT(CX(I-1,NLINES)**2+(CU(I-1,NLINES)-U(I-1,NLINES))**2+
X CR(I-1,NLINES)**2)
SOLID(1,1)=((SOCC(1,2)+SCCO(1,1)/AA)/AA+SOCC(1,3)+(SCCO(1,4)+
X SOCO(1,5)*AA)*AA)
Q=0.5/SOLID(1,1)
A=V*(1.0-DFL(I))+U(I-1,NLINES)-CU(I-1,NLINES)-U(I,NLINES))*Q
CO(1,1)=-2.*(U(I,NLINES)+A*Q)/(1.-Q*Q)
CO(1,2)=(CR(I,NLINES)**2+CX(I,NLINES)**2+U(I,NLINES)**2-A*A)/(
X 1.0-Q*Q)
ERAS1=CO(1,1)**2-4.*CO(1,2)
IF (ERAS1.LT.0.) CALL ERROR(33)
ERAS1=SQRT(ERAS1)
B=-CO(1,1)-ERAS1
IF (B.LE.0.0) B=-CO(1,1)+ERAS1
CUCO(1,2)=R(I,NLINES)*B*0.5
X CUCO(1,1)/R(I,NLINES)-(CUCO(1,3)+(CUCO(1,4)+CUCO(1,5)*R(I,NLINES)

BCAL.	-	EFN	SOURCE STATEMENT	-	IFN(S)	-	12/15/67
X)*R(I,NLINES))							BCAL1052
RETURN							BCAL1053
END							BCAL1054

12/15/87

BCAL1. - EFN SOURCE STATEMENT - IFN(S) -

SUBROUTINE B2CAL1

C *** CALCULATE THE B-COEFFICIENT OF WHIRL VELOCITY AT THE ROTOR
C EXIT FOR THE STATOR HUB ENTRANCE ABSOLUTE MACH NUMBER

REAL MACH, MAPR, MOLEWT, JOULE

DIMENSION ATAS(25,11), FLOW(32)

LOGICAL IERROR, YES

COMMON /MATRIX/ ALPHA(10,11), ATAR(29,11), B2(29),
X BETA(10,11), BH(32), BLADE(29), BT(32),
X CU(10,11), CP(32,11), CPCO(6), CR(32,11),
X CSLOPE(10,11), CU2(11), CU(32,11), CUCO(29,5),
X CX(32,11), CXM(10,11), CXNEW(10,11), CXRATO(29),
X CXS(10,11), DA(10), DELM(11), DEPV(10,11),
X DF(20), DFACT(29,11), DFL(29), DFLOW(32),
X EMACH(29,11), FOUNO(20,3,10), FROEL(10,11), GAMMA(32,11),
X HMN(29), HUB(32), IKK(10), MACH(29,11),
X OBAR(29,11), PC(32,11), R(32,11), KCURVE(10,11),
X RH(32), RHU(32,11), RINT(11), ROSTAG(11),
X RS(32), RSLCPE(10,11), RTRAIL(11), SOCO(29,5),
X SOLID(29,11), SSCU(29,5), TERM1(10,11), TERMA(11),
X TERMB(11), TERMC(11), TIP(32), TITLE(12),
X TO(32,11), TSTAT(11), U(32,11), W(11),
X X(32)

COMMON /SCALER/ A, AA, A10A0, A202A0, A303A0, A404A0,
X A505A0, B, BB, CC, CM, CMEAN, CMEANP, CUINTG,
X CPI2, CPI3, CPI4, CPI5, CPI6, CPO2, CPO3, CPU4,
X CPO5, CAMP, DCP, DD, DIFCM, DT, DUMMY, ERAS1,
X G, GASK, GJ, GR, GR2, JOULE, MAPR, MOLEWT,
X POCO, Q, RPM, TCP, TERMD, TESTBH, TESTDS, TESTMS,
X TOCO, TOL, TCLAT, TOLB2, TOLMIN, TOLMS, TOLTIP, TOLCP,
X TOLCX, TOLR, TOTINT, TOTPR, V, VMI
COMMON /INTEGR/ I, IB, IB1, IDUMP, IERROR, IFIRST,
X IG, ICUTTR, IPASS, IS, IT, J, JIN, JJ,
X JM, JMI, K, K1, KK, L, LIMIT, LSTAGE,
X MSTAGE, NLINES, NTUBES, NX, NX1, YES
EQUIVALENCE (ATAR(1,1), ATAS(1,1)), (FLOW(1), DFLOW(1))
COMMON /ENERGY/ H, T, GAMMER

SQCO=CX(1,1)**2 +CR(1,1)**2

V= SQCO +CU(1,1)**2

H=-V/GJ

J= 1

T= TO(1,1)

CALL ENTALP

CALL GAM

VMI= 32.174*GASK*GAMMER*TSTAT(1)

A= VMI*HMN(1)**2 -SQCO

IF (A.LE.0.0) CALL ERROR(30)

CU(1,1)= SQRT(A)

CUCO(1,2)=CU(1,1)*R(1,1)-CUCO(1,1)/R(1,1)-(CUCO(1,3) + (CUCO(1,4) +

X CUCO(1,5)*R(1,1))*R(1,1))*R(1,1)

10 RETURN

END

BCAL2. - EFN SOURCE STATEMENT - IFN(S) -

12/15/87

SUBROUTINE BZCAL2

```

C      *** CALCULATE THE B-COEFFICIENT OF WHIRL VELOCITY AT THE HUB FOR
C      EXIT FOR THE RELATIVE FLOW ANGLE AT THE HUB ROTOR AXII
BCAL1111
BCAL1112
BCAL1113
BCAL1114
BCAL1115
BCAL1116
BCAL1117
BCAL1118
BCAL1119
BCAL1120
BCAL1121
BCAL1122
BCAL1123
BCAL1124
BCAL1125
BCAL1126
BCAL1127
BCAL1128
BCAL1129
BCAL1130
BCAL1131
BCAL1132
BCAL1133
BCAL1134
BCAL1135
BCAL1136
BCAL1137
BCAL1138
BCAL1139
BCAL1140
BCAL1141
BCAL1142
BCAL1143
BCAL1144
BCAL1145
BCAL1146
BCAL1147
BCAL1148
BCAL1149
BCAL1150
BCAL1151
BCAL1152
BCAL1153

REAL MACH, MAPR, MOLEWT, JOULE
DIMENSION ATAS(29,11), FLOW(32)
LOGICAL IERROR, YES
COMMON /MATRIX/ ALPHA(10,11), ATAR(29,11), B2(29),
X BETA(10,11), BH(32), BLADE(29), BT(32),
X CU(10,11), CP(32,11), CFCO(6), CR(32,11),
X CSLOPE(10,11), CU2(11), CU(32,11), CUCC(2,5),
X CX(32,11), CXM(10,11), CXNEW(10,11), CXRATE(29),
X CXS(10,11), DA(10), DELM(11), DEPV(10,11),
X DF(20), DFACT(29,11), DFL(29), DFLOW(32),
X EMACH(29,11), FOUNO(20,3,10), FRDEL(10,11), GAMMA(32,11),
X HMN(29), HUB(32), IKK(10), MACH(29,11),
X OBAR(29,11), PG(32,11), R(32,11), RCURVE(10,11),
X RH(32), RHO(32,11), RINT(11), RCSTAG(11),
X RS(32), RSLOPE(10,11), RIRAIL(11), SCCO(29,5),
X SOLID(29,11), SSCO(29,5), TERM1(10,11), TERMA(11),
X TERMB(11), TERM(11), TIP(32), TITL(12),
X TC(32,11), TSTAT(11), U(32,11), W(11),
X X(32)
COMMON /SCALEK/ A, AA, A10A0, A202A0, A303A0, A404A0,
X AS05A0, B, BB, CC, CM, CMEAN, CMEANP, CUNITG,
X CPI2, CPI3, CPI4, CPI5, CPI6, CP02, CP03, CP04,
X CP05, CAMP, DCP, DD, DIFCM, DT, DUMMY, ERAS1,
X G, GASK, GJ, GK, GR2, JOULE, MAPR, MOLEWT,
X POCO, C, RPM, TCP, TERMD, TEST0H, TEST0S, TESTAS,
X TCCO, TOL, TCLAT, TCLB2, TCLMIN, TOLMS, TCLTIP, TOLCP,
X TOLCX, TOLR, TCTINT, TCTPR, V, VMI
COMMON /INTEGR/ I, IB, IB1, IDUMP, IERROR, IFIRST,
X IG, ICUTR, IPASS, IS, IT, J, JIN, JJ,
X JM, JMI, K, K1, KK, L, LIMIT, LSTAGE,
X MSTAGE, ALINES, NTUBLS, NX, NX1, YES
EQUIVALENCE (ATAR(1,1),ATAS(1,1)), (FLOW(1),DFLOW(1))

ERAS1= SQRT(CX(1,1)**2+CP(1,1)**2)
CUCC(1,2)= (U(1,1)-ERAS1 *TAN(HMN(1+1))) *R(1,1) - CUCC(1,1) /
X R(1,1)-CUCC(1,3)*R(1,1)-CUCC(1,4)*R(1,1)**2-CUCC(1,5)*R(1,1)**3
20 RETURN
END

```

12/15/67

BCAL3. - EFN SOURCE STATEMENT - IFN(S) -

SUBROUTINE B2CAL3

*** CALCULATE THE E-COEFFICIENT OF WHIRL VELOCITY AT THE ROTOR
EXIT FOR THE STATOR D-FACTOR

REAL MACH, MAPR, MOLEWT, JOULE
DIMENSION ATAS(29,11), FLOW(32)
LOGICAL IERROR, YES
COMMON /MATRIX/ ALPHA(10,11), ATAR(29,11), B2(29),
X BETA(10,11), BH(32), BLADE(29), BT(32),
X CO(10,11), CP(32,11), CPCO(6), CR(32,11),
X CSLOPE(10,11), CU2(11), CU(32,11), CUCO(29,5),
X CX(32,11), CXM(10,11), CXNEW(10,11), CXRATO(29),
X CXS(10,11), DA(10), DELM(11), DEPV(10,11),
X DF(20), DFACT(29,11), DFL(29), DFLOW(32),
X EMACH(29,11), FOUNO(20,3,10), FRDEL(10,11), GAMMA(32,11),
X HMN(29), HUB(32), IKK(10), MACH(29,11),
X OBAR(29,11), PC(32,11), R(32,11), RCURVE(10,11),
X RH(32), RHO(32,11), RINT(11), RCTAG(11),
X RS(32), RSLOPE(10,11), RTRAIL(11), SOCO(29,5),
X SOLID(29,11), SSCU(29,5), TERM1(10,11), TERMA(11),
X TERMB(11), TERMC(11), TIP(32), TITLE(12),
X TU(32,11), TSTAT(11), U(32,11), W(11),
X X(32)
COMMON /SCALER/ A, AA, A10A0, A202A0, A303A0, A404A0,
X A505A0, B, BB, CC, CF, CMEAN, CMEANP, CUINTG,
X CPI2, CPI3, CPI4, CPI5, CPI6, CPO2, CPO3, CPO4,
X CPO5, CAMP, DCP, DD, DIFCM, DT, DUMMY, ERAS1,
X G, GASK, GJ, GR, GR2, JOULE, MAPR, MOLEWT,
X POCO, Q, RPM, TCP, TERMD, TESTBH, TESTDS, TESTMS,
X TOCO, TOL, TOLAT, TOLB2, TOLMIN, TOLMS, TOLTP, TOLCP,
X TGLCX, TOLR, TLTINT, TOTPR, V, VMI
COMMON /INTEGR/ I, IB, IB1, IDUMP, IERROR, IFIRST,
X IG, IOUTTR, IPASS, IS, IT, J, JIN, JJ,
X JM, JMI, K, K1, KK, L, LIMIT, LSTAGE,
X MSTAGE, NLINES, NTUBES, NX, NX1, YES
EQUIVALENCE (ATAR(1,1), ATAS(1,1)), (FLOW(1), DFLOW(1))

AA= (-SQRT(CX(I+1,1)**2 + CU(I+1,1)**2 + CR(I+1,1)**2) -
X CU(I+1,1)/2./SOLID(I+1,1))/(DFL(I+1)-1.)
BB=.5/(DFL(I+1)-1.)/SOLID(I+1,1)
CC= AA*BB/(BB*BB-1.)
AA=((CX(I,1)**2+CR(I,1)**2)-AA*AA)/(1.-BB*BB)
AA= CC*CC - AA

*** ERROR TRANSFER TO A NEW DATA SET

IF (AA.LT.0.) CALL ERROR(11)
AA= SQRT(AA)

*** CHECK FOR MULTIPLE POSITIVE ROOTS
CU(I,1)=-CC-AA

IF (CU(I,1).LE.0.0) CU(I,1)=AA-CC
CUCO(I,2)=CU(I,1)*R(I,1)-CUCO(I,1)/R(I,1) - (CUCO(I,3) + (CUCO(I,4

BCAL3.	-	EFN	SOURCE STATEMENT	-	IFN(S)	-	12/15/67
X) + CUCC(1,5)*R(1,1))*R(1,1))*R(1,1)							BCAL1210
30 RETURN							BCAL1211
END							BCAL1212

12/11/67

CAXIA. - EFN SOURCE STATEMENT - IFN(S) -

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C      *** CALCULATES AXIAL VELOCITIES WHICH SATISFY THE
C      AXIAL-VELOCITY EQUATION
C
SUBROUTINE CAXIAL
LOGICAL FIT
COMMON /ENERGY/ H, T, GAMMER
REAL MACH, MAPR, MCLWLT, JOULE
DIMENSION ATAS(29,11), FLOW(32)
LOGICAL IERRCR, YES
COMMON /MATRIX/ ALPHA(10,11), ATAR(29,11), B2(29),
X BETA(10,11), BH(32), BLADE(29), BT(32),
X CC(10,11), CP(32,11), CPO(6), CR(32,11),
X CSLOPE(10,11), CU2(11), CU(32,11), CUCU(29,5),
X CX(32,11), CXM(10,11), CXNEW(10,11), CXRAT(29),
X CXS(10,11), LA(10), DELM(11), DEPV(10,11),
X DF(20), DFACT(29,11), DFL(29), DFLOW(32),
X EMACH(29,11), FOUNO(20,3,10), FROEL(10,11), GAMMA(32,11),
X HMN(29), HUB(32), IKK(10), MACH(29,11),
X OBAR(29,11), PU(32,11), R(32,11), RCURVL(10,11),
X RH(32), KHO(32,11), RINT(11), RCSTAG(11),
X RS(32), RSLOPE(10,11), RTRAIL(11), SCCO(29,5),
X SOLID(29,11), SSCU(29,5), TERM1(10,11), TERMA(11),
X TERM8(11), TERMC(11), TIP(32), TITLE(12),
X TC(32,11), TSTAT(11), U(32,11), W(11),
X X(32)
COMMON /SCALER/ A, AA, A1GA0, A202A0, A303A0, A404A0,
X A505A0, B, BB, CC, CM, CMEAN, CMEANP, CUINTG,
X CPI2, CPI3, CPI4, CPI5, CPI6, CPO2, CPO3, CPU4,
X CPU5, CAMP, DCP, CD, DIFCM, DT, DUMMY, ERAS1,
X G, GASK, GJ, GR, GR2, JOULE, MAPR, MULEWT,
X POCO, Q, RPM, TCP, TERMO, TEST8H, TESTDS, TESTMS,
X TCCO, TOL, TOLAT, TOLB2, TOLMIN, TOLMS, TOLTIP, TOLCP,
X TOLCX, TOLR, TOTINT, TOTPR, V, VMI
COMMON /INTEGR/ I, IB, IB1, IDUMP, IERRCR, IFIRST,
X IG, ICUTTR, IPASS, IS, IT, J, JIN, JJ,
X JM, JMI, K, KI, KK, L, LIMIT, LSTAGE,
X MSTAGE, NLINES, NTUBES, NX, NX1, YES
EQUIVALENCE (ATAR(1,1), ATAS(1,1)), (FLOW(1), DFLOW(1))
C
C      *** SET LIMITS ON AXIAL VELOCITY TO RESTRAIN THE ITERATION.
C
TEST= 1.56
LIMIT= 1.6
L= 0
DO 1 I=18,NX
L= L+1
C
C      *** SATISFY CONTINUITY.
C
CALL STREAM
DO 1 J=1,NLINES
C      *** SAVE THE AXIAL VELOCITIES.

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12/15/67

CAXIA. - EFN SOURCE STATEMENT - IFN(S) -

BETA(L,J)=CX(I,J)	CAXI 353
1 CONTINUE	CAXI 354
LAMP= 10.0	CAXI 355
C *** INITIALIZE THE ITERATION COUNTER	CAXI 356
LOOPY=0	CAXI 357
5 CONTINUE	CAXI 358
C *** TURN THE CONVERGENCE TRIGGER ON.	CAXI 359
YES= .FALSE.	CAXI 360
LOOPY=LOOPY+1	CAXI 361
C *** ERROR WILL PRINT THE RESULTS OF THE LAST ITERATION	CAXI 362
C AND TRANSFER TO A NEW DATA SET	CAXI 363
IF (LOOPY.GT.250) CALL ERROR(4)	CAXI 364
DO 125 J=1,NLINES	CAXI 365
C *** GET FIRST AND SECOND DERIVATIVES OF R WITH RESPECT TO X	CAXI 366
125 CALL XDERIV(R,RSLLE,RORVE)	CAXI 367
L=0	CAXI 368
DO 130 I=1B,NX	CAXI 369
L=L+1	CAXI 370
CM2=CX(I,JM)**2	CAXI 371
DO 120 J=1,NLINES	CAXI 372
C *** SAVE THE AXIAL VELOCITIES	CAXI 373
CX(I,J)= (4.)*BETA(L,J) +CX(I,J)*0.2	CAXI 381
BETA(L,J)=CX(I,J)	CAXI 382
CU2(J)=CU(I,J)**2	CAXI 383
120 DEPV(L,J)=CU2(J)/R(I,J)	CAXI 384
CALL INTEC (DEPV,2)	CAXI 385
A= THERM1(TO(I,JM))	CAXI 386
DO 130 J=1,NLINES	CAXI 387
C *** CALCULATE THE ENTHALPY AND CENTRIFUGAL FORCE TERMS AS WELL AS	CAXI 388
C THE RADIAL VELOCITY TERM.	CAXI 389
130 TERM1(L,J)= (GJ*(THERM1(TO(I,J))-A)	CAXI 390
X*CR(I,JM)**2 -CR(I,J)**2	CAXI 391
X -(CU2(J) -CU2(JM)) -2.0*RI(I,J))	CAXI 392
X /CM2	CAXI 393
C *** FIND ENTROPY GRADIENT TERM IN AXIAL-VELOCITY EQUATION	CAXI 394
C *** OBTAIN FIRST DERIVATIVE OF DEPV WITH RESPECT TO RADIUS,	CAXI 395
C RESULT IS IN CU	CAXI 396
C *** NOTE... THE REFERENCE TERMS HAVE BEEN LEFT OUT OF THIS	CAXI 397
C EQUATION SINCE THEIR DERIVATIVES ARE ZERO	CAXI 398
L=0	CAXI 399
DO 235 I=1B,NX	CAXI 400
L=L+1	CAXI 401
DO 235 J=1,NLINES	CAXI 402
	CAXI 403
	CAXI 404
	CAXI 405
	CAXI 406
	CAXI 407
	CAXI 408
	CAXI 409
	CAXI 410
	CAXI 411
	CAXI 412

12/15/67

C	*** DETERMINE PART OF THE ENTROPY TERM.	412
	DEPV(L,J)= THERM3(TO(I,J))/DCP -ALOG(PO(I,J))	CAXI 413
	H= -(CX(I,J)**2 +CR(I,J)**2 +CU(I,J)**2)/GJ	CAXI 414
	T= TO(I,J)	CAXI 415
	CALL ENTALP	CAXI 416
233	CONTINUE	CAXI 417
	ALPHA(L,1)= 0.0	CAXI 418
	DO 235 J=2,NLINES	CAXI 420
		CAXI 421
C	*** INTEGRATE THE STATIC TEMPERATURE WITH RESPECT TO ENTROPY.	422
	235 ALPHA(L,J)= ALPHA(L,J-1) +0.5*GR*(TSTAT(J) +TSTAT(J-1))	CAXI 423
	X *(DEPV(L,J) -DEPV(L,J-1))	CAXI 424
210	DO 220 J=1,NLINES	CAXI 425
		CAXI 426
		CAXI 427
C	*** OBTAIN THE FIRST DERIVATIVE OF RADIAL VELOCITY WITH RESPECT	428
C	TO AXIAL LENGTH.	
		CAXI 430
220	CALL XDERIV(CR,CSLOPE,CO)	CAXI 431
	L=0	CAXI 432
	DO 490 I=IB,NX	CAXI 433
	ILL= 0	CAXI 434
		CAXI 435
C	*** HELP IS ALTERED TO REDUCE THE EFFECT OF CURVATURE WHEN	CAXI 436
C	THE ITERATION IS NOT NEAR THE SOLUTION	CAXI 437
		CAXI 438
	HELP=1.0	CAXI 439
	L=L+1	CAXI 440
225	DO 240 J=1,NLINES	CAXI 441
C	*** COMPUTE RADIAL VELOCITIES.	441
240	CR(I,J)=CX(I,J)*RSLOPE(L,J)	CAXI 442
	CM=CX(I,J)	CAXI 447
	CM2= HELP*CM**2	CAXI 448
245	DO 250 J=1,NLINES	CAXI 449
		CAXI 450
C	*** FIND STREAMLINE-CURVATURE TERM IN AXIAL-VELOCITY EQUATION	CAXI 451
		CAXI 452
250	DEPV(L,J)= CX(I,J)*CSLOPE(L,J)/CM2	CAXI 453
	CALL INTEG (DEPV,2)	CAXI 454
365	ILL= ILL +1	CAXI 455
370	DO 400 J=1,NLINES	CAXI 456
		CAXI 457
C	*** COMBINE THE TERMS IN THE AXIAL VELOCITY EQUATION.	458
		CAXI 459
	TERMD= (RINT(J) +RINT(J) +(ALPHA(L,JM) -ALPHA(L,J))/CM2	CAXI 460
	X +TERM1(L,J))/HELP	CAXI 461
	IF (TERMD) 381,365,363	CAXI 462
385	TERMD=1.0	CAXI 463
	GO TO 400	CAXI 464
		CAXI 465
C	*** CHECK VALUES OF VELOCITY RATIO AGAINST REASONABLE LIMITS	CAXI 466
		CAXI 467
381	IF (TERMD.GT.-.95) GO TO 390	CAXI 468
		CAXI 469
C	*** ALTER HELP TO REDUCE CURVATURE EFFECTS (TEMPORARILY)	CAXI 470
		CAXI 471

12/15/67

CAXIA. - EFN SOURCE STATEMENT - IFN(S) -

HELP= HELP*1.1	CAXI 472
IF (ILL.LT.25) GO TO 365	CAXI 473
TERMD=0.1	CAXI 474
GO TO 400	CAXI 475
383 IF (TERMD.LT.TEST) GO TO 390	CAXI 476
HELP= HELP*1.1	CAXI 477
IF (ILL.LT.25) GO TO 365	CAXI 478
TERMD= LIMIT	CAXI 479
GO TO 400	CAXI 480
C *** CALCULATE NEW AXIAL VELOCITY.	481
390 TERMD=SQRT(1.0+TERMD)	CAXI 481
400 CXNEW(L,J)=TERMD*CM	CAXI 482
410 CONTINUE	CAXI 483
	CAXI 484
C *** COMPARE VELOCITIES INTO CURVATURE EQUATION WITH THOSE OUT	CAXI 485
	CAXI 486
DO 440 J=1,NLINES	CAXI 487
IF (ABS((CXNEW(L,J)-CX(I,J))/CX(I,J)).GT.TOLCX) GO TO 450	CAXI 488
440 CONTINUE	CAXI 489
GO TO 455	CAXI 490
	CAXI 493
C *** UNSUCCESSFUL CONVERGENCE ON CX	CAXI 494
	CAXI 495
450 YES= .TRUE.	CAXI 491
455 DO 460 J=1,NLINES	CAXI 492
CX(I,J)= (CX(I,J) +CXNEW(L,J))*0.5	CAXI 496
460 CR(I,J)= CX(I,J)*RSLOPE(L,J)	CAXI 497
	CAXI 498
C *** SATISFY CONTINUITY	CAXI 499
	CAXI 500
CALL STREAM	CAXI 501
	CAXI 502
C *** MAKE AN ADJUSTMENT ON THE STREAMLINE POSITIONS.	503
	CAXI 504
CALL MOVE	CAXI 505
490 CONTINUE	CAXI 506
	CAXI 507
C *** CHECK CONVERGENCE OF AXIAL VELOCITIES	CAXI 508
	CAXI 509
1010 L=0	CAXI 510
DO 700 I=1B,NX	CAXI 511
L=L+1	CAXI 512
DO 700 J=1,NLINES	CAXI 513
IF (ABS((BETA(L,J)-CX(I,J))/CX(I,J)).GT.TOLCX) GO TO 1020	CAXI 514
700 CONTINUE	CAXI 515
L= 0	CAXI 516
	CAXI 517
	CAXI 518
GO TO 1021	CAXI 519
1020 YES= .TRUE.	CAXI 520
1021 L= 0	CAXI 521
L=L+1	CAXI 522
C *** MOVE THE LIMITS ON AXIAL VELOCITY.	523
TEST= 1.02*TEST	CAXI 523
LIMIT= SQRT(1.0+TEST)	CAXI 524
IF (YES) GO TO 5	CAXI 525

CAXIA. - EFN SOURCE STATEMENT - IFN(S) -

12/15/67

IT= 0
RETURN
END

CAXI 525
CAXI 527
CAXI 528

```

SUBROUTINE COPY
REAL MACH, MAPR, MLEWT, JOULE
DIMENSION ATAS(29,11), FLCW(32)
LOGICAL IERROR, YES
COMMON /MATRIX/ ALPHA(10,11), ATAR(29,11), B2(29),
X BETA(10,11), BH(32), BLADE(29), BT(32),
X CC(10,11), CP(32,11), CFCO(6), CR(32,11),
X CSLGPE(10,11), CU2(11), CU(32,11), CUCG(29,5),
X CX(32,11), CXM(10,11), CXNEW(10,11), CXRATG(29),
X CXS(10,11), DA(10), DELM(11), DEPV(10,11),
X DF(20), DFACT(29,11), DFL(29), DFLGW(32),
X EMACH(29,11), FOUNO(20,3,10), FRDEL(10,11), GAMMA(32,11),
X HMN(29), HUB(32), IKK(10), MACH(29,11),
X GBAR(29,11), PC(32,11), R(32,11), RCURVE(10,11),
X RH(32), RHO(32,11), RINT(11), ROSTAG(11),
X RS(32), RSLGPE(10,11), RTRAIL(11), SLCG(29,5),
X SCLID(29,11), SSCG(29,5), TERM1(10,11), TERMA(11),
X TERM8(11), TERMC(11), TIP(32), TITLE(12),
X TC(32,11), TSTAT(11), U(32,11), W(11),
X X(32)
COMMON /SCALER/ A, AA, A10A0, A202A0, A303A0, A404A0,
X A505A0, B, BB, CC, CM, CMEAN, CMEANP, COINTG,
X CPI2, CPI3, CPI4, CPI5, CPI6, CPO2, CPO3, CPO4,
X CPO5, CAMP, DCP, DD, DIFCM, DT, DUMMY, ERAS1,
X G, GASK, GJ, GR, GR2, JGULE, MAPR, MLEWT,
X POCO, Q, RPM, TCP, TERMD, TESTBH, TESTDS, TESTMS,
X TUCG, TOL, TCLAT, TOLB2, TOLMIN, TOLMS, TCLTIP, TOLCP,
X TGLCX, TOLR, TUTINI, TCTPR, V, VMI
COMMON /INTEGR/ I, IB, IB1, IDUMP, IERROR, IFIRST,
X IG, ICUTR, IPASS, IS, IT, J, JIN, JJ,
X JM, JMI, K, K1, KK, L, LIMIT, LSTAGE,
X MSTAGE, NLINES, NTUBES, NX, NX1, YES
EQUIVALENCE (ATAR(1,1), ATAS(1,1)), (FLOW(1), DFLGW(1))

L= I-2
AX= RPM*0.10471975
RH(I)= HUB(I)
RS(I)= TIP(I)
CALL RSTART
DO 50 J=1,NLINES
CX(I,J)= CX(L,J)
ATAR(I,J)= ATAR(L,J)
50 CR(I,J)= CR(L,J)
CALL PRFIT2
L= 2
CALL STREAM
RETURN
END

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12/15/67

DATA. - EFN SOURCE STATEMENT - IFN(S) -

```

BLOCK DATA
REAL MACH, MAPR, MOLEWT, JOULE
DIMENSION ATAS(29,11), FLOW(32)
LOGICAL IERROR, YES
COMMON /MATRIX/ ALPHA(10,11), ATAR(29,11), B2(29),
X BETA(10,11), BH(32), BLADE(29), BT(32),
X CC(10,11), CP(32,11), CPCO(6), CR(32,11),
X CSLOPE(10,11), CU2(11), CU(32,11), CUCU(29,5),
X CX(32,11), CXM(10,11), CXNEW(10,11), CXRATU(29),
X CXS(10,11), DA(10), DELM(11), DEPV(10,11),
X DF(20), DFACT(29,11), DFL(29), DFLOW(32),
X EMACH(29,11), FOUNO(20,3,10), FRDEL(10,11), GAMMA(32,11),
X HMN(29), HUB(32), IKK(10), MACH(29,11),
X OBAK(29,11), PO(32,11), R(32,11), RCURVE(10,11),
X RH(32), RHO(32,11), RINT(11), ROSTAG(11),
X RS(32), RSLOPE(10,11), RTRAIL(11), SCCU(29,5),
X SOLID(29,11), SSCU(29,5), TERM1(10,11), TERMA(11),
X TERMB(11), TERMC(11), TIP(32), TITLE(12),
X TO(32,11), TSTAT(11), U(32,11), W(11),
X X(32)
COMMON /SCALER/ A, AA, A10A0, A202A0, A303A0, A404A0,
X A505A0, B, BB, CC, CM, CMEAN, CMEANP, CUINTG,
X CPI2, CPI3, CPI4, CPI5, CPI6, CPG2, CP03, CP04,
X CP05, CAMP, OCP, DD, DIFCM, DT, DUMMY, ERAS1,
X G, GASK, GJ, GR, GR2, JOULE, MAPR, MOLEWT,
X POCO, C, RPM, TCP, TERMO, TESTBH, TESTDS, TESTMS,
X TOCO, TOL, TOLAT, TOLB2, TOLMIN, TOLMS, TOLTIP, TOLLP,
X TOLCX, TOLR, TCTINT, TOTPR, V, VMI
COMMON /INTEGR/ I, IB, IB1, IDUMP, IERROR, IFIRST,
X IG, ICUTTR, IPASS, IS, IT, J, JIN, JJ,
X JM, JMI, K, K1, KK, L, LIMIT, LSTAGE,
X MSTAGE, NLINES, NTUBES, NX, NX1, YES
EQUIVALENCE (ATAR(1,1),ATAS(1,1)), (FLOW(1),DFLOW(1))
DATA G, GJ, JOULE/ 1545.44, 50070.466, 778.12 /
DATA (DF(I),I=1,20)/C.0,.1,.15,.2,.25,.3,.35,.4,.45,.5,.55,.6,.65,
X.7,.75,.8,.85,.9,.95,1.0/
END

```

SUBROUTINE DATAL

C *** THIS SUBROUTINE PREPARES A MASTER TAPE OF LOSS DATA.
C IF A PERMANENT FILE IS USED THIS ROUTINE IS TO BE
C DISCARDED (THE \$ENTRY MUST BE CHANGED ALSO).

```

REAL MACH, MAPR, MOLEWT, JOULE
DIMENSION ATAS(29,11), FLCW(32)
LOGICAL IERROR, YES
COMMON /MATRIX/ ALPHA(10,11), ATAR(29,11), B2(29),
X BETA(10,11), BH(32), BLADE(29), BT(32),
X CU(10,11), CP(32,11), CPCO(6), CR(32,11),
X CSLUPE(10,11), CU2(11), CU(32,11), CUCU(29,5),
X CX(32,11), CXM(10,11), CXNEW(10,11), CXRATO(29),
X CXS(10,11), DA(10), DELM(11), DEPV(10,11),
X DF(20), DFACT(29,11), DFL(29), DFLCW(32),
X EMACH(29,11), FOUNO(20,3,10), FRDEL(10,11), GAMMA(32,11),
X HMN(29), HUB(32), IKK(10), MACH(29,11),
X GEAR(29,11), PO(32,11), R(32,11), RCURVE(10,11),
X RH(32), RHG(32,11), RINT(11), ROSTAG(11),
X RS(32), RSLUPE(10,11), RTRAIL(11), SUCU(29,5),
X SOLID(29,11), SUCU(29,5), TERM1(10,11), TERMA(11),
X TERMB(11), TERMC(11), TIP(32), TITLE(12),
X TO(32,11), TSTAT(11), U(32,11), W(11),
X X(32)
COMMON /SCALER/ A, AA, A10AO, A202AO, A303AO, A404AO,
X A505AO, B, BB, CC, CM, CMEAN, CMEANP, CUINTG,
X CPI2, CPI3, CPI4, CPI5, CPI6, CPU2, CPU3, CPU4,
X CPO5, CAMP, DCP, DD, DIFCM, DT, DUMMY, ERAS1,
X G, GASK, GJ, GR, GR2, JOULE, MAPR, MOLEWT,
X POCU, C, RPM, TCP, TERMC, TESTBH, TESTOS, TESTMS,
X TCCO, TOL, TGLAT, TGLB2, TOLMIN, TOLMS, TOLTIP, TOLCP,
X TOLCX, TOLR, TOTINT, TOTPR, V, VMI
COMMON /INTGR/ I, Id, IB1, IDUMP, IERROR, IFIRST,
X IG, ICUTR, IPASS, IS, IT, J, JIN, JJ,
X JM, JF1, K, K1, KK, L, LIMIT, LSTAGE,
X MSTAGE, NLINES, NTUBES, NX, NX1, YES
EQUIVALENCE (ATAR(1,1),ATAS(1,1)), (FLOW(1),DFLCW(1))

READ (5,910) IG
910 FORMAT (24I1)
REWIND 2
DO 920 I=1,IG
READ (5,925) ((CX(K,J),K=1,20),J=1,3)
920 WRITE (2) ((CX(K,J),K=1,20),J=1,3)
925 FORMAT (12F6.0)
960 END FILE 2
CALL MAIN
RETURN
END

```

SUBROUTINE DRIVE

C

*** OPTIMIZES TO ONE OF FOUR LIMITS

```

REAL MACH, MAPR, MOLEWT, JOULE
DIMENSION ATAS(25,11), FLOW(32)
LOGICAL IERROR, YES
COMMON /MATRIX/ ALPHA(10,11), ATAR(29,11), B2(29),
X BETA(10,11), BH(32), BLADE(29), BT(32),
X CC(10,11), CP(32,11), CPOD(6), CR(32,11),
X CSLOPE(10,11), CU2(11), CU(32,11), CUCU(29,5),
X CX(32,11), CXM(10,11), CXNEW(10,11), CARATU(29),
X CXS(10,11), DA(10), DELM(11), DEPV(10,11),
X DF(20), DFACT(29,11), DFL(29), DFLCW(32),
X EMACH(29,11), FOUNO(20,3,10), FROEL(10,11), GAMMA(32,11),
X HMN(29), HUB(32), IKK(10), MACH(29,11),
X UBAR(29,11), PC(32,11), R(32,11), RCURVE(10,11),
X RH(32), RHO(32,11), RINT(11), RCSTAG(11),
X RS(32), KSLOPE(10,11), KTRAIL(11), SUCU(29,5),
X SOLID(29,11), SSCU(29,5), TERM1(10,11), TERMA(11),
X TERMB(11), TERMC(11), TIP(32), TITLE(12),
X TC(32,11), TSTAT(11), U(32,11), W(11),
X X(32)
COMMON /SCALER/ A, AA, A1GAO, A2G2AO, A3G3AO, A4G4AO,
X A5G5AO, B, BB, CC, CM, CMEAN, CMEANP, COINIG,
X CPI2, CPI3, CPI4, CPI5, CPI6, CPU2, CPO3, CPO4,
X CPU5, CAMP, DCP, CD, DIFCM, DT, DUMMY, ERAS1,
X G, GASK, GJ, GR, GR2, JOULE, MAPR, MOLEWT,
X POCO, Q, RPM, TCP, TERMD, TESTBH, TESTOS, TESTMS,
X TUCO, TOL, TOLAT, TOLB2, TOLMIN, TOLMS, TOLTIP, TOLCP,
X TOLCX, TOLR, TOTINT, TOTPR, V, VMI
COMMON /INTEGR/ I, IB, IB1, IDUMP, IERROR, IFIRST,
X IG, ICUTTR, IPASS, IS, IT, J, JIN, JJ,
X JM, JMI, K, K1, KK, L, LIMIT, LSTAGE,
X MSTAGE, NLINES, NTUBES, NX, NX1, YES
EQUIVALENCE (ATAR(1,1),ATAS(1,1)), (FLOW(1),DFLOW(1))

```

DRIV1589
 DRIV1590
 DRIV1591
 DRIV1592
 DRIV1593
 DRIV1594
 DRIV1595
 DRIV1596
 DRIV1597
 DRIV1598
 DRIV1599
 DRIV1600
 DRIV1601
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 DRIV1633
 DRIV1634
 DRIV1635
 DRIV1636
 DRIV1637
 DRIV1638
 DRIV1639
 DRIV1640
 DRIV1641
 DRIV1642

C

*** SAVE THE WHIRL VELOCITY AT THE HUB

SAVEN=CU(I,1)

C

*** SAVE THE CURRENT B-COEFFICIENT OF WHIRL VELOCITY

SAVE=CUCU(I,2)

C

*** CALCULATE THE B-COEFFICIENT FROM RELATIVE FLOW ANGLE LIMIT

CALL B2CAL2

C

*** STORE THIS COEFFICIENT

B2RF= CUCU(I,2)
 CUCU(I,2) = 1.0E25

DRIVE. - EFN SOURCE STATEMENT - IFN(S) -

12/15/67

```

C      *** CALCULATE THE B-COEFFICIENT OF WHIRL VELOCITY FROM THE
C      ROTOR TIP D-FACTOR IF REQUIRED
      IF (DFL(I).NE.0.C) CALL B2CAL
C      *** STORE THIS COEFFICIENT
      B2CR= CUCC(I,2)
C      *** CALCULATE THE B-COEFFICIENT OF WHIRL VELOCITY FROM THE HUB
C      STATOR ENTRANCE ABSOLUTE MACH NUMBER LIMIT
      CALL B2CAL1
C      *** STORE THIS COEFFICIENT
      B2MN= CUCC(I,2)
      J=1
C      *** CALCULATE SOLIDITY FOR THE STATOR D-FACTOR
      AA=(R(I,J)+R(I+1,J))*0.5
      SOLID(I+1,J)=(SOCU(I+1,1)/AA+SOCU(I+1,2)/AA +SOCU(I+1,3)
X +(SOCU(I+1,4) +SOCU(I+1,J)*AA)*AA
C      *** CALCULATE B-COEFFICIENT OF WHIRL VELOCITY FROM STATOR
C      HUB D-FACTOR
      CALL B2CAL3
C      *** SELECT MINIMUM B-COEFFICIENT
      100 CUCC(I,2)= AMIN1( B2CR, B2MN, B2RF, CUCC(I,2))
      CU(I,1)=SAVEN
C      *** CHECK RELATIVE ERROR OF B-COEFFICIENT IF WITHIN THE
C      TOLERANCE, RESTORE THE PREVIOUS VALUES
      A= R(I,1)
      A= (CUCC(I,1)/A +CUCC(I,2)/A +CUCC(I,3)
X +(CUCC(I,4) +CUCC(I,5)*A)*A
      IF (ABS((A-CU(I,1))/A).LT.TOLB2) GO TO 110
C      *** DETERMINE NEW PARAMETERS
      CALL PRFIT2
C      *** SOLVE CONTINUITY EQUATION
      CALL STREAM
      IERROR= .TRUE.
      120 RETURN
      110 CUCC(I,2)=SAVE
      GO TO 120
      END

```

12/15/67

H. - EFN SOURCE STATEMENT - IFN(S) -

```

C SUBROUTINE ENTALP H. 1700
C *** CALCULATES THE TEMPERATURE RISE CORRESPONDING TO AN H. 1701
C ENTHALPY CHANGE H. 1702
C H. 1703
C H. 1704
C H. 1705
REAL MACF, MAPR, MOLEWT, JOULE H. 1706
DIMENSION ATAS(29,11), FLOW(32) H. 1707
LOGICAL IERROR, YES H. 1708
COMMON /MATRIX/ ALPHA(10,11), ATAR(29,11), B2(29), H. 1709
X BETA(10,11), BH(32), BLADE(29), BT(32), H. 1710
X CU(10,11), CP(32,11), CPCU(6), CR(32,11), H. 1711
X CSLOPE(10,11), CUZ(11), CU(32,11), CUCU(29,5), H. 1712
X CX(32,11), CXM(10,11), CXNEW(10,11), CXRATG(29), H. 1713
X CXS(10,11), DA(10), DELM(11), DEPV(10,11), H. 1714
X DF(20), DFACT(29,11), DFL(29), DFLOW(32), H. 1715
X EMACH(29,11), FOUNO(20,3,10), FRDEL(10,11), GAMMA(32,11), H. 1716
X HMN(29), HUB(32), IKK(10), MACH(29,11), H. 1717
X OBAR(29,11), PU(32,11), R(32,11), RCURVE(10,11), H. 1718
X RH(32), RHO(32,11), RINT(11), ROSTAG(11), H. 1719
X RS(32), RSLOPE(10,11), RTRAIL(11), SCCU(29,5), H. 1720
X SOLID(29,11), SSCU(29,5), TERM1(10,11), TERMA(11), H. 1721
X TERMB(11), TERMC(11), TIP(32), TITLE(12), H. 1722
X TG(32,11), TSTAT(11), U(32,11), W(11), H. 1723
X X(32) H. 1724
COMMON /SCALER/ A, AA, A10A0, A202A0, A303A0, A404A0, H. 1725
X A505A0, B, BB, CC, CM, CMEAN, CMEANP, CUINTG, H. 1726
X CPI2, CPI3, CPI4, CPI5, CPI6, CPC2, CPC3, CPD4, H. 1727
X CPD5, CAMP, DCP, DD, DIFCM, DT, DUMMY, ERAS1, H. 1728
X G, GASK, GJ, GR, GR2, JOULE, MAPR, MOLEWT, H. 1729
X POCO, Q, RPM, TCP, TERMD, TESTBH, TESTDS, TESIMS, H. 1730
X TCCO, TOL, TCLAF, TOLB2, TCLMIN, TULMS, TGLTIP, TULCP, H. 1731
X TOLCX, TOLR, TCTINT, TCTPR, V, VMI H. 1732
COMMON /INTEGR/ I, IB, IB1, IDUMP, IERROR, IFIRST, H. 1733
X IG, ICUTTR, IPASS, IS, IT, J, JIN, JJ, H. 1734
X JM, JM1, K, K1, KK, L, LIMIT, LSTAGE, H. 1735
X MSTAGE, NLINES, NTUBES, NX, NX1, YES H. 1736
EQUIVALENCE (ATAR(1,1), ATAS(1,1)), (FLOW(1), DFLOW(1)) H. 1737
COMMON /ENERGY/ F, T, GAMMER H. 1738
HOT= THERM1(T) H. 1739
TSTAT(J)= H/CP(I,J) +T H. 1740
DO 10 N=1,25 H. 1741
HIT= THERM1(TSTAT(J)) H. 1742
A= H -HIT +HOT H. 1743
TSTAT(J)= A/CP(I,J) +TSTAT(J) H. 1744
10 IF (ABS(A).LE.TOLMIN) GO TO 20 H. 1745
CALL ERROR (26) H. 1746
20 RETURN H. 1747
END H. 1748

```

12/15/67

ERR. - EFN SOURCE STATEMENT - IFN(S) -

SUBROUTINE ERROR(IER)

ERR.1749

ERR.1750

C *** PRINTS, RECOGNIZES AND SOMETIME CORRECTS ERRORS

ERR.1751

ERR.1752

ERR.1753

ERR.1754

ERR.1755

ERR.1756

ERR.1757

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ERR.1793

ERR.1794

ERR.1795

ERR.1796

ERR.1797

ERR.1798

ERR.1799

ERR.1800

ERR.1801

ERR.1802

INTEGER BLADE

DIMENSION WORD(6)

REAL MACH, MAPR, MOLEWT, JOULE

DIMENSION ATAS(29,11), FLOW(32)

LOGICAL IERROR, YES

COMMON /MATRIX/ ALPHA(10,11), ATAR(29,11),

X BETA(10,11), BH(32), BLADE(29), BT(32),

X CC(10,11), CP(32,11), CPCO(6), CR(32,11),

X CSLOPE(10,11), CU2(11), CU(32,11), CUCO(29,5),

X CX(32,11), CXM(10,11), CXNEW(10,11), CXRATU(29),

X CXS(10,11), CA(10), DELM(11), DEPV(10,11),

X DF(20), DFACT(29,11), DFL(29), DFLCW(32),

X EMACH(29,11), FOUNO(20,3,10), FRDEL(10,11), GAMMA(32,11),

X HMN(29), HUB(32), IKK(10), MACH(29,11),

X OBAR(29,11), PU(32,11), R(32,11), RCUKVL(10,11),

X RH(32), RHO(32,11), RINT(11), ROSTAG(11),

X KS(32), RSLOPE(10,11), RTKAIL(11), SGOO(29,5),

X SOLID(29,11), SSCG(29,5), TERM1(10,11), TERMA(11),

X TERMB(11), TERMC(11), TIP(32), TITLE(12),

X TG(32,11), TSTAT(11), U(32,11), W(11),

X X(32)

COMMON /SCALER/ A, AA, A10A0, A202A0, A303A0, A404A0,

X A505A0, B, BB, CC, CM, CMEAN, CMEANP, CUINTG,

X CPI2, CPI3, CPI4, CPI5, CPI6, CPU2, CPU3, CPU4,

X CPU5, CAMP, DCP, DD, DIFCP, DT, DUMMY, ERAS1,

X G, GASK, GJ, GR, GR2, JOULE, MAPR, MOLEWT,

X POCO, Q, RPM, TCP, TERMD, TESTBH, TESTUS, TESTMS,

X TCCG, TOL, TOLAT, TOLB2, TOLMIN, TOLMS, TOLTIP, TOLCP,

X TOLCX, TOLR, TOTINT, TOTPR, V, VMI

COMMON /INTEGR/ I, IB, IB1, IDUMP, IERROR, IFIRST,

X IG, ICUTTR, IPASS, IS, IT, J, JIN, JJ,

X JM, JMI, K, KI, KK, L, LIMIT, LSTAGE,

X MSTAGE, NLINES, NTUBES, NX, NX1, YES

EQUIVALENCE (ATAR(1,1), ATAS(1,1)), (FLOW(1), DFLOW(1))

DATA (WORD(1), I=1,6)/6HROTOUT,6HSTACOUT,5HCHECK,5HINEST,6HSTREAM,

X 6HPRFIT2/

1 FORMAT (1H0///40X21H*** ERROR MESSAGE *** /)

WRITE (6,1)

GO TO (11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,

X 30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50,

X 51), IER

11 WRITE (6,536) L

936 FORMAT (1H025X67H*** NOTE... LOSS DATA COULD BE IN ERROR - CHECK IERR.1797

INDEX ON LOSS DATA. /28X48H THE VALUE OF THE LOSS DATA INDEX IS SET

EQUAL TO 13,14H --- CONTINUE. //)

K1= L

GO TO 1030

12/15/67

ERR. - EFN SOURCE STATEMENT - IFN(S) -

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12 WRITE (5,112) I,CMEAN,FLOW(I),(TO (I,J),PO (I,J),CO(I,J),CR(I,J)ERR.1803
X ,J=1,NLINES) ERR.1804
112 FORMAT (1F020X53H"THE VALUE OF THE MEAN AXIAL VELOCITY AT AXIAL STAERR.1805
TION I3,25H,CALCULATED IN SUBROUTINE /21X83H"STREAM IS GREATER THANERR.1806
X THAT CORRESPONDING TO MACH ONE. THIS SITUATION HAS OCCURRED / 21XERR.1807
X 86H"IN TWO CONSECUTIVE ITERATION ON CONTINUITY. THE PARAMETERS CAUERR.1808
XSING THIS SITUATION ARE. /21X21H"MEAN AXIAL VELOCITY = F10.4,10X ERR.1809
X 11H"MASS FLOW = F10.4 // 36X10H TCTAL7X5HTOTAL6X5HWHIRL 6X ERR.1810
X 6H"RADIAL /36X10H TEMP.7X5HPRES.4X8HVELOCITY4X8HVELOCITY // ERR.1811
X (36X4F12.4) / ) ERR.1812
GO TO 1000 ERR.1813
ERR.1814
13 WRITE (6,113) I ERR.1815
113 FORMAT (1F020X78H"CONTINUITY COULD NOT BE SATISFIED IN SUBROUTINE SERR.1816
TREAM /21X37H"ON THE MEAN AXIAL VELOCITY ATEPR.1817
X STATION I3,20H,GO TO NEW DATA SET. / ) ERR.1818
GO TO 1000 ERR.1819
ERR.1820
14 WRITE (6,114) ERR.1821
114 FORMAT (1F020X77H"THE AXIAL-VELOCITY EQUATION COULD NOT BE SATISFIEERR.1822
XD IN SUBROUTINE CAXIAL AFTER /21X57H ITERATING ON AXIAL VELERR.1823
XOCITY. GO TO NEXT DATA SET. / ) ERR.1824
GO TO 1000 ERR.1825
ERR.1826
15 GO TO 1010 ERR.1827
16 WRITE (6,116) ERR.1828
116 FORMAT (1F020X83H"THE NUMBER OF STREAMLINES REQUESTED IS NOT ONE OFERR.1829
X THE PERMISSIBLE VALUES (5,7,9,11) /21X25H"....EXECUTION TERMINATEDERR.1830
X. / ) ERR.1831
GO TO 1020 ERR.1832
ERR.1833
17 WRITE (6,117) ERR.1834
117 FORMAT (21X77H"THE MAXIMUM NUMBER OF STAGES TO BE CONSIDERED EXCEEDERR.1835
XS 12 THE CALCULATION WILL /21X47H"CONTINUE AND CONSIDER ONLY THE FIERR.1836
XRST 12 STAGES. / ) ERR.1837
MSTAGE= 12 ERR.1838
GO TO 1030 ERR.1839
ERR.1840
18 WRITE (6,118) I,J ERR.1841
118 FORMAT (1F020X80H"THE VALUE OF THE ABSCLUTE VELOCITY CALCULATED IN ERR.1842
XITERATING ON THE AXIAL VELOCITY /21X37H"IN SUBROUTINE CAXIAL AT AXIERR.1843
XAL STATION I3,21H ON STREAMLINE NUMBER I3,13H EXCEEDS THAT / 21X ERR.1844
X 72H"CORRESPONDING TO TCTAL TEMPERATURE. THE VALUES OF THE PARAMETEERR.1845
XRS CAUSING /21X30H"THIS SITUATION ARE AS FOLLOWS. // 25X10H"STREAMLIERR.1846
XNE 4X5HTOTAL5X8H"SPECIFIC6X5HAXIAL7X5HWHIRL6X6H"RADIAL /25X8H NUMBEERR.1847
XR 6X5HTEMP.7X4HHEAT6X8HVELOCITY4X8HVELOCITY4X8HVELOCITY / ) ERR.1848
WRITE (6,2118) (J,TO(I,J),CP(I,J),CX(I,J),CU(I,J),CR(I,J), ERR.1849
X J=1,NLINES) ERR.1850
2118 FORMAT (25X I6,4X5F12.4) ERR.1851
GO TO 1000 ERR.1852
ERR.1853
19 WRITE (6,119) MSTAGE ERR.1854
119 FORMAT (1F020X63H"THE DESIRED MASS-AVERAGED PRESSURE RATIO HAS NOT ERR.1855
XBEEN MET AFTER I3, 8H STAGES./21X48H"THE RESULTS OF THESE STAGES WIER.1856
XLL NOW BE PRINTED. / ) ERR.1857
GO TO 1030 ERR.1858

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12/15/67

20 WRITE (6,120)	ERR.1859
120 FORMAT (1F020X81FINLET TEMP. AND/OR PRESSURE IS NON-POSITIVE,IF 0	ERR.1860
XTHE PROGRAM WILL GO TO NEW DATA. /)	ERR.1861
PUCU= ABS(PUCU)	ERR.1862
TOCU= ABS(TOCU)	ERR.1863
IF (PUCU*TOCU.EQ.0.) GO TO 1010	ERR.1864
GO TO 1030	ERR.1865
	ERR.1866
	ERR.1867
	ERR.1868
21 WRITE (6,121)	ERR.1869
121 FORMAT (1F020X73FIN CORRECTING FOR EXCESSIVE STATOR HUB C-FACTOR,	ERR.1870
XSQUAKE ROOT OF NEGATIVE /21X43HNUMBER WAS ENCOUNTERED. GO TO NEW	ERR.1871
XATA SET. /)	ERR.1872
GO TO 1000	ERR.1873
	ERR.1874
22 ANCRD= WCFD(4)	ERR.1875
GO TO 656	ERR.1876
	ERR.1877
23 WRITE (6,123)	ERR.1878
123 FORMAT (/20X 60HTHE FRACTIONAL MASS FLOW, MASS FLOW OR GEOMETRY IS	ERR.1879
X IN ERROR.)	ERR.1880
GO TO 1010	ERR.1881
	ERR.1882
24 WRITE (6,124) I	ERR.1883
LIMIT= 1	ERR.1884
124 FORMAT (1F020X69AFTER 40 ATTEMPTS AN OPTIMAL STAGE COULD NOT BE D	ERR.1885
XETERMINED AT STATION 13,1H./21X49HSOLUTION WILL CONTINUE WITH PRE	ERR.1886
XENT WORK LOADING. /)	ERR.1887
GO TO 1030	ERR.1888
	ERR.1889
25 WRITE (6,125) I	ERR.1890
125 FORMAT (1F0 2CX 39HFAILURE OF THE MACH NO. TEST AT STATION 13)	ERR.1891
GO TO 1000	ERR.1892
26 WRITE (6,126) I	ERR.1893
126 FORMAT (1F020X55HFAILURE IN THE RELATIVE FLOW ANGLE ITERATION AT S	ERR.1894
XTATION 13)	ERR.1895
GO TO 1000	ERR.1896
	ERR.1897
27 WRITE (6,127) BLADE(I), I	ERR.1898
127 FORMAT (/20X 20HAN IMPROPER VALUE OF 14, 62H FOR THE BLADE TYPE HA	ERR.1899
XS BEEN READ IN. WE WILL CONTINUE WITH A /20X 22HVALUE OF 1 FOR ST	ERR.1900
XATION 13, 1H.)	ERR.1901
BLADE(I)= 1	ERR.1902
GO TO 1030	ERR.1903
	ERR.1904
28 WRITE (6,128)	ERR.1905
128 FORMAT (1F020X70HFAILURE IN THE MAIN SUBROUTINE TO ITERATE WITHIN	ERR.1906
XLIMITS WITH CURVATURE /21X53HEFFECTS ENCOUNTERED. OUTPUT AT THI	ERR.1907
XS POINT FOLLOWS. /)	ERR.1908
GO TO 1000	ERR.1909
	ERR.1910
29 WRITE (6,129)	ERR.1911
129 FORMAT (1F020X77HITERATION ON EFFICIENCY HAS FAILED .	ERR.1912
XOUTPUT AT THIS POINT FOLLOWS. /)	ERR.1913
GO TO 1000	ERR.1914

12/15/67

ERR. - EFN SOURCE STATEMENT - IFN(S) -

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30 WRITE (6,130) ERR.1915
130 FORMAT (1F020X66FAN ILLEGAL VALUE HAS BEEN USED FOR THE OUTPUT TRIERR.1916
  XGGER. CALCULATION /21X36HCONTINUED WITH THE TRIGGER SET TO 1. /) ERR.1917
  IOUTTR= 1 ERR.1918
  GO TO 1030 ERR.1919
  ERR.1920
  ERR.1921
31 WRITE (6,131) I ERR.1921
131 FORMAT (/20X 79HTHE BLOCKAGE FACTOR AT THE HUB IS NON-POSITIVE EXEEPR.1922
  XCUTION CONTINUED WITH A VALUE /20X 17HOF 1.0 AT STATION 13,1H.) ERR.1923
  BH(1)= 1.0 ERR.1924
  GO TO 1030 ERR.1925
  ERR.1926
  ERR.1927
32 CONTINUE ERR.1927
  GO TO 1000 ERR.1928
  ERR.1929
  ERR.1930
33 WRITE (6,133) I ERR.1930
133 FORMAT (1F020X52FFAILURE ON D-FACTOR ITERATION AT STATERR.1931
  XION 13, 2CH GO TO NEW DATA SET. /) ERR.1932
  GO TO 1035 ERR.1933
  ERR.1934
  ERR.1935
34 GO TO 1010 ERR.1936
  ERR.1937
35 WRITE (6,135) ERR.1937
135 FORMAT (1F020X90HSQ. ROOT ERROR.. BLOCKAGE AT TIP IS NEGATIVE IN SERR.1938
  XUBROUTINE MAIN. SET = TO 1. AND CONTINUE. / ) ERR.1939
  BT(1)= 1.0 ERR.1940
  GO TO 1030 ERR.1941
  ERR.1942
  ERR.1943
36 WRITE (6,136) ERR.1943
136 FORMAT (/20X 34HTHE ENTHALPY ITERATION HAS FAILED. ) ERR.1944
  GO TO 1035 ERR.1945
  ERR.1946
  ERR.1947
37 WRITE (6,150) I ERR.1947
150 FORMAT (1F020X71FSQ. ROOT ERROR.. IN SUBROUTINE STREAM A NEGATIVE ERR.1948
  XSTATIC TEMPERATURE HAS /21X24HBEEN COMPUTED AT STATION 13,23H. CHERR.1949
  XCK THE INPUT DATA. /) ERR.1950
  GO TO 1000 ERR.1951
  ERR.1952
  ERR.1953
38 WRITE (6,138) I, DFL(1) ERR.1953
  DFL(1)= 0.4 ERR.1954
138 FORMAT (/20X 10HAT STATION 13, 20H A C-FACTOR LIMIT OFE12.4, ERR.1955
  X 17H HAS BEEN READ IN /20X29HTHIS WILL BE CHANGED TO 0.4 .) ERR.1956
  GO TO 1030 ERR.1957
  ERR.1958
  ERR.1959
39 WRITE (6,139) I, FRDEL(L,J) ERR.1959
139 FORMAT (/20X 10HAT STATION 13, 35H THE MACH NO. THAT CORRESPONDS TERR.1960
  XO A / 20X 22HPRANDLE-MEYER ANGLE OF F6.2, 20H COULD NOT BE FOUND.)ERR.1961
  GO TO 1000 ERR.1962
  ERR.1963
  ERR.1964
40 WRITE (6,140) I ERR.1964
140 FORMAT (/20X 72HTHE RADIAL AND AXIAL COMPONENTS OF VELOCITY AT THEERR.1965
  X STATOR HUB OF STATION 13 / 20X50HTOGETHER YIELDS A MACH NO. GREATERR.1966
  XER THAN THE LIMIT.) ERR.1967
  GO TO 1000 ERR.1968
  ERR.1969
41 AWORD= WORD(5) ERR.1970

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12/15/67

ERR. - EFN SOURCE STATEMENT - IFN(S) -

GO TO 656	ERR.1971
42 WRITE (6,142)	ERR.1972
142 FORMAT (//20X 69HEITHER A PRESSURE RATIO LESS THAN ONE OR A TEMPEAERR.1973	
XTURE LESS THAN ZERO /20X 70HHAS BEEN CALCULATED. THE WHIRL VELOCIERR.1974	
ITY POLYNOMIAL SHOULD BE CHECKED.)	ERR.1975
GO TO 1035	ERR.1976
	ERR.1977
	ERR.1978
43 WRITE (6,143) DFL(1),SOLID(1,1)	ERR.1979
143 FORMAT (1F020X81HSQ. RCCT ERROR.. IN SUBROUTINE B2CAL THE EXPRESSIERR.1980	
XGN FOR COMPUTING THE COEFFICIENT /21X80HOF 1.0/R IN THE WHIRL VELOERR.1981	
XCITY DISTRIBUTION HAS NO SOLUTION. THE D-FACTOR LIMIT, /21XE18.8, ERR.1982	
X19H, AND THE SOLIDITY, F9.5,20H, SHOULD BE CHECKED. /)	ERR.1983
GO TO 1000	ERR.1984
	ERR.1985
	ERR.1986
44 WRITE (6,144)	ERR.1987
144 FORMAT (20X 88HTHE FRACTIONAL MASS FLOWS ARE NOT MONOTONIC. THEY ERR.1988	
XWILL BE ALTERED TO REASONABLE VALUES.)	ERR.1989
A= 1.0/FLCAT(NTUBES)	ERR.1990
DELM(1)= 0.0	ERR.1991
DO 1044 I=2,NLINES	ERR.1992
1044 DELM(I)= DELM(I-1) +A	ERR.1993
GO TO 1030	ERR.1994
	ERR.1995
656 WRITE (6,156) AWCRO,I	ERR.1996
156 FORMAT (1F020X27FEXP. ERROR.. IN SUBROUTINE A6,34H A NEGATIVE STATEERR.1997	
XIC TEMPERATURE HAS /21X24HBEEN COMPUTED AT STATION I3,23H. CHECK TERR.1998	
XHE INPUT DATA. /)	ERR.1999
1000 CALL OUTPUT	ERR.2000
45 CONTINUE	ERR.2001
46 CONTINUE	ERR.2002
47 CONTINUE	ERR.2003
48 CONTINUE	ERR.2004
49 CONTINUE	ERR.2005
50 CONTINUE	ERR.2006
51 CONTINUE	ERR.2007
WRITE (6,2119)	ERR.2008
2119 FORMAT (1F020X32HNCW PROCEED TO THE NEXT DATA SET /)	ERR.2009
1010 CALL MAIN	ERR.2010
1020 CALL EXIT	ERR.2011
1030 RETURN	ERR.2012
1035 CALL PDUMP(ALPHA,X(32),1,1,YES,2,A,VMI,1)	ERR.2013
GO TO 1010	ERR.2014
END	

12/15/67

GAME. - EFN SOURCE STATEMENT - IFN(S) -

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SUBROUTINE GAM
REAL MACH, MAPR, MOLEWT, JOULE
DIMENSION ATAS(29,11), FLOW(32)
LOGICAL IERROR, YES
COMMON /MATRIX/ ALPHA(10,11), ATAR(29,11), B2(29),
X BETA(10,11), BH(32), BLADE(29), BT(32),
X CO(10,11), CP(32,11), CPCO(6), CR(32,11),
X CSLOPE(10,11), CU2(11), CUI(32,11), CUCC(29,5),
X CX(32,11), CXM(10,11), CXNEW(10,11), CXRATU(29),
X CXS(10,11), CA(10), DELM(11), DEPV(10,11),
X DF(20), DFAC1(29,11), DFL(29), DFLW(32),
X EMACH(29,11), FOUNO(20,3,10), FRDEL(10,11), GAMMA(32,11),
X HMN(29), HGB(32), IKK(10), MACH(29,11),
X OBAR(29,11), PG(32,11), R(32,11), RCURVE(10,11),
X RH(32), RHG(32,11), RINT(11), RCSTAG(11),
X RS(32), RSLQPE(10,11), KTRAIL(11), SCCU(29,5),
X SOLID(29,11), SSCU(29,5), TERM1(10,11), TERMA(11),
X TERMB(11), TERMC(11), TIP(32), TITLE(12),
X TC(32,11), TSTAT(11), U(32,11), W(11),
X X(32)
COMMON /SCALER/ A, AA, A1CA0, A202A0, A303A0, A40+A0,
X A505A0, E, BB, CC, CM, CMEAN, CMEANP, CUNITG,
X CPI2, CPI3, CPI4, CPI5, CPI6, CP02, CP03, CP04,
X CP05, CAMP, DCP, DD, DIFCN, DT, DUMMY, ERAS1,
X G, GASK, GJ, GR, GR2, JOULE, MAPR, MOLEWT,
X PCCO, Q, RPM, TCP, TERMD, TESTBH, TESTDS, TESTMS,
X TCCO, TOL, TOLAT, TOLB2, TCLMIN, TOLMS, TOLTIP, TOLCP,
X TOLCX, TOLR, TOTINT, TOTPR, V, VMI
COMMON /INTEGR/ I, IB, IB1, IDUMP, IERROR, IFIRST,
X IG, ICUTR, IPASS, IS, IT, J, JIN, JJ,
X JM, JF1, K, K1, KK, L, LIMIT, LSTAGE,
X MSTAGE, NLINES, NTUBES, NX, NX1, YES
EQUIVALENCE (ATAR(1,1),ATAS(1,1)), (FLOW(1),DFLOW(1))
COMMON /ENERGY/ H, T, GAMMER
A= CPCO(1) +(CPCO(2) +(CPCO(3) +(CPCO(4) +(CPCO(5) +CPCO(6)
X *TSTAT(J) )*TSTAT(J) )*TSTAT(J) )
X *TSTAT(J) )*TSTAT(J)
GAMMER= A/(A -DCP)
RETURN
END

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GAME2016
 GAME2017
 GAME2018
 GAME2019
 GAME2020
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12/15/67

INEST. - EFN SOURCE STATEMENT - IFN(S) -

SUBROUTINE INEST

INES2057

INES2058

INES2059

INES2060

INES2061

INES2062

INES2063

INES2064

INES2065

INES2066

INES2067

INES2068

INES2069

INES2070

INES2071

INES2072

INES2073

INES2074

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INES2092

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INES2094

INES2095

INES2096

INES2097

INES2098

INES2099

INES2100

INES2101

INES2102

INES2103

INES2104

INES2105

INES2106

INES2107

INES2108

INES2109

INES2110

C
C

*** MAKES INITIAL ESTIMATES OF AXIAL VELOCITIES FOR
STATIONS BETWEEN BLADE ROWS

REAL MACH, MAPR, MOLEWT, JOULE
DIMENSION ATAS(29,11), FLOW(32)
LOGICAL IERROR, YES

COMMON /MATRIX/ ALPHA(10,11), ATAR(29,11), B2(29),
X BETA(10,11), BH(32), BLADE(29), BT(32),
X CG(10,11), CP(32,11), CPGO(6), CR(32,11),
X CSLOPE(10,11), CU2(11), CU(32,11), CUCO(29,5),
X CX(32,11), CXM(10,11), CXNEW(10,11), CXRATO(29),
X CXS(10,11), DA(10), DELM(11), DEPV(10,11),
X DF(20), DFACT(29,11), DFL(29), DFLOW(32),
X EMACH(29,11), FOUNO(20,3,10), FROEL(10,11), GAMMA(32,11),
X HMN(29), HUB(32), IKK(10), MACH(29,11),
X OEAR(29,11), PC(32,11), K(32,11), RCURVE(10,11),
X RH(32), RHO(32,11), RINT(11), ROSTAG(11),
X KS(32), RSLUPE(10,11), RTRAIL(11), SGOO(29,5),
X SOLID(29,11), SSCO(29,5), TERM1(10,11), TERMA(11),
X TERMB(11), TERMC(11), TIP(32), TITLE(12),
X TU(32,11), TSTAT(11), U(32,11), W(11),
X X(32)
COMMON /SCALER/ A, AA, A1CAG, A2O2AO, A3O3AO, A4O4AO,
X A5O5AO, B, BB, CC, CM, CMEAN, CMEANP, COINTG,
X CPI2, CPI3, CPI4, CPI5, CPI6, CP02, CP03, CP04,
X CP05, CAMP, DCP, DD, DIFCA, DT, DUMMY, ERAS1,
X G, GASK, GJ, GK, GR2, JOULE, MAPR, MOLEWT,
X POCG, C, RPM, TCP, TERMD, TESTBH, TESTDS, TESTMS,
X TCCG, TOL, TOLAT, TULB2, TOLMIN, TOLMS, TOLTIP, TOLCP,
X TOLCX, TOLR, TCTINT, TUTPR, V, VMI
COMMON /INTEGR/ I, IB, IB1, IDUMP, IERROR, IFIRST,
X IG, ICUTTR, IPASS, IS, IT, J, JIN, JJ,
X JM, JM1, K, K1, KK, L, LIMIT, LSTAGE,
X MSTAGE, NLINES, NTUBES, NX, NX1, YES
EQUIVALENCE (ATAR(1,1), ATAS(1,1)), (FLOW(1), DFLOW(1))

HELP=1.0

C

*** ESTIMATE MID-STREAM VELOCITIES

ROSTAG(JM)=PO(1, JM)/(TC(1, JM)*GASK)
CX(1, JM)=FLOW(1)/(ROSTAG(JM)*(RS(1)**2-RH(1)**2))/3.1415927
V=(CX(1, JM)**2+CU(1, JM)**2)/GJ/CP(1, JM)
ERAS1= 1.0-V/TU(1, JM)

C

*** ERROR TRANSFER TO A NEW DATA SET

IF (ERAS1.LE.0.0) CALL ERROR(12)
CX(1, JM)= CX(1, JM)/(ERAS1*(1./(GAMMA(1, JM)-1.)))
70 CONTINUE
CM2=CX(1, JM)**2
CMZ=CM2*HELP

12/15/67

INEST. - EFN SOURCE STATEMENT - IFN(S) -

C	*** CALCULATE VALUES OF CU**2 AND ESTIMATE STATIC TEMPERATURES	INES2111
	DO 100 J=1,NLINES	INES2112
	CU2(J)=CU(I,J)**2	INES2113
	V=(CM2+CU2(J))/GJ/CP(I,J)	INES2114
100	TSTAT(J)=TU(I,J)-V	INES2115
		INES2116
		INES2117
		INES2118
C	*** CALCULATE VALUES OF TERMA AND RADIAL DERIVATIVE TERM	INES2119
	DO 110 J=1,NLINES	INES2120
	TERMA(J)=GJ*(CP(I,J)*TL(I,J)-CP(I,JM)*TC(I,JM))-(CU2(J)-CU2(JM))	INES2121
	IF (TO(I,J).LT.0.) CALL ERROR(50)	INES2122
	RATP=(TO(I,J)**(GAMMA(I,J)/(GAMMA(I,J)-1.)))/PC(I,J)	INES2123
110	DEPV(L,J)=ALOG(RATP)	INES2124
		INES2125
		INES2126
C	*** CALCULATE DERIVATIVE OF DEPV WITH RESPECT TO RADIUS,	INES2127
C	RESULT IS IN CO	INES2128
	CALL RDERIV(DEPV,10)	INES2129
		INES2130
		INES2131
C	*** CALCULATE VALUES OF TERMB	INES2132
	DO 120 J=1,NLINES	INES2133
120	DEPV(L,J)=CU2(J)/R(I,J) +GR2*TSTAT(J)*CO(L,J)	INES2134
	CALL INTEG(DEPV,2)	INES2135
	DO 200 J=1,NLINES	INES2136
	TERMB(J)=2.0*RINT(J)	INES2137
		INES2138
C	*** CALCULATE CX/CM AND CX DISTRIBUTIONS	INES2139
	DUMMY=((TERMA(J)-TERMB(J))/CM2)+1.0	INES2140
	IF (DUMMY)130,140,140	INES2141
130	CONTINUE	INES2142
	HELP=HELP*1.25	INES2143
	GO TO 70	INES2144
140	IF (DUMMY-1.0)155,150,155	INES2145
150	CXM(L,J)=1.0	INES2146
	GO TO 160	INES2147
155	CXM(L,J)=SQRT(DUMMY)	INES2148
160	CX(I,J)=CXM(L,J)*CX(I,JM)	INES2149
200	CONTINUE	INES2150
	AA= CX(I,JM)*1.6	INES2151
	BB= CX(I,JM)*0.4	INES2152
	DO 400 J=1,NLINES	INES2153
	IF (CX(I,J).GT.AA) CX(I,J)=AA	INES2154
	IF (CX(I,J).LT.BB) CX(I,J)=BB	INES2155
400	CONTINUE	INES2156
210	RETURN	INES2157
	END	INES2158
		INES2159

12/15/67

INLET. - EFN SOURCE STATEMENT - IFN(S) -

SUBROUTINE INLET

C *** YIELDS INITIAL ESTIMATE OF FLUID FLOW IN THE INLET

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REAL MACH, MAPR, MOLEWT, JOULE
DIMENSION ATAS(29,11), FLOW(32)
LOGICAL IERROR, YES
COMMON /MATRIX/ ALPHA(10,11), ATAR(29,11), B2(29),
X BETA(10,11), BH(32), BLADE(29), BT(32),
X CC(10,11), CP(32,11), CPCU(6), CR(32,11),
X CSLOPE(10,11), CU2(11), CU(32,11), CUCU(29,5),
X CX(32,11), CXM(10,11), CXNEW(10,11), CXRATU(29),
X CXS(10,11), CA(10), DELM(11), DEPV(10,11),
X DF(20), DFACT(29,11), DFL(29), DFLOW(32),
X EMACH(29,11), FOUNO(20,3,10), FRDEL(10,11), GAMMA(32,11),
X HMN(29), HUB(32), IKK(10), MACH(29,11),
X OBAR(29,11), PC(32,11), R(32,11), RCURVE(10,11),
X RH(32), RHO(32,11), RINT(11), RCSTAG(11),
X RS(32), RSLUPE(10,11), RTRAIL(11), SECU(29,5),
X SCLID(29,11), SSCU(29,5), TERM1(10,11), TERMA(11),
X TERMB(11), TERML(11), TIP(32), TITLE(12),
X TC(32,11), TSTAT(11), U(32,11), W(11),
X X(32)
COMMON /SCALER/ A, AA, A1GA0, A202A0, A303A0, A404A0,
X A505A0, E, BB, CC, CM, CMEAN, CMEANP, CUINTG,
X CPI2, CPI3, CPI4, CPI5, CPI6, CPU2, CPU3, CPU4,
X CPU5, DAMP, DCP, CD, DIFCM, DT, DUMMY, ERAS1,
X G, GASK, GJ, GK, GR2, JOULE, MAPR, MOLEWT,
X POCU, C, RFM, TGP, TERMO, TESTBH, TESTDS, TESTMS,
X TUCO, TOL, TCLAT, TCLB2, TCLMIN, TOLMS, TOLTIP, TOLCP,
X TOLCX, TOLR, TOTINT, TOTPK, V, VMI
COMMON /INTEGR/ I, IB, IB1, IDUMP, IERROR, IFIRST,
X IG, ICUTTR, IPASS, IS, IT, J, JIN, JJ,
X JM, JMI, K, K1, KK, L, LIMIT, LSTAGE,
X MSTAGE, NLINES, NTUBES, NX, NX1, YES
EQUIVALENCE (ATAR(1,1),ATAS(1,1)), (FLOW(1),DFLOW(1))

```

DO 10 I=1,5

C *** GET INITIAL STREAMLINE RADIUS ESTIMATE

CALL RSTART

C *** DETERMINE FLOW PARAMETERS

CALL PRFIT2

C *** GET INITIAL ESTIMATE OF FLUID FLOW

CALL INEST

C *** SOLVE CONTINUITY EQUATION

10 CALL STREAM

INLET. - EFN SOURCE STATEMENT - IFN(S) -
RETURN
END

12/15/67

INLE2215
INLE2216

12/15/67

INTEG. - EFN SOURCE STATEMENT - IFN(S) -

SUBROUTINE INTEG (VDEP,IFCON)

*** PERFORMS NUMERICAL INTEGRATIONS OF THE VDEP VS. R CURVE
 *** TRAPEZOIDAL RULE INTEGRATION

DIMENSION VDEP(10,11)

REAL MACH, MAPR, MULEWT, JOULE

DIMENSION ATAS(29,11), FLOW(32)

LOGICAL IEKRROR, YES

COMMON /MATRIX/ ALPHA(10,11), ATAR(29,11), B2(29),
 X BETA(10,11), BH(32), BLADE(29), BT(32),
 X CC(10,11), CP(32,11), CPCO(6), CR(32,11),
 X CSLOPE(10,11), CU2(11), CU(32,11), CUCO(29,5),
 X CX(32,11), CXM(10,11), CXNEW(10,11), CXRATC(29),
 X CXS(10,11), DA(10), DELM(11), DEPV(10,11),
 X DF(20), DFACT(29,11), DFL(29), DFLW(32),
 X EMACH(29,11), FCUND(20,3,10), FRDEL(10,11), GAMMA(32,11),
 X HMN(29), HUB(32), IKK(10), MACH(29,11),
 X OBAR(29,11), PO(32,11), R(32,11), RCURVE(10,11),
 X RH(32), RHO(32,11), RINT(11), RSTAG(11),
 X RS(32), RSLGPE(10,11), RTRAIL(11), SCCO(29,5),
 X SOLID(29,11), SSCO(29,5), TERM1(10,11), TERMA(11),
 X TERMB(11), TERMC(11), TIP(32), TITLE(12),
 X TO(32,11), TSTAT(11), U(32,11), W(11),
 X X(32)
 COMMON /SCALER/ A, AA, A10A0, A202A0, A303A0, A404A0,
 X A505A0, B, BB, CC, CM, CMEAN, CMEANP, CUINTG,
 X CPI2, CPI3, CPI4, CPI5, CPI6, CPD2, CPC3, CPD4,
 X CPD5, DAMP, DCP, DC, DIFCM, DT, DUMMY, ERAS1,
 X G, GASK, GJ, GR, GR2, JOULE, MAPR, MULEWT,
 X POCU, C, RPM, TCP, TERMD, TESTBH, TESTDS, TESTMS,
 X TCCO, TOL, TOLAT, TOLB2, TOLMIN, TOLMS, TOLTP, TOLCP,
 X TOLCX, TOLR, TOTINT, TOTPR, V, VMI
 COMMON /INTEGR/ I, IB, IB1, IDUMP, IEKRROR, IFIRST,
 X IG, ICUTTR, IPASS, IS, IT, J, JIN, JJ,
 X JM, JPI, K, KI, KK, L, LIMIT, LSTAGE,
 X MSTAGE, NLINES, NTUBES, NX, NX1, YES
 EQUIVALENCE (ATAR(1,1), ATAS(1,1)), (FLOW(1), DFLW(1))

RINT(1)=0.0

GO TO (50,90),IFCON

*** CALCULATES INTEGRAL OF VDEP * R DR

50 DO 15 J=1,NTUBES

10 DA(J)=(VDEP(L,J)*R(I,J)+VDEP(L,J+1)*R(I,J+1))*(R(I,J+1)-R(I,J))*.

15 RINT(J+1)=RINT(J)+DA(J)

GO TO 150

*** CALCULATE NTUBES VALUES OF INCREMENTAL INTEGRALS FOR CURVE
 VDEP VS. R (R(J) TO R(J+1))

90 DO 115 J=1,NTUBES

INTEG. - EFN SOURCE STATEMENT - IFN(S) -

12/15/67

```
100 DA(J)=(VDEP(L,J)+VDEP(L,J+1))*(R(I,J+1)-R(I,J))*0.5
115 RINT(J+1)= RINT(J) +DA(J)
150 B= RINT(J)
    DO 200 J=1,NLINES
200 RINT(J)= RINT(J)-B
    RETURN
    END
```

```
INTE2272
INTE2273
INTE2274
INTE2275
INTE2276
INTE2277
INTE2278
```

12/15/67

REAL FUNCTION LCSE(ARG,PERHT,TYPE)

LOSE2041

LOSE2042

2043

C *** YIELDS LOSS PARAMETER FROM INPUT MAPS AS A FUNCTION OF
C PERCENT BLADE HEIGHT AND D-FACTOR AND CIRCULAR INTERPOLATION
C ALONG THE RADII(S).

INTEGER TYPE, FIRST

LOSE2046

DOUBLE PRECISION TITLE

LOSE2047

REAL MACH, MAPR, MULEWT, JOULE

LOSE2048

DIMENSION ATAS(29,11), FLOW(32)

LOSE2049

LOGICAL IERRCR, YES

LOSE2050

COMMON /MATRIX/ ALPHA(10,11), ATAR(29,11), B2(29),

LOSE2051

X BETA(10,11), BH(32), BLADE(29), BT(32),

LOSE2052

X CO(10,11), CP(32,11), CPCO(6), CR(32,11),

LOSE2053

X CSLOPE(10,11), CU2(11), CU(32,11), CUCC(29,5),

LOSE2054

X CX(32,11), CXM(10,11), CXNEW(10,11), CXRATO(29),

LOSE2055

X CXS(10,11), CA(10), DELM(11), DEPV(10,11),

LOSE2056

X DF(20), DFACT(29,11), DFL(29), DFLOW(32),

LOSE2057

X EMACH(29,11), FOUNO(20,3,10), FRDEL(10,11), GAMMA(32,11),

LOSE2058

X HMN(29), HUB(32), IKK(10), MACH(29,11),

LOSE2059

X OBAR(29,11), PD(32,11), R(32,11), RCURVE(10,11),

LOSE2060

X RH(32), RHO(32,11), RINT(11), ROSTAG(11),

LOSE2061

X RS(32), RSLOPE(10,11), RTRAIL(11), SUCC(29,5),

LOSE2062

X SOLID(29,11), SSCD(29,5), TERM1(10,11), TERMA(11),

LOSE2063

X TERMB(11), TERMC(11), TIP(32), TITLE(12),

LOSE2064

X TO(32,11), TSTAT(11), U(32,11), W(11),

LOSE2065

X X(32)

LOSE2066

COMMON /SCALER/ A, AA, A10AC, A202AO, A303AO, A404AO,

LOSE2067

X A505AO, B, BE, CC, CM, CMEAN, CMEANP, CUINTG,

LOSE2068

X CPI2, CPI3, CPI4, CPI5, CPI6, CP02, CP03, CP04,

LOSE2069

X CP05, DAMP, DCP, UD, DIFCM, DT, DUMMY, ERAS1,

LOSE2070

X G, GASK, GJ, GR, GR2, JOULE, MAPR, MULEWT,

LOSE2071

X POCO, C, RPM, TCP, TERMD, TESTBH, TESTDS, TESTMS,

LOSE2072

X TUCC, TOL, TLLAT, TOLB2, TOLMIN, TOLMS, TOLTIP, TOLCP,

LOSE2073

X TOLCX, TOLR, TCTINT, TUTPR, V, VMI

LOSE2074

COMMON /INTEGR/ I, IB, IB1, IDUMP, IERROR, IFIRST,

LOSE2075

X IG, ICUTTR, IPASS, IS, IT, J, JIN, JJ,

LOSE2076

X JM, JM1, K, K1, KK, L, LIMIT, LSTAGE,

LOSE2077

X MSTAGE, NLINES, NTUBES, NX, NX1, YES

LOSE2078

EQUIVALENCE (ATAR(1,1), ATAS(1,1)), (FLOW(1), DFLOW(1))

LOSE2079

LOSE2080

FIRST=1

LOSE2081

10 FIRST=FIRST+1

LOSE2082

IF (DF(FIRST).LT.ARG.AND.FIRST.LT.20) GO TO 10

LOSE2083

JJ=1

LOSE2084

IF (PERHT.GT.0.5) JJ=3

LOSE2085

DEL=(ARG-DF(FIRST-1))/(DF(FIRST)-DF(FIRST-1))

LOSE2086

FCT1=((FCLND(FIRST,2,TYPE)-FOUNO(FIRST-1,2,TYPE))*DEL)

LOSE2087

X +FOUNO(FIRST-1,2,TYPE)

LOSE2088

FCT2=((FOUNO(FIRST,JJ,TYPE)-FOUNO(FIRST-1,JJ,TYPE))*DEL)

LOSE2089

X +FOUNO(FIRST-1,JJ,TYPE)

LOSE2090

DEL= FCT2-FCT1

LOSE2091

IF (ABS(DEL).GT.C.001) GO TO 20

LOSE2092

LCSE= FCT1

LOSE2093

LOSE2094

LOSE. - EFN SOURCE STATEMENT - IFN(S) -

12/15/67

```
RETURN
20 RAD= 0.5*SQRT(DEL**2 +0.16)/SIN(ATAN(2.5*DEL))
LOSE= FCT1 +RAD*(1.0 -COS(ATAN(ABS(PERHT -0.5)/RAD)))
RETURN
END
```

LOSE2095
LOSE2096
LOSE2097
LOSE2098
LOSE2099

12/15/67

SUBROUTINE LOSS

LOSS2334

LOSS2335

LOSS2336

LOSS2337

LOSS2338

LOSS2339

LOSS2340

LOSS2341

LOSS2342

LOSS2343

LOSS2344

LOSS2345

LOSS2346

LOSS2347

LOSS2348

LOSS2349

LOSS2350

LOSS2351

LOSS2352

LOSS2353

LOSS2354

LOSS2355

LOSS2356

LOSS2357

LOSS2358

LOSS2359

LOSS2360

LOSS2361

LOSS2362

LOSS2363

LOSS2364

LOSS2365

LOSS2366

LOSS2367

LOSS2368

LOSS2369

LOSS2370

LOSS2371

LOSS2372

LOSS2373

LOSS2374

LOSS2375

LOSS2376

LOSS2377

LOSS2378

LOSS2379

LOSS2380

LOSS2381

LOSS2382

LOSS2383

LOSS2384

LOSS2385

LOSS2386

LOSS2387

C *** MATCHES LOSS WITH ADIABATIC EFFICIENCY

INTEGER BLADE

REAL LOSE

REAL MACH, MAPR, MOLEWT, JOULE

DIMENSION ATAS(29,11), FLOW(32)

LOGICAL IERROR, YES

COMMON /MATRIX/	ALPHA(10,11),	ATAR(29,11),	B2(29),	LOSS2343
X BETA(10,11),	BH(32),	BLADE(29),	BT(32),	LOSS2344
X CO(10,11),	CP(32,11),	CPCO(6),	CR(32,11),	LOSS2345
X CSLOPE(10,11),	CU2(11),	CU(32,11),	CUCO(29,5),	LOSS2346
X CX(32,11),	CXM(10,11),	CXNEW(10,11),	CXRATC(29),	LOSS2347
X CXS(10,11),	DA(10),	DELM(11),	DEPV(10,11),	LOSS2348
X DF(20),	DFACT(29,11),	DFL(29),	DFLOW(32),	LOSS2349
X EMACH(29,11),	FOUND(20,3,10),	FRDEL(10,11),	GAMMA(32,11),	LOSS2350
X HMN(29),	HUB(32),	IKK(10),	MACH(29,11),	LOSS2351
X OEAR(29,11),	PC(32,11),	R(32,11),	RCURVE(10,11),	LOSS2352
X RH(32),	RHO(32,11),	RINT(11),	RESTAG(11),	LOSS2353
X RS(32),	RSLOPE(10,11),	RTRAIL(11),	SCCO(29,5),	LOSS2354
X SOLID(29,11),	SSCC(29,5),	TERM1(10,11),	TERMA(11),	LOSS2355
X TERMB(11),	TERMC(11),	TIP(32),	TITLE(12),	LOSS2356
X TO(32,11),	TSTAT(11),	U(32,11),	W(11),	LOSS2357
X X(32)				LOSS2358

COMMON /SCALER/	A,	AA,	A10A0,	A202A0,	A303A0,	A404A0,	LOSS2359
X A505A0,	B,	BB,	CC,	CM,	CMEAN,	CMEANP,	COINTG,
X CPI2,	CPI3,	CPI4,	CPI5,	CPI6,	CPC2,	CPO3,	CPU4,
X CPO5,	DAMP,	DCP,	DD,	DIFCM,	DT,	DUMMY,	ERAS1,
X G,	GASK,	GJ,	GK,	GR2,	JOULE,	MAPR,	MOLEWT,
X POCO,	Q,	RPM,	TCP,	TERMD,	TESTBH,	TESTDS,	TESTMS,
X TOCO,	TOL,	TOLAT,	TOLB2,	TOLMIN,	TOLMS,	TCLTIP,	TOLCP,
X TOLCX,	TOLK,	TUTINT,	TCTPR,	V,	VMI		
COMMON /INTEGR/	I,	IB,	IB1,	IDUMP,	IERROR,	IFIRST,	LOSS2367
X IG,	IGUTR,	IPASS,	IS,	IT,	J,	JIN,	JJ,
X JM,	JPI,	K,	K1,	KK,	L,	LIMIT,	LSTAGE,
X MSTAGE,	NLINES,	NTUBES,	NX,	NX1,	YES		
EQUIVALENCE	(ATAR(1,1),	ATAS(1,1)),	(FLOW(1),	DFLOW(1))			LOSS2371
COMMON /ENERGY/	H,	T,	GAMMER				LOSS2372

C *** UBAR CONTAINS THE LOSS FUNCTION

L=-1

DO 10 I=IFIRST,LSTAGE,2

L=L+2

DO 10 J=1,NLINES

C *** CALCULATE ABSOLUTE RELATIVE VELOCITY

CXM(L,J)=CX(I-1,J)**2+(CU(I-1,J)-C(I-1,J))**2+CR(I-1,J)**2

C *** CALCULATE ABSOLUTE VELOCITY

CXM(L+1,J)=CX(I,J)**2 + CU(I,J)**2 + CR(I,J)**2

12/15/67

LCSS. - EFN SOURCE STATEMENT - IFN(S) -

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C      *** CALCULATE RELATIVE FLOW ANGLE
      BETA(L,J)= ATAN((U(I-1,J)-CU(I-1,J))/SQRT(CX(I-1,J)**2 +
X CR(I-1,J)**2))
C      *** CALCULATE RELATIVE FLOW ANGLE
      BETA(L+1,J)=ATAN((U(I,J)-CU(I,J))/SQRT(CX(I,J)**2+CR(I,J)**2))
C      *** CALCULATE ABSOLUTE FLOW ANGLE
      ALPHA(L+1,J)=ATAN(CU(I,J)/SQRT(CX(I,J)**2 + CR(I,J)**2))
C      *** CALCULATE ABSOLUTE FLOW ANGLE
      ALPHA(L+2,J)=ATAN(CU(I+1,J)/SQRT(CX(I+1,J)**2 + CR(I+1,J)**2))
      CXS(L,J)=CX(I-1,J)**2 +CU(I-1,J)**2 +CR(I-1,J)**2
C      *** CALCULATE RELATIVE MACH NUMBER
      H= -CXS(L,J)/GJ
      T= TO(I-1,J)
      CALL ENTALP
      CALL GAM
      MACH(I,J)= SQRT(CXP(L,J)/(GR2*GAMMER*TSTAT(J)))
C      *** CALCULATE ABSOLUTE MACH NUMBER
      H= -CXM(L+1,J)/GJ
      T= TO(I,J)
      CALL ENTALP
      CALL GAM
      MACH(I+1,J)= SQRT(CXM(L+1,J)/(GR2*GAMMER*TSTAT(J)))
10 CONTINUE
   L=0
   DO 20 I=IFIRST,LSTAGE
     L=L+1
     DO 20 J=1,NLINES
C      *** CONSTANT TERM USED IN LOSS
      TERM1(L,J)= SQRT((GAMMA(I-1,J)+1.)/(GAMMA(I-1,J)-1.))
20 CONTINUE
   L=-1
   DO 30 I=IFIRST,LSTAGE,2
     L=L+2
     DO 30 J=1,NLINES
C      *** COMPUTE SUPERSONIC TURNING ANGLE
      A= (R(I,J) +R(I-1,J))*C.5
      B= (R(I,J) +R(I+1,J))*C.5
      FRDEL(L,J)= ((SSCO(I,1)/A +SSCO(I,2))/A +SSCO(I,3) + (SSCO(I,4)
X +SSCO(I,5)*A)*A)*(BETA(L,J) -BETA(L+1,J))
      FRDEL(L+1,J)= ((SSCO(I+1,1)/B +SSCO(I+1,2))/B +SSCO(I+1,3) +(

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12/15/87

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      LOSS.      - FFA SOURCE STATEMENT - IFN(S) -

      X SSCU(I+1,4) +SSCU(I+1,5)*B)*B)*(ALPHA(L+1,J) -ALPHA(L+2,J))      LOSS2444
C      *** TEST FOR SUPERSONIC VLOCITY      LOSS2445
      IF(MACH(I,J).LT.1.0) GO TO 28      LOSS2446
      A=(MACH(I,J)-1.)*(MACH(I,J)+1.0)      LOSS2447
C      *** IF FLOW IS SUPERSONIC ADD PRANDTL-MEYER ANGLE TO      LOSS2448
C      SUPERSONIC TURNING ANGLE      LOSS2449
      FRDEL(L,J)= FRDEL(L,J) + TERM1(L,J)*ATAN(SQRT(A)/TERM1(L,J)) -      LOSS2450
      X ATAN(SQRT(A))      LOSS2451
28 IF (MACH(I+1,J).LT.1.) GO TO 30      LOSS2452
      A= (MACH(I+1,J)-1.)*(MACH(I+1,J)+1.0)      LOSS2453
C      *** IF FLOW IS SUPERSONIC ADD PRANDTL-MEYER ANGLE TO      LOSS2454
C      SUPERSONIC TURNING ANGLE      LOSS2455
      FRDEL(L+1,J)= FRDEL(L+1,J) + TERM1(L+1,J)*ATAN(SQRT(A)/TERM1(L+1,      LOSS2456
      X J))- ATAN(SQRT(A))      LOSS2457
30 CONTINUE      LOSS2458
      L=0      LOSS2459
      DO 60 I=IFIRST,LSTAGE      LOSS2460
      L=L+1      LOSS2461
      DO 60 J=1,NLINES      LOSS2462
C      *** INITIALIZE PROFILE SHOCK AND LOSS FUNCTION      LOSS2463
      OBAR(I,J)=0.0      LOSS2464
C      *** CALCULATE PROFILE SHOCK      LOSS2465
      Q=0.1      LOSS2466
      CXS(L,J)=1.      LOSS2467
      IF (FRDEL(L,J).LT.0.0) GO TO 44      LOSS2468
      DO 43 IS=1,100      LOSS2469
C      *** CALCULATES DIFFERENCE BETWEEN PRANDTL-MEYER ANGLE FOR MACH      LOSS2470
C      NUMBER CXS(L,J) AND SUPERSONIC EXPANSION ANGLE      LOSS2471
      VMI= SHOCK(CXS(L,J),FRDEL(L,J))      LOSS2472
      IF (ABS(VMI).LE.0.001) GO TO 44      LOSS2473
      IF (VMI.GT.0.0) GO TO 43      LOSS2474
      CXS(L,J)=CXS(L,J)-Q      LOSS2475
      Q= Q/3.0      LOSS2476
43 CXS(L,J)= CXS(L,J) + Q      LOSS2477
      CALL ERROR(29)      LOSS2478
44 IF (MACH(I,J).GE.1.0) GO TO 45      LOSS2479
C      *** CALCULATE SUBSONIC SHOCK      LOSS2480
      EMACH(I,J)=MACH(I,J)*(1.0+CXS(L,J))*0.5      LOSS2481
      IF (EMACH(I,J)-1.0) GO,60,50      LOSS2482
C      *** CALCULATE SUPERSONIC SHOCK      LOSS2483
      LOSS2484
      LOSS2485
      LOSS2486
      LOSS2487
      LOSS2488
      LOSS2489
      LOSS2490
      LOSS2491
      LOSS2492
      LOSS2493
      LOSS2494
      LOSS2495
      LOSS2496
      LOSS2497
      LOSS2498
      LOSS2499

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12/15/67

LESS. - EFN SOURCE STATEMENT - IFN(S) -

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45 EMACH(I,J)=(MACH(I,J)+CXS(L,J))*0.5
C      *** COMPUTE STUCK LOSS
50 CBAR(I,J)=(1.0-(((GAMMA(I-1,J)+1.0)*0.5*EMACH(I,J)**2)
X / (1.0+0.5*(GAMMA(I-1,J)-1.0)*EMACH(I,J)**2)))
X **((GAMMA(I-1,J)/(GAMMA(I-1,J)-1.0))*(GAMMA(I-1,J)*2.0
X / (GAMMA(I-1,J)+1.0)*EMACH(I,J)**2-(GAMMA(I-1,J)-1.0)
X / (GAMMA(I-1,J)+1.0))*((1.0/(1.0-GAMMA(I-1,J)))
X / (1.0-1.0/(1.0+(GAMMA(I-1,J)-1.0)*MACH(I,J)**2*0.5)
X ** (GAMMA(I-1,J)/(GAMMA(I-1,J)-1.0))))
60 CONTINUE
65 L=-1
DO 80 I=IFIRST,LSTAGE,2
L=L+2
DO 80 J=1,NLINES
A= (R(I,J) + R(I-1,J)) * 0.5
C      *** CALCULATE ROTOR MEAN SOLIDITY
SOLID(I,J)= (SOCC(I,1)/A + SOCC(I,2)) / A + SOCC(I,3) +
X (SOCC(I,4) + SOCC(I,5)*A)*A
C      *** CALCULATE ROTOR D-FACTOR
AA=SQRT((CX(I-1,J)**2+(U(I-1,J)-CU(I-1,J))**2+CR(I-1,J)**2))
DFACT(I,J)= 1.0-SQRT((CX(I,J)**2+(U(I,J)-CU(I,J))**2+CR(I,J)**2))
X /AA + (U(I-1,J)-CU(I-1,J)-U(I,J)+CU(I,J))/2./SOLID(I,J)/AA
A= RS(I-1) - RH(I-1)
C      *** COMPUTE ROTOR PROFILE LOSSES
C      *** LOSE READS THE PROFILE LOSS FROM THE INPUT MAPS
CBAR(I,J)= CBAR(I,J) +LOSE(DFACT(I,J), (R(I-1,J) -RH(I-1))/A,
X BLADE(I))*2.0*SOLID(I,J)/ COS(AMIN1(BETA(L+1,J),1.2217))
A= (R(I+1,J) + R(I,J))*0.5
C      *** CALCULATE STATOR MEAN SOLIDITY
SOLID(I+1,J)= (SOCC(I+1,1)/A + SOCC(I+1,2))/A + SOCC(I+1,3) +
X (SOCC(I+1,4) + SOCC(I+1,5)*A)*A
C      *** COMPUTE STATOR D-FACTOR
AA=SQRT((CX(I,J)**2+CU(I,J)**2+CR(I,J)**2))
DFACT(I+1,J)=1.0-SQRT((CX(I+1,J)**2+CU(I+1,J)**2+CR(I+1,J)**2))/
X AA+(CU(I,J)-CU(I+1,J))/2./SOLID(I+1,J)/AA
C      *** COMPUTE STATOR PROFILE LOSSES
A= RS(I) - RH(I)
C      *** LOSE READS THE PROFILE LOSS FROM THE INPUT MAPS
CBAR(I+1,J)= CBAR(I+1,J) +LOSE(DFACT(I+1,J), (R(I,J) -RH(I))/A,
X BLADE(I+1))*2.0*SOLID(I+1,J)/ COS(AMIN1(ALPHA(L+2,J),1.2217))

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LOSS. - EFN SOURCE STATEMENT - IFN(S) -

12/15/67

```

80 CONTINUE                                LOSS2556
  L=-1                                      LOSS2557
  DO 100 I=IFIRST,LSTAGE,2                 LOSS2558
  L=L+2                                     LOSS2559
  DO 100 J=1,NLINES                        LOSS2560
C      *** CALCULATE ROTOR EFFICIENCY BASED ON LOSS LOSS2561
C                                          LOSS2562
C                                          LOSS2563
C      *** CALCULATE THE STATIC ENTHALPY MINUS THE TOTAL LOSS2564
C      ENTHALPY                           LOSS2565
C                                          LOSS2566
C                                          LOSS2567
C      H= -(CX(I-1,J)**2 +CR(I-1,J)**2 +CU(I-1,J)**2)/GJ LOSS2568
C      T= TO(I-1,J)                       LOSS2569
C                                          LOSS2570
C      *** GET THE STATIC TEMPERATURE      LOSS2571
C                                          LOSS2572
C      CALL ENTALP                         LOSS2573
C      B= THERM3(T)                       LOSS2574
C                                          LOSS2575
C      *** CALCULATE THE STATIC PRESSURE AT THE ROTOR INLET LOSS2576
C                                          LOSS2577
C      PSTAT= PO(I-1,J)*EXP((THERM3(TSTAT(J)) -B)/DCP) LOSS2578
C      H= U(I-1,J)*(U(I-1,J) -2.0*CU(I-1,J))/GJ   LOSS2579
C      CALL ENTALP                         LOSS2580
C                                          LOSS2581
C      *** COMPUTE THE TOTAL RELATIVE PRESSURE LOSS2582
C                                          LOSS2583
C      PREL= PO(I-1,J)*EXP((THERM3(TSTAT(J)) -B)/DCP) LOSS2584
C      H= (U(I,J) -U(I-1,J))*(U(I,J) +U(I-1,J))/GJ LOSS2585
C      T= TSTAT(J)                       LOSS2586
C      CALL ENTALP                         LOSS2587
C      B= THERM3(T)                       LOSS2588
C                                          LOSS2589
C      *** COMPUTE THE TOTAL IDEAL PRESSURE LOSS2590
C                                          LOSS2591
C      P IDEAL= P REL *EXP((THERM3(TSTAT(J)) -B)/DCP) LOSS2592
C                                          LOSS2593
C      *** CALCULATE THE EXIT RELATIVE TOTAL PRESSURE FROM THE LOSS2594
C      LOSS COEFFICIENT                   LOSS2595
C                                          LOSS2596
C      P= P IDEAL -OBAR(I,J)*(P REL -P STAT) LOSS2597
C      H=-U(I,J)*(2.0*CU(I,J) -U(I,J))/GJ   LOSS2598
C      T= TO(I,J)                       LOSS2599
C      CALL ENTALP                         LOSS2600
C                                          LOSS2601
C      *** COMPUTE NEW TOTAL PRESSURE AT ROTOR EXIT LOSS2602
C                                          LOSS2603
C      P= P*EXP((THERM3(T) -THERM3(TSTAT(J)))/DCP) LOSS2604
C                                          LOSS2605
C      *** GET THE IDEAL EXIT TOTAL TEMPERATURE LOSS2606
C                                          LOSS2607
C      CALL THERM2(P/PO(I-1,J),T,TO(I-1,J)) LOSS2608
C                                          LOSS2609
C      *** COMPUTE THE CORRESPONDING EFFICIENCY LOSS2610
C                                          LOSS2611

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12/15/67

LOSS. - LFN SOURCE STATEMENT - IFN(S) -

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      EFF= (THERM1(T)      -THERM1(TO(I-1,J)))
X      /(THERM1(TO(I,J))-THERM1(TO(I-1,J)))
      PC(I,J)= F
C      *** CHECK THE CONVERGENCE
      IF (ABS((ATAR(I,J) -EFF)/ATAR(I,J)).GT.TOLAT) IPASS=3
      ATAR(I,J)= EFF
C      *** CALCULATE STAGE EFFICIENCY BASED ON LOSS
      H= -(CX(I,J)**2 +CR(I,J)**2 +CU(I,J)**2)/GJ
      T= TO(I,J)
      CALL ENTALP
C      *** CALCULATE THE STATIC PRESSURE AT THE INLET TO THE STATOR
      P STAT= PC(I,J)*EXP((THERM2(TSTAT(J)) -THERM3(T))/DCP)
C      *** CALCULATE THE STATOR EXIT PRESSURE (TOTAL) FROM
C      THE LOSS COEFFICIENT
      P= PC(I,J) -DEAR(I+1,J)*(PC(I,J) -P STAT)
      PC(I+1,J)= P
C      *** GET THE IDEAL TOTAL TEMPERATURE
      CALL THERM2(P/PC(I-1,J),T,TO(I-1,J))
C      *** COMPUTE THE EFFICIENCY
      EFF= (THERM1(T)      -THERM1(TO(I-1,J)))
X      /(THERM1(TO(I,J))-THERM1(TO(I-1,J)))
C      *** CHECK STAGE EFFICIENCY FOR CONVERGENCE
      IF (ABS((ATAR(I+1,J) -EFF)/ATAR(I+1,J)).GT.TOLAT) IPASS= 3
      ATAS(I+1,J)= EFF
100 CONTINUE
101 CONTINUE
      NN=LSTAGE+1
      DO 966 I=NN,NX
      DO 966 J=1,NLINES
966 PC(I,J)=PC(I-1,J)
      RETURN
      END

```

LOSS2612
 LOSS2613
 LOSS2614
 LOSS2615
 LOSS2616
 LOSS2617
 LOSS2618
 LOSS2619
 LOSS2620
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12/15/07

MOVE. - EFN SOURCE STATEMENT - IFN(S) -

SUBROUTINE MOVE

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C      *** CAUSES THE RELOCATION OF THE STREAMLINES BASED ON
C      FRACTIONAL MASS FLOW. (STREAM MUST BE CALLED FIRST)

REAL MACH, MAPR, MOLEWT, JOULE
DIMENSION ATAS(29,11), FLOW(32)
LOGICAL IERROR, YES
COMMON /MATRIX/ ALPHA(10,11), ATAR(29,11), B2(29),
X BETA(10,11), BH(32), BLADE(29), BT(32),
X CO(10,11), CP(32,11), CPCO(6), CR(32,11),
X CSLOPE(10,11), CU2(11), CU(32,11), CUCU(29,5),
X CX(32,11), CXM(10,11), CXNEW(10,11), CXRAT(29),
X CXS(10,11), DA(10), DELM(11), DEPV(10,11),
X DF(20), DFACT(29,11), DFL(29), DFLOW(32),
X EMACH(29,11), FLUND(20,3,10), FRDEL(10,11), GAMMA(32,11),
X HMN(29), HUB(32), IKK(10), MACH(29,11),
X OBAR(29,11), PC(32,11), R(32,11), RCURVE(10,11),
X RH(32), RHO(32,11), RINT(11), RUSTAG(11),
X RS(32), KSLOPE(10,11), RTRAIL(11), SOCO(29,5),
X SOLID(29,11), SSCO(29,5), TERM1(10,11), TERMA(11),
X TERMB(11), TERMC(11), TIP(32), TITLE(12),
X TC(32,11), TSTAT(11), U(32,11), w(11),
X X(32)
COMMON /SCALER/ A, AA, A10A0, A202A0, A303A0, A404A0,
X A505A0, B, BB, CC, CM, CMEAN, CMEANP, CUINTG,
X CPI2, CPI3, CPI4, CPI5, CPI6, CPU2, CPC3, CPU4,
X CPD5, CAMP, DCP, DD, DIFCM, DT, DUMMY, ERAS1,
X G, GASK, GJ, GR, GR2, JOULE, MAPR, MOLEWT,
X POCO, C, RPM, TCP, TERMC, TESTBH, TESTDS, TESTMS,
X TOCO, TOL, TOLAT, TOLB2, TOLMIN, TOLMS, TOLTIP, TOLCP,
X TOLCX, TOLR, TOTINT, TOTPR, V, VMI
COMMON /INTEGR/ I, IB, IB1, IDUMP, IERROR, IFIRST,
X IG, ICUTTR, IPASS, IS, IT, J, JIN, JJ,
X JM, JM1, K, K1, KK, L, LIMIT, LSTAGE,
X MSTAGE, NLINES, NTUBES, NX, NX1, YES
EQUIVALENCE (ATAR(1,1),ATAS(1,1)), (FLOW(1),DFLOW(1))

TERMC(1)=0.0
TERMC(NLINES)=1.0
TERMA(1)= R(I,1)
TERMA(NLINES)= R(I,NLINES)
TERMB(1)=CXM(L,1)
TERMB(NLINES)=CXM(L,NLINES)
SUM=0.0
DO 350 J=2,NTUBES
TERMC(J)= TERMC(J-1) +CA(J-1)/TOTINT
TERMA(J)= R(I,J)
TERMB(J)=CXM(L,J)
350 IF (ABS(TERMC(J) -DELM(J)).GT.0.005) YES= .TRUE.

C      *** CALCULATE STREAMLINE RADII TO GIVE SPECIFIED MASS FLOW
C      FRACTION THROUGH EACH STREAMTUBE

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12/15/67

MOVE' - EFN SOURCE STATEMENT - IFN(S) -

DO 505 J=2,NTUBES	MOVE2713
CALL SLINE(DELM(J),TERMC,TERMA,NLINES,RTRAIL(J))	MOVE2714
504 RTRAIL(J)= R(I,J) +(RTRAIL(J) -R(I,J))/DAMP	MOVE2715
	MOVE2716
C *** CALCULATE VALUES OF CX AT NEW STREAMLINE RADII	MOVE2717
	MOVE2718
CALL SLINE(RTRAIL(J),TERMA,TERMB,NLINES,DEPV(L,J))	MOVE2719
505 CONTINUE	MOVE2720
CX(I,1)=CXM(L,1)*CMEANP	MOVE2721
CX(I,NLINES)=CXM(L,NLINES)*CMEANP	MOVE2722
DO 510 J=2,NTUBES	MOVE2723
CX(I,J)=DEPV(L,J)*CMEANP	MOVE2724
R(I,J)=RTRAIL(J)	MOVE2725
510 U(I,J)= R(I,J)*RPM	MOVE2726
RETURN	MOVE2727
END	MOVE2728
	MOVE2729

12/15/67

OUTLET. - EFN SOURCE STATEMENT - IFN(S) -

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SUBROUTINE OUTLET
C      *** YIELDS INITIAL FLOW ESTIMATE FOR THE OUTLET

REAL MACH, MAPR, MOLEWT, JOULE
DIMENSION ATAS(29,11), FLOW(32)
LOGICAL IERROR, YES
COMMON /MATRIX/ ALPHA(10,11), ATAR(29,11), B2(29),
X BETA(10,11), BH(32), BLADE(29), BT(32),
X CC(10,11), CP(32,11), CPOD(6), CR(32,11),
X CSLOPE(10,11), CUZ(11), CU(32,11), CUCC(29,5),
X CX(32,11), CXM(10,11), CXNEW(10,11), CXRATG(29),
X CXS(10,11), CA(10), DELM(11), DEPV(10,11),
X DF(20), DFACT(29,11), DFL(29), DFLCW(32),
X EMACH(29,11), FCUND(20,3,10), FROEL(10,11), GAMMA(32,11),
X HMN(29), HUB(32), IKK(10), MACH(29,11),
X UBAR(29,11), PG(32,11), R(32,11), PCURVE(10,11),
X RH(32), RFG(32,11), RINT(11), RESTAG(11),
X RS(32), RSLOPE(10,11), RTRAIL(11), SLOC(29,5),
X SCLID(29,11), SSCU(29,5), TERM1(10,11), TERMA(11),
X TERMB(11), TERMC(11), TIP(32), TITLE(12),
X TO(32,11), TSTAT(11), U(32,11), W(11),
X X(32)
COMMON /SCALER/ A, AA, A1GAG, A2U2AO, A3L3AO, A4O4AO,
X A5O5AO, B, BB, CC, CM, CMEAN, CMEANP, CUNFG,
X CPI2, CPI3, CPI4, CPI5, CPI6, CPO2, CPO3, CPO4,
X CPO5, CAMP, DCP, DD, DIFCM, DT, DUMMY, ERAS1,
X G, GASK, GJ, GR, GR2, JOULE, MAPR, MOLEWT,
X PCCO, C, RPY, TCP, TERMD, TESTBH, TESTDS, TESTMS,
X TOCC, TOL, TOLAT, TOLB2, TELMIN, TOLMS, TELTIP, TOLCP,
X TOLCX, TOLR, TCTINT, TOTPR, V, VMI
COMMON /INTEGR/ I, IB, IB1, IDUMP, IERROR, IFIRST,
X IG, ICUTTR, IPASS, IS, IT, J, JIN, JJ,
X JM, JM1, K, K1, KK, L, LIMIT, LSTAGE,
X MSTAGE, NLINES, NTUBES, NX, NX1, YES
EQUIVALENCE (ATAR(1,1), ATAS(1,1)), (FLOW(1), DFLCW(1))

C      *** INITIALIZE OUTLET LCUP

K=I+1
CALL AN EXIT
DO 10 I=K,NX

C      *** GET INITIAL VALUES OF STREAMLINE RADII

CALL RSTART
DO 5 J=1,NLINES

C      *** SET FLOW PROPERTIES AS CONSTANT ALONG STREAMLINE

CP(I,J)=CF(LSTAGE,J)
GAMMA(I,J)=GAMMA(LSTAGE,J)
CU(I,J)=CU(LSTAGE,J)*R(LSTAGE,J)/R(I,J)
TO(I,J)=TC(LSTAGE,J)

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12/15/67

	OUTLE. - EFN SOURCE STATEMENT - IFN(S) -	
	5 PC(I,J)=PC(LSTAGE,J)	OUTL2785
C	*** GET INITIAL ESTIMATE OF AXIAL VELOCITY	OUTL2786
	IF (LSTAGE.NE.7) GO TO 6	OUTL2787
	CALL INEST	OUTL2788
	GO TO 10	OUTL2789
	6 DO 9 J=1,NLINES	OUTL2790
	9 CX(I,J)= CX(I-1,J)	OUTL2791
		OUTL2792
		OUTL2793
		OUTL2794
C	*** CALCULATE SIMPLE RADIAL EQUILIBRIUM SOLUTION OF FLOW	OUTL2795
C	CONDITIONS	OUTL2796
		OUTL2797
	10 CALL STREAM	OUTL2798
	RETURN	OUTL2799
	END	OUTL2800

12/15/67

OUTPT. - EFN SOURCE STATEMENT - IFN(5) -

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SUERCUTINE OUTPUT                                OUTP2802
                                                    OUTP2803
DIMENSION PMA(29), PMAB(29), TMA(29), TMA3(29), TMAEP(29)  OUTP2804
REAL MACH, MAPR, MOLEWT, JOULE                      OUTP2805
DIMENSION ATAS(29,11), FLOW(32)                     OUTP2806
LOGICAL IERROR, YES                                  OUTP2807
COMMON /MATRIX/ ALPHA(10,11), ATAK(29,11), B2(29),    OUTP2808
X BETA(10,11), BH(32), BLADE(29), BT(32),             OUTP2809
X CC(10,11), CF(32,11), CFCU(6), CR(32,11),           OUTP2810
X CSLUPE(10,11), CU2(11), CU(32,11), CUCU(29,5),      OUTP2811
X CX(32,11), CXM(10,11), CXNEW(10,11), CXRATC(29),    OUTP2812
X CXS(10,11), CA(10), CELM(11), DEPV(10,11),          OUTP2813
X DF(20), DFACT(29,11), DFL(29), DFLOW(32),          OUTP2814
X EMACH(29,11), FOUNO(20,3,10), FKDEL(10,11), GAMMA(32,11), OUTP2815
X HMN(29), HCB(32), IKK(10), MACH(29,11),            OUTP2816
X OBAR(29,11), PU(32,11), R(32,11), RCURVE(10,11),    OUTP2817
X RH(32), RHU(32,11), RINT(11), ROSTAG(11),           OUTP2818
X RS(32), RSLUPE(10,11), RTRAIL(11), SCCU(29,5),      OUTP2819
X SOLID(29,11), SSCC(29,5), TERM1(10,11), TERMA(11),  OUTP2820
X TERMB(11), TERC(11), TIP(32), TITLE(12),           OUTP2821
X TU(32,11), TSTAT(11), U(32,11), W(11),             OUTP2822
X X(32)                                                OUTP2823
COMMON /SCALER/ -A, AA, A1CA0, A202A0, A303A0, A404A0, OUTP2824
X A505A0, B, BB, CC, CM, CMEAN, CMEANP, COINTG,      OUTP2825
X CPI2, CPI3, CPI4, CPI5, CPI6, CPU2, CPU3, CPU4,    OUTP2826
X CPU5, CAMP, DCP, DD, DIFCM, DT, DUMMY, ERAS1,      OUTP2827
X G, GASK, GJ, GR, GR2, JOULE, MAPR, MOLEWT,        OUTP2828
X POCO, C, RFM, TCP, TERMD, TESTBH, TESTDS, TESTMS,  OUTP2829
X TOCG, TOL, TCLAT, TCLB2, TOLMIN, TOLMS, TOLTIP, TOLCP, OUTP2830
X TOLCX, TOLR, TCTINT, TOTPK, V, VMI                OUTP2831
COMMON /INTEGR/ I, IB, IB1, IDUMP, IERROR, IFIRST,   OUTP2832
X IG, IOUTTR, IPASS, IS, IT, J, JIN, JJ,             OUTP2833
X JM, JM1, K, K1, KK, L, LIMIT, LSTAGE,              OUTP2834
X MSTAGE, NLINES, NTUBES, NX, NX1, YES               OUTP2835
EQUIVALENCE (ATAK(1,1),ATAS(1,1)), (FLOW(1),DFLOW(1)) OUTP2836
COMMON /ENERGY/ E, T, GAMMER                         OUTP2837
                                                    OUTP2838
TMAEP(5)= TTERM1(TC(1,1))                            OUTP2839
B= TMAEP(5)                                           OUTP2840
I= TOCG                                              OUTP2841
IB=1                                                OUTP2842
IB1= 2                                              OUTP2843
NX1= 5                                              OUTP2844
DO610 J=1,NLINES,IOUTTR                            OUTP2845
RSLUPE(1,J)=0.                                       OUTP2846
RCURVE(1,J)=0.                                       OUTP2847
610 CALL XDERIV(R,RSLUPE,RCURVE)                   OUTP2848
WRITE (6,201)                                         OUTP2849
201 FORMAT (1H1)                                       OUTP2850
N=0                                                  OUTP2851
DO 58 I=1,5                                           OUTP2852
DO 58 J=1,NLINES,IOUTTR                             OUTP2853
                                                    OUTP2854
C *** CALCULATE ABSOLUTE VELOCITY (INLET)           OUTP2855

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12/15/67

OUTPT. - LFN SOURCE STATEMENT - IFN(S) -

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C      CXM(I,J)=SQRT(CX(I,J)**2+CU(I,J)**2+CR(I,J)**2)
      H= -CXM(I,J)**2/GJ
      CALL ENTALP
      CALL GAM
      CXNEW(I,J)= TSTAT(J)
C      *** CALCULATE ABSOLUTE MACH NUMBER (INLET)
      CXS(I,J)= CXM(I,J)/SQRT(GR2*GAMMER*TSTAT(J))
C      *** CALCULATE ABSOLUTE FLOW ANGLE (INLET)
      A= SQRT(CX(I,J)**2 + CR(I,J)**2)
      ALPHA(I,J)= ATAN(CU(I,J)/A)*57.2957795
      RCURVE(I,J)=RCURVE(I,J)/(SQRT(1.+RSLOPE(I,J)**2)**3)
      RSLOPE(I,J)=ATAN(RSLOPE(I,J))*57.2957795
58  CONTINUE
      DO 71 I=1,5
      IF (I.GE.5) GO TO 64
C      *** PRINT INLET DATA
      WRITE (6,61) I
61  FORMAT(1HC/10X18F----STATION NUMBER 13,5H ---- //5X70HS.L. STREAMLINE
XINE ABS. MACH ABS. VEL. AXIAL VEL. RADIAL VEL. 4X
X39HSTREAMLINE STREAMLINE FLOW ANGLE/5X27HND. RADIUS (IN.)
X NUMBER 6X8H(FT/SEC) 6X8H(FT/SEC) 5X8H(FT/SEC) 5X12HSLOPE (DEGS)
X 4X9PCURVATURE 5X9H(DEGREES) / )
      GO TO 265
C      *** PRINT INLET GUIDE VANE EXIT DATA
64  WRITE (6,264) I
264 FORMAT (1F0/10X18F----STATION NUMBER 13,31H ---- (INLET GUIDE VANE
XNE EXIT) //5X70HS.L. STREAMLINE ABS. MACH ABS. VEL. AXIAL
XL VEL. RADIAL VEL. 4X38HSTREAMLINE STREAMLINE FLOW ANGLE /
X 5X27HND. RADIUS (IN.) NUMBER 6X8H(FT/SEC) 6X8H(FT/SEC) 5X3H(FT
X/SEC)5X12HSLOPE (DEG) 4X9HCURVATURE 5X9H(DEGREES) / )
      DO 67 J=1,NLINES,ICUTTR
      CALL GAM
      ERAS1= GR2*GAMMER*TSTAT(J)
C      *** COMPUTE RELATIVE VELOCITY (FIRST ROTOR ENTRANCE)
      CC(5,J)= CX(5,J)**2 + (CU(5,J)-U(5,J))**2 + CR(5,J)**2
      CU(5,J)=SQRT(CC(5,J))
      WRITE (6,68) J,R(I,J),CXS(I,J),CXM(I,J),CX(I,J),CR(I,J),
X RSLOPE(I,J),RCURVE(I,J),ALPHA(I,J)

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OUTPT. - EFN SOURCE STATEMENT - IFN(S) -

12/15/67

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C      *** COMPUTE RELATIVE MACH NUMBER (FIRST ROTOR ENTRANCE)
67 CXS(5,J)= CU(5,J)/SQRT(ERAS1)
   WRITE (6,272)

272 FORMAT (1F0,4X15H5.L. STREAMLINE3X11HTOTAL PRES. 3X11HTOTAL TEMP.
   X 3X 5HREL. VEL.3X10HWHIRL VEL. 6X8HRELATIVE 7X 5HREL. FLOW 4X
   X 11HWHHEEL SPEED / 5X29HNO. RADIUS (IN.) (LB/SQ IN.) 4X9H(DEGREES)
   X 4X 8H(FT/SEC) 5X8H(FT/SEC) 7X 8HMACH NO. 7X 9HANG.(DEG) 6X
   X 8H(FT/SEC) )

   DO 273 J=1,NLINES,1OUTTR

C      *** CALCULATE RELATIVE FLOW ANGLE INTO THE FIRST ROTOR

72 BETA(2,J)=ATAN((U(5,J)-CU(5,J))/SQRT(CX(5,J)**2+CR(5,J)**2))
   X *57.2957795
273 WRITE (6,274) J,R(1,J),PU(5,J),TO(5,J),CU(5,J),    CU(5,J),
   X CXS(5,J),BETA(2,J),U(5,J)

274 FORMAT (17,F11.4,F14.2,3F13.2,F15.3,2F15.3)

68 FORMAT(17,F11.4,F13.3,2F14.2,F14.4,2F14.2,F15.1 )

   GO TO 71
265 DO 69 J=1,NLINES,1OUTTR
69 WRITE (6,68) J,R(1,J),CXS(1,J),CXM(1,J),CX(1,J),CR(1,J),
   X RSLOPE(1,J),RCURVE(1,J),ALPHA(1,J)
   WRITE (6,271)
   DO 269 J=1,NLINES,1OUTTR
269 WRITE (6,270) J,R(1,J),PC(1,J),TO(1,J)

270 FORMAT (17,F11.4,F14.2,F13.2)

271 FORMAT (1F0,4X43H5.L. STREAMLINE TOTAL PRES. TOTAL TEMP. / 5X
   X42HNO. RADIUS (IN.) (LB/SQ IN.) (DEGREES) / )

71 CONTINUE
   IF (LIMIT.EQ.0) WRITE (6,250)
250 FORMAT (1F0///34X51H**---***---** THIS MACHINE WAS OPTIMIZED **---**
   1*---** //)

C      *** INITIALIZE MASS AVERAGE ROUTINE

TMA(5)=1.0
PMA(5)=1.0
DO 100 IS=6,LSTAGE,2

C      *** SET INDICES FOR DERIVATIVE ROUTINE

IB=IS-1
IB1= IS
NX1=IS+1
N=N+1

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	OUTP1. - LFN SOURCE STATEMENT - IFN(S) -	12/15/67
C	*** CALCULATE ROTOR LENGTH AND STATOR LENGTH	OUTP2966
	DEPV(5,1)= X(IS)-X(IS-1)	OUTP2969
	DEPV(5,2)= X(IS+1)-X(IS)	OUTP2970
		OUTP2971
C	*** CALCULATE ROTOR HUB AND STATOR HUB RAMP ANGLE	OUTP2972
	ALPHA(3,1)= ATAN((RH(IS)-RH(IS-1))/DEPV(5,1))*57.2957795	OUTP2973
	ALPHA(4,1)= ATAN((RH(IS+1)-RH(IS))/DEPV(5,2))*57.2957795	OUTP2974
		OUTP2975
		OUTP2976
C	*** CALCULATE ROTOR TIP AND STATOR TIP RAMP ANGLE	OUTP2977
	ALPHA(3,2)= ATAN((RS(IS)-RS(IS-1))/DEPV(5,1))*57.2957795	OUTP2978
	ALPHA(4,2)= ATAN((RS(IS+1)-RS(IS))/DEPV(5,2))*57.2957795	OUTP2979
	IX=IS+1	OUTP2980
	DO 35 JJ=IS,IX	OUTP2981
	DO 10 J=1,NLINES	OUTP2982
	TERMB(J)=TU(JJ,J)	OUTP2983
		OUTP2984
		OUTP2985
C	*** CALCULATE THEORETICAL TEMPERATURE RISE	OUTP2986
	CALL THERM2(PO(JJ,J)/14.6966,TERMB(J),518.688)	OUTP2987
	TERMB(J)= TERMB(J)/518.688	OUTP2988
		OUTP2989
		OUTP2990
C	*** COMPUTE MASS FLOW RATE PER STREAMLINE	OUTP2991
	10 DEPV(9,J)= RHO(JJ,J)*CX(JJ,J)*R(JJ,J)	OUTP2992
	L=9	OUTP2993
	I=JJ	OUTP2994
		OUTP2995
		OUTP2996
C	*** INTEGRATE MASS FLOW RATE, RESULT IN RINT	OUTP2997
	CALL INTEG(DEPV,2)	OUTP2998
	SUM= RINT(NLINES)-RINT(1)	OUTP2999
	DO 20 J=1,NLINES	OUTP3000
	20 DEPV(8,J)= (TERMB(J)-1.)*DEPV(9,J)	OUTP3001
	L=8	OUTP3002
	CALL INTEG(DEPV,2)	OUTP3003
	V=RINT(NLINES)-RINT(1)	OUTP3004
		OUTP3005
		OUTP3006
C	*** CALCULATE MASS AVERAGED TEMPERATURE AND PRESSURE	OUTP3007
	TMA(JJ)= (V/SUM+1.)*518.688	OUTP3008
	PMA(JJ)=EXP((THERM3(TMA(JJ))-COINTG)/DCP)*14.6966/PB(1,1)	OUTP3009
	DO 30 J=1,NLINES	OUTP3010
	30 DEPV(8,J)= (TC(JJ,J)/518.688-1.)*DEPV(9,J)	OUTP3011
	CALL INTEG(DEPV,2)	OUTP3012
	V=RINT(NLINES)-RINT(1)	OUTP3013
	TMA(JJ)= (V/SUM+1.)*518.688/TO(1,1)	OUTP3014
		OUTP3015
		OUTP3016
C	*** COMPUTE MASS AVERAGED EFFICIENCY	OUTP3017
	TMAEP(JJ)= THERM1(TMA(JJ)*TOCO)	OUTP3018
	35 CONTINUE	OUTP3019
		OUTP3020
		OUTP3021
C	*** DETERMINE MASS AVERAGE TEMPERATURES AND PRESSURES	OUTP3022
		OUTP3023

12/15/67

OUTPT. - EFN SOURCE STATEMENT - IFN(S) -

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TMA(I)=TMA(I)/TMA(I-1)
TMA(I+1)=TMA(I+1)/TMA(I-1)
PMA(I)=PMA(I)/PMA(I-1)
AA= TMA(I)*TO(1,1)
BB= AA
CC= TMA(I+1)*TO(1,1)
DD= CC
C      *** YIELDS THEORETICAL TEMPERATURE RISE
CALL THERM2(PMA(I),AA,TO(1,1))
CALL THERM2(PMA(I)/PMA(I-1),BB,TMA(I-1)*TO(1,1))
CALL THERM2(PMA(I+1),CC,TO(1,1))
CALL THERM2(PMA(I+1)/PMA(I-1),DD,TMA(I-1)*TCLL)
C      *** OVERALL MASS AVERAGE ROTOR EFFICIENCY
CXS(6,1)=(THERM1(AA)-TMAEP(5))/(TMAEP(I)-TMAEP(5))
PMA(I+1)=PMA(I+1)/PMA(I-1)
C      *** MASS AVERAGE ROTOR EFFICIENCY
CXS(6,2)=(THERM1(BB)-TMAEP(I-1))/(TMAEP(I)-TMAEP(I-1))
C      *** OVERALL MASS AVERAGE STAGE EFFICIENCY
CXS(7,1)=(THERM1(CC)-TMAEP(5))/(TMAEP(I+1)-TMAEP(5))
C      *** MASS AVERAGE STAGE EFFICIENCY
CXS(7,2)=(THERM1(DD)-TMAEP(I-1))/(TMAEP(I+1)-TMAEP(I-1))
DO 40 J=1,NLINES
FRDEL(1,J)= THERM1(TC(I-1,J))
FRDEL(2,J)= THERM1(TC(I,J))
FRDEL(3,J)= THERM1(TC(I+1,J))
TERMD=TO(I,J)
TERMA(1)=TO(I,J)
CALL THERM2(PC(I,J)/PC(I-1,J),TERMD,TO(I-1,J))
C      *** YIELDS THEORETICAL TEMPERATURE RISE
CALL THERM2(PC(I+1,J)/PC(I-1,J),TERMA(1),TO(I-1,J))
C      *** DETERMINE ROTOR AND STAGE EFFICIENCY
ATAR(I,J)=(THERM1(TERMD)-FRDEL(1,J))/(FRDEL(2,J)-FRDEL(1,J))
ATAS(I+1,J)=(THERM1(TERMA(1))-FRDEL(1,J))/(FRDEL(3,J)-FRDEL(1,J))
C      *** COMPUTE ABSOLUTE VELOCITY (ROTOR EXIT)
CXM(1,J)=SQRT(CX(I,J)**2+CU(I,J)**2+CR(I,J)**2)
C      *** CALCULATE ROTOR STATIC TEMPERATURE
H= -CXM(1,J)**2/CJ

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12/15/67

OUTP1. - EFN SOURCE STATEMENT - IFN(S) -

	T= TO(1S,J)	OUTP3080
	CALL ENTALP	OUTP3081
	CXNEW(1,J)= TSTAT(J)	OUTP3082
	CALL GAM	OUTP3083
	ERAS1= GR2*GAMMEK*TSTAT(J)	OUTP3084
	CO(8,J)= PO(1S,J)*EXP((THERM3(TSTAT(J))-THERM3(T))/DCP)	OUTP3085
C	*** CALCULATE ROTOR RELATIVE VELOCITY	OUTP3086
	CO(5,J)= CX(1S,J)**2 + (CU(1S,J)-U(1S,J))**2 + CR(1S,J)**2	OUTP3087
	CU(5,J)=SQRT(CO(5,J))	OUTP3088
C	*** CALCULATE STATOR RELATIVE VELOCITY	OUTP3089
	CO(6,J)= CX(1S+1,J)**2+(CU(1S+1,J)-U(1S+1,J))**2+CR(1S+1,J)**2	OUTP3090
	CU(6,J)=SQRT(CO(6,J))	OUTP3091
C	*** CALCULATE ROTOR RELATIVE MACH NUMBER	OUTP3092
	CXS(1,J)= CO(5,J)/SQRT(ERAS1)	OUTP3093
C	*** GET A*/S (ROTOR)	OUTP3094
	IF (EMACH(1S,J).LT.1.0) EMACH(1S,J)=1.0	OUTP3095
	EMACH(1S,J)= MACH(1S,J)*COS(BETA(2,J)/57.2957755)/EMACH(1S,J) /	OUTP3096
	X ((1.0 +0.5*(GAMMA(1S-1,J) -1.0)* MACH(1S ,J)**2) /	OUTP3097
	X (1.0 +0.5*(GAMMA(1S-1,J) -1.0)*EMACH(1S ,J)**2))	OUTP3098
	X ** (0.5*(GAMMA(1S-1,J)+1.0)/(GAMMA(1S-1,J)-1.0))	OUTP3099
	A=SQRT(CX(1S,J)**2+CR(1S,J)**2)	OUTP3100
C	*** CALCULATE ABSOLUTE FLOW ANGLE	OUTP3101
	ALPHA(1,J)= ATAN(CU(1S,J)/A)*57.2957755	OUTP3102
C	*** CALCULATE RELATIVE FLOW ANGLE	OUTP3103
	BETA(1,J)=ATAN((U(1S,J)-CU(1S,J))/A)*57.2957755	OUTP3104
C	*** CALCULATE TOTAL TEMPERATURE RATIO (ROTOR)	OUTP3105
	CO(1,J)= TO(1S,J)/TU(1S-1,J)	OUTP3106
C	*** CALCULATE TOTAL PRESSURE RATIO (ROTOR)	OUTP3107
	CO(3,J)= FO(1S,J)/PO(1S-1,J)	OUTP3108
C	*** CALCULATE TOTAL TEMPERATURE RATIO (STATOR)	OUTP3109
	CO(2,J)= TO(1S+1,J)/TC(1S,J)	OUTP3110
C	*** CALCULATE TOTAL PRESSURE RATIO (STATOR)	OUTP3111
	CO(4,J)= PO(1S+1,J)/PC(1S,J)	OUTP3112
C	*** GET FIRST AND SECCND DERIVATIVES OF RADIUS WITH RESPECT	OUTP3113
C	TO AXIAL LENGTH. RESULTS ARE IN RSLOPE AND RCURVE	OUTP3114

	OUTPT. - EFN SOURCE STATEMENT - IFN(S) -	12/15/67
	CALL XDERIV(K,RSLOPE,RCURVE)	OUTP3136
		OUTP3137
C	*** CALCULATE ROTOR CURVATURE	OUTP3138
	RCURVE(2,J)= RCURVE(2,J)/(SQRT(1.+RSLOPE(2,J)**2)**3)	OUTP3139
		OUTP3140
		OUTP3141
C	*** CALCULATE STATOR CURVATURE	OUTP3142
	RCURVE(3,J)= RCURVE(3,J)/(SQRT(1.+RSLOPE(3,J)**2)**3)	OUTP3143
		OUTP3144
		OUTP3145
C	*** CALCULATE ROTOR SLOPE	OUTP3146
	RSLOPE(2,J)= ATAN(RSLOPE(2,J))*57.2957795	OUTP3147
		OUTP3148
		OUTP3149
		OUTP3150
C	*** CALCULATE STATOR SLOPE	OUTP3151
	RSLOPE(3,J)= ATAN(RSLOPE(3,J))*57.2957795	OUTP3152
		OUTP3153
		OUTP3154
C	*** GET A*/S (STATOR)	OUTP3155
	IF (EMACH(IS+1,J).LT.1.0) EMACH(IS+1,J) = 1.0	OUTP3156
	EMACH(IS+1,J)= MACH(IS+1,J)*COS(ALPHA(1,J)/57.2957795)/EMACH(IS+1,J)	OUTP3157
	X J) /	OUTP3158
	X ((1.0 +0.5*(GAMMA(IS ,J) -1.0)* MACH(IS+1,J)**2) /	OUTP3159
	X (1.0 +0.5*(GAMMA(IS ,J) -1.0)*EMACH(IS+1,J)**2))	OUTP3160
	X ** (.5*(GAMMA(IS,J)+1.0)/(GAMMA(IS,J)-1.0))	OUTP3161
		OUTP3162
		OUTP3163
C	*** CALCULATE ABSOLUTE VELOCITY (STATOR)	OUTP3164
	CXM(2,J)= SQRT(CX(IS+1,J)**2+CU(IS+1,J)**2+CR(IS+1,J)**2)	OUTP3165
		OUTP3166
		OUTP3167
C	*** CALCULATE STATIC TEMPERATURE (STATOR)	OUTP3168
	H= -CXM(2,J)**2/CJ	OUTP3169
	T= TD(IS+1,J)	OUTP3170
	CALL ENTALP	OUTP3171
	CXNEW(2,J)= TSTAT(J)	OUTP3172
	CALL GAM	OUTP3173
	ERAS1= GR2*GAMMER*TSTAT(J)	OUTP3174
		OUTP3175
		OUTP3176
C	*** CALCULATE ABSOLUTE MACH NUMBER (STATOR)	OUTP3177
	CXS(2,J)= CXM(2,J)/SQRT(ERAS1)	OUTP3178
		OUTP3179
		OUTP3180
C	*** CALCULATE STATOR RELATIVE MACH NUMBER	OUTP3181
	CO(7,J)= CO(6,J)/SQRT(ERAS1)	OUTP3182
		OUTP3183
		OUTP3184
C	*** CALCULATE STATIC PRESSURES	OUTP3185
	CC(9,J)= PO(IS+1,J)*EXP((THERM3(TSTAT(J))-THERM3(T))/DCP)	OUTP3186
		OUTP3187
		OUTP3188
C	*** CALCULATE RELATIVE FLOW ANGLE (STATOR)	OUTP3189
	BETA(2,J)= -ATAN((CU(IS+1,J)-U(IS+1,J))/SQRT(CX(IS+1,J)**2+CR(IS+1,J)**2))	OUTP3190
		OUTP3191

12/15/67

OUTPT. - EFN SOURCE STATEMENT - IFN(S) -

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X J)**2))*57.2957795                                OUTP3192
C *** CALCULATE ABSCLLITE FLOW ANGLE (STATOR)          OUTP3193
ALPHA(2,J)= ATAN(CU(IS+1,J)/SQRT(CX(IS+1,J)**2+CR(IS+1,J)**2)) OUTP3194
X *57.2957795                                         OUTP3195
40 CONTINUE                                           OUTP3196
C *** CONVERT INPUT DATA BACK TO DEGREES            OUTP3197
HMN(IS+1)=HMN(IS+1)*57.2957795                      OUTP3198
C *** WRITE STAGE PARAMETERS                          OUTP3199
WRITE (6,50) N, CFL(IS), HMN(IS+1), HMN(IS), DFL(IS+1) OUTP3200
50 FORMAT(1H1///30X47H***--*** FINAL FLOW PARAMETERS FOR STAGE NUMBER OUTP3201
X 14, 9H ***--*** ///45X30H*** STAGE INPUT PARAMETERS *** /// 24X OUTP3202
X 24H ROTOR TIP D-FACTOR LIMIT F33.4// 24X 47HHUB RELATIVE FLOW ANGLE OUTP3203
XE LIMIT AT THE ROTOR EXIT F10.1// 24X 33HSTATOR HUB MACH NUMBER L1 OUTP3204
XMIT (IN) F24.4// 24X 25HSTATOR HUB D-FACTOR LIMIT F32.4// 24X 11H- OUTP3205
X--ROTOR--- 48X 12H---STATOR---/// 12X 5HWHIRL 5X 16HRATIO SUPERSONIC OUTP3206
XIC 3X 8HSOLIDITY 23X 5HWHIRL 5X 16HRATIO SUPERSONIC 3X 8HSOLIDITY OUTP3207
X / 11X 8HVELOCITY 2X 16HTO TOTAL TURNING 33X 8HVELOCITY 3X 16HTO TOUTP3208
XOTAL TURNING //) OUTP3209
WRITE (6,55) CUCC(IS,1), SSCC(IS,1), SOCC(IS,1), OUTP3210
X CUCC(IS+1,1), SSCC(IS+1,1), SOCC(IS+1,1), OUTP3211
X B2(IS), SSCC(IS,2), SOCC(IS,2), OUTP3212
X CUCC(IS+1,2), SSCC(IS+1,2), SOCC(IS+1,2), OUTP3213
X (CUCC(IS,J), SSCC(IS,J), SOCC(IS,J), OUTP3214
X CUCC(IS+1,J), SSCC(IS+1,J), SOCC(IS+1,J), J=3,5) OUTP3215
55 FORMAT (5X1HA3E15.6,14X1HA3E15.6/ OUTP3216
X 5X1HB3E15.6,14X1HB3E15.6/ OUTP3217
X 5X1HC3E15.6,14X1HC3E15.6/ OUTP3218
X 5X1HD3E15.6,14X1HD3E15.6/ OUTP3219
X 5X1HE3E15.6,14X1HE3E15.6,/// OUTP3220
X 44X 31H*** STAGE SCALAR QUANTITIES *** //) OUTP3221
SQCO= CX(IS,JM)/CX(IS-1,JM) OUTP3222
A= CX(IS+1,JM)/CX(IS,JM) OUTP3223
Q= (RS(IS) -RH(IS))/DEPV(5,2) OUTP3224
AA= (RS(IS-1)-RH(IS-1))/DEPV(5,1) OUTP3225
WRITE (6,56) AA, RH(IS), RS(IS), ALPHA(3,1), OUTP3226
X ALPHA(3,2), DEPV(5,1), FLOW(IS), CXS(6,2), Q, OUTP3227
X RH(IS+1), RS(IS+1), ALPHA(4,1), ALPHA(4,2), DEPV(5,2), OUTP3228
X FLOW(IS+1), CXS(7,2), SQCO, BH(IS), BT(IS), OUTP3229
X PMAB(IS), TMAB(IS), PMA(IS), TMA(IS), CXS(6,1), OUTP3230
X A, BH(IS+1), BT(IS+1), FMAB(IS+1), TMAB(IS+1), OUTP3231
X PMA(IS+1), TMA(IS+1), CXS(7,1) OUTP3232
56 FORMAT (12X33H ASPECT GEOMETRIC HUB GEOMETRIC 5X 8HHUB RAMP 5X OUTP3233
X 8HTIP RAMP 4X39H AXIAL LENGTH MASS FLOW MASS AVE. / 12X OUTP3234
X 61H RATIO RADIUS (IN.) TIP RAD.(IN.) ANGLE (DEG) ANGLE (DEG) OUTP3235
X 6X 5H (IN.) 6X 26H (LB/SEC) ADIABATIC EFF. // 9H -ROTOR-- F8.3, OUTP3236

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12/15/67

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      OUTPT.      - EFN      SOURCE STATEMENT - IFN(S) -

X F13.4,F14.4,F13.3,F14.3,F13.4,F14.4,F15.4 // 9H -STATOR- F8.3,      OUTP3248
X F13.4,F14.4,F13.3,F14.3,F13.4,F14.4,F15.4 ///                      OUTP3249
X 75X 2(10FCUMULATIVE 4X), 11H CUMULATIVE / 9X 10HVEL. RATIO 2X      OUTP3250
X 37HHUB BLOCKAGE TIP BLOCKAGE MASS AVE. 5X 9HMASS AVE. 5X          OUTP3251
X 3(9HMASS AVE. 6X), / 9X 11HAT THE MEAN 4X                          OUTP3252
X 6HFACTOR 8X6HFACTOR 5X 9HPR. RATIO 4X22HTEMP. RATIO PR. RATIO    OUTP3253
X 5X27HTEMP. RATIO ADIABATIC EFF. // 9H -ROTOR-- F8.3,F13.4,F14.4,    OUTP3254
X F13.4,F14.4,F13.4,F14.4,F15.4 // 9H -STATOR- F8.3,F13.4,F14.4,    OUTP3255
X F13.4,F14.4,F13.4,F14.4,F15.4 ///)                                OUTP3256
                                     OUTP3257
      WRITE (6,275) BLADE(15), BLADE(15+1)                            OUTP3258
                                     OUTP3259
275 FORMAT (11X 9HLOSS DATA / 11X 8HSET USED // 9H -ROTOR-- 17 //   OUTP3260
      X 9H -STATOR- 17 )                                              OUTP3261
                                     OUTP3262
      WRITE (6,285) CUCL(15,2)                                         OUTP3263
                                     OUTP3264
285 FORMAT (1F0//35X47HB COEFFICIENT OF WHIRL VELOCITY AT ROTOR EXIT = OUTP3265
      X E18.8 //)                                                    OUTP3266
                                     OUTP3267
C      *** PRINT ROTOR EXIT QUANTITIES                                OUTP3268
                                     OUTP3269
      WRITE (6,57)                                                    OUTP3270
                                     OUTP3271
57 FORMAT(1H1///41X26H**-----** R O T O R   E X I T **-----**//2X4HS.L. OUTP3272
      X 57H STREAMLINE      AXIAL VEL.      WHIRL VEL.      RADIAL VEL.      OUTP3273
      X 52HABS. VEL.      ABS. MACH      ABS. FLOW      REL. FLOW /3X3HNO. OUTP3274
      X 58H RADIUS (IN.) (FT/SEC)      (FT/SEC)      (FT/SEC)      OUTP3275
      X 52H(FT/SEC)      NUMBER      ANGLE (DEG)      ANGLE (DEG) / ) OUTP3276
                                     OUTP3277
      DO 60 J=1,NLINES,ICUTTR                                          OUTP3278
      WRITE (6,59) J,R(15,J),CX(15,J),CU(15,J),CR(15,J),CXM(1,J),    OUTP3279
      X MACH(15+1,J),ALPHA(1,J),BETA(1,J)                            OUTP3280
                                     OUTP3281
59 FORMAT(15,F11.4,F13.3,2F14.2,F14.3,F15.4,2F14.3 )                OUTP3282
                                     OUTP3283
60 CONTINUE                                                            OUTP3284
      WRITE (6,65)                                                    OUTP3285
                                     OUTP3286
65 FORMAT(1H0/2X4HS.L.43H TOTAL TEMP. TOTAL PRES. ADIABATIC          OUTP3287
      X 38HDIFFUSION WHEEL SPEED SOLIDITY 8X 4HA*/S 5X              OUTP3288
      X11HLOSS CCEFF.                                                OUTP3289
      X                                                                OUTP3290
      X 5HRATIO6X10EFFICIENCY5X6HFACTOR 7X 8H(FT/SEC) / )          OUTP3291
                                     OUTP3292
      DO 70 J=1,NLINES,ICUTTR                                          OUTP3293
      WRITE (6,66) J,CC(1,J),CG(3,J),ATAR(15,J),UFACT(15,J),U(15,J), OUTP3294
      X SOLID(15,J),EMACH(15,J),OBAR(15,J)                            OUTP3295
                                     OUTP3296
66 FORMAT (15,F11.4,F13.4,2F14.4,F13.2,F15.3,F15.4,F14.4)          OUTP3297
                                     OUTP3298
70 CONTINUE                                                            OUTP3299
      WRITE (6,281)                                                    OUTP3300
                                     OUTP3301
281 FORMAT (1H0//2X4HS.L.110H TOTAL TEMP. TOTAL PRES. STATIC TEMP. OUTP3302
      X STATIC PRES.      SLOPE      CURVATURE      REL. VEL.      REL. MOUTP3303

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12/15/67

OUTPT. - EFN SOURCE STATEMENT - IFN(S) -

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XACH /3X3HNO.3X 5H(DEGREES)3X11H(LB/SQ IN.) 4X9H(DEGREES) 5X      OUTP3304
X 11H(LB/SC IN.) 2X9H(DEGREES)9X4H/IN.8X8H(FT/SEC) 7X6HNUMBER /)  OUTP3305
                                     OUTP3306
      DO 282 J=1,NLINES,1OUTTR  OUTP3307
282 WRITE (6,283)J,TC(1S,J),PC(1S,J),CXNEW(1,J),CO(8,J),RSLOPE(2,J),  OUTP3308
      X RCURVE(2,J),CC(5,J),CXS(1,J)  OUTP3309
                                     OUTP3310
283 FORMAT (1S,F11.2,2F14.2,F15.2,F11.2,F15.3,F16.4,F13.4)  OUTP3311
                                     OUTP3312
C      *** PRINT STATOR EXIT QUANTITIES  OUTP3313
                                     OUTP3314
      WRITE (6,75)  OUTP3315
                                     OUTP3316
75 FORMAT (1F17.7,40X38H**-----** S T A T O R E X I T **-----** /// 2X  OUTP3317
X4HS.L.57H STREAMLINE AXIAL VEL. WHIRL VEL. RADIAL VEL.  OUTP3318
X 52HABS. VEL. ABS. MACH ABS. FLOW REL. FLOW /3X3HNO.  OUTP3319
X 58H RADIUS (IN.) (FT/SEC) (FT/SEC) (FT/SEC)  OUTP3320
X 52H(FT/SEC) NUMBER ANGLE (DEG) ANGLE (DEG) / )  OUTP3321
                                     OUTP3322
      DO 80 J=1,NLINES,1OUTTR  OUTP3323
      WRITE (6,59) J,R(1S+1,J),CX(1S+1,J),CL(1S+1,J),CR(1S+1,J),  OUTP3324
      X CXM(2,J),CXS(2,J),ALPHA(2,J),BETA(2,J)  OUTP3325
80 CONTINUE  OUTP3326
      WRITE (6,65)  OUTP3327
      DO 85 J=1,NLINES,1OUTTR  OUTP3328
      WRITE (6,66) J,CC(2,J),CC(4,J),ATAS(1S+1,J),DFACT(1S+1,J),  OUTP3329
      X U(1S+1,J),SOLID(1S+1,J),EMACH(1S+1,J),GBAR(1S+1,J)  OUTP3330
85 CONTINUE  OUTP3331
      WRITE (6,281)  OUTP3332
      DO 284 J=1,NLINES,1OUTTR  OUTP3333
284 WRITE (6,283) J,TC(1S+1,J),PC(1S+1,J),CXNEW(2,J),CC(9,J),RSLOPE(3,  OUTP3334
      XJ),RCURVE(3,J),CC(6,J),CC(7,J)  OUTP3335
100 CONTINUE  OUTP3336
                                     OUTP3337
C      *** PRINT OUTLET QUANTITIES  OUTP3338
                                     OUTP3339
      WRITE (6,110)  OUTP3340
                                     OUTP3341
110 FORMAT (1F140X40F***--*** OUTLET FLOW PARAMETERS ***--*** ///  OUTP3342
X 13X3HSTA7X5HAXIAL7X9HGECMETRIC5X9HGECMETRIC4X12HHUB BLOCKAGE 5X  OUTP3343
X 12HTIP BLOCKAGE / 13X3HNO.5X10HCOORDINATE4X10HHUB RADIUS 4X  OUTP3344
X 10HTIP RADIUS6X6HFACTOR 9X6HFACTOR / 24X5H(IN.)9X5H(IN.)9X5H(IN.)  OUTP3345
X /)  OUTP3346
                                     OUTP3347
      JJ=LSTAGE + 1  OUTP3348
      DO 120 J=JJ,NX  OUTP3349
120 WRITE (6,115) J,X(J),RH(J),RS(J),BH(J),BT(J)  OUTP3350
                                     OUTP3351
115 FORMAT (10X1S,F15.3,F14.2,F13.3,F15.3,F14.3)  OUTP3352
                                     OUTP3353
      WRITE (6,130) JJ  OUTP3354
                                     OUTP3355
130 FORMAT (1F07.5,50X14HSTATION NUMBER 14 // 5H S.L.3X10HSTREAMLINE 4X  OUTP3356
X 10HAXIAL VEL. 3X10HWHIRL VEL. 4X11HRADIAL VEL. 4X 9HABS. VEL. 5X  OUTP3357
X 9HABS. MACH 4X11HTOTAL TEMP. 3X11HTOTAL PRES. / 4H NO.3X11HRADIUS  OUTP3358
X IN. 4X 8H(FT/SEC) 6X8H(FT/SEC) 6X8H(FT/SEC) 6X8H(FT/SEC) 7X  OUTP3359

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12/15/67

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      OUTPT.      - EFN      SOURCE STATEMENT - IFN(S) -

X  6HNUMBER 7X 9H(DEG.S R) 4X11H(LB/SQ IN.) /)

      KJ=0
      DO 140 IJ=JJ,NX
      KJ=KJ+1
      DO 140 J=1,NLINES

C      *** CALCULATE ABSOLUTE VELOCITY      (OUTLET)

      CXM(KJ,J)= SQRT(CX(IJ,J)**2 + CU(IJ,J)**2 + CR(IJ,J)**2)

C      *** CALCULATE STATIC TEMPERATURE      (OUTLET)

      H= -CXM(KJ,J)**2/GJ
      T= TO(IJ,J)
      CALL ENTALP
      CALL GAM
      CXNEW(KJ,J)= TSTAT(J)
      ERAS1= GR2*GAMMER*TSTAT(J)

C      *** CALCULATE ABSOLUTE MACH NUMBER (OUTLET)

      CXS(KJ,J)= CXM(KJ,J)/SQRT(ERAS1)
140 CONTINUE
      KJ=0
      DO 150 IJ=JJ,NX
      IF(IJ.GT.JJ) WRITE (6,160) IJ
      KJ=KJ+1
      DO 150 J=1,NLINES,IOUTTR
150 WRITE (6,165) J,R(IJ,J),CX(IJ,J),CU(IJ,J),CR(IJ,J),CXM(KJ,J),
      X CXS(KJ,J),TO(IJ,J),PG(IJ,J)

160 FORMAT (1F05O14HSTATICN NUMBER 14//)

165 FORMAT (I4,F12.4,F13.3,2F14.2,F13.2,F14.4,F14.2,F14.1)

      RETURN

C      *** FINISHED AT LAST.....

      END

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OUTP3360
 OUTP3361
 OUTP3362
 OUTP3363
 OUTP3364
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 OUTP3396
 OUTP3397
 OUTP3398
 OUTP3399
 OUTP3400

12/15/67

PRFIT. - EFN SOURCE STATEMENT - IFN(S) -

SUBROUTINE PRFIT2

C

*** DETERMINE FLOW PARAMETERS

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REAL MACH, MAPR, MOLEWT, JOULE
DIMENSION ATAS(25,11), FLCW(32)
LOGICAL IERROR, YES
COMMON /MATRIX/ ALPHA(10,11), ATAR(29,11), B2(29),
X BETA(10,11), BH(32), BLADE(29), BT(32),
X CC(10,11), CP(32,11), CPCO(6), CR(32,11),
X CSLOPE(10,11), CU2(11), CU(32,11), CUCO(29,5),
X CX(32,11), CXM(10,11), CXNEH(10,11), CXRATC(29),
X CXS(10,11), DA(10), DELM(11), DEPV(10,11),
X DF(20), DFACT(29,11), DFL(25), DFLOW(32),
X EMACH(29,11), FCUND(20,3,10), FRDEL(10,11), GAMMA(32,11),
X HMN(29), HUB(32), IKK(10), MACH(29,11),
X OEAR(29,11), PD(32,11), R(32,11), RCURVE(10,11),
X RH(32), RHC(32,11), RINT(11), RCTAG(11),
X RS(32), RSLOPE(10,11), RTRAIL(11), SCCO(29,5),
X SOLID(29,11), SSCU(29,5), TERM1(10,11), TERMA(11),
X TERMB(11), TERMC(11), TIP(32), TITLE(12),
X TC(32,11), TSTAT(11), U(32,11), W(11),
X X(32)
COMMON /SCALER/ A, AA, A1GA0, A202A0, A303A0, A404A0,
X AS05A0, B, BB, CC, CM, CMEAN, CMEANP, COINTG,
X CPI2, CPI3, CPI4, CPI5, CPI6, CPO2, CPO3, CPO4,
X CPO5, CAMP, DCP, CD, DIFCM, DT, DUMMY, ERASI,
X G, GASK, GJ, GR, GR2, JOULE, MAPR, MOLEWT,
X POCO, Q, RFM, TCP, TERMD, TESTBH, TESTDS, TESTMS,
X TOCO, TOL, TOLAT, TOLB2, TOLMIN, TOLMS, TOLTIP, TOLCP,
X TOLCX, TOLR, TCTINT, TOTPR, V, VMI
COMMON /INTEGR/ I, IB, IB1, IDUMP, IERROR, IFIRST,
X IG, ICUTTR, IPASS, IS, IT, J, JIN, JJ,
X JM, JMI, K, KI, KK, L, LIMIT, LSTAGE,
X MSTAGE, NLINES, NTUBES, NX, NX1, YES
EQUIVALENCE (ATAR(1,1), ATAS(1,1)), (FLOW(1), DFLOW(1))
COMMON /ENERGY/ F, T, GAMMER

```

C

*** I LESS THAN 5 INDICATES AN INLET STATION

IF (I.LT.5) GO TO 60

C

```

*** IF I IS GREATER THAN LSTAGE IT IS AN OUTLET STATION. IT IS
ASSUMED THAT TOTAL TEMPERATURE AND TOTAL PRESSURE ARE
CONSTANT ALONG A STREAMLINE AND THAT ANGULAR MOMENTUM IS
CONSERVED

```

C

C

C

```

IF (I.LE.LSTAGE) GO TO 10
DO 8 J=1,NLINES
5 GAMMA(I,J)=GAMMA(I-1,J)
6 CP(I,J)=CP(I-1,J)
7 CU(I,J)=R(I-1,J)*CU(I-1,J)/R(I,J)
TO(I,J)=TC(LSTAGE,J)
8 PC(I,J)=PC(LSTAGE,J)

```

12/15/67

PRFIT. - EFN SOURCE STATEMENT - IFN(S) -

```

      GO TO 60
C      *** CALCULATE WHIRL VELOCITY AT EACH STREAMLINE
10  T= TOCO
    B= THERM3(TOCO)
    DO 12 J=1,NLINES
12  CU(I,J)=(CUCU(I,1)/R(I,J)+CUCU(I,2))/R(I,J)+CUCU(I,3)+(CUCU(I,4)+C
    UCG(I,5)*R(I,J))*R(I,J)
    IF (I.NE.5) GO TO 20
    DO 16 J=1,NLINES
    H= -(CX(5,J)**2 +CR(5,J)**2 +CU(5,J)**2)/GJ
    CALL ENTALP
C      *** CALCULATE PRESSURE LOSS ACROSS INLET GUIDE VANE. AN INLET
C      GUIDE VANE IS SIMULATED BY SPECIFYING A TANGENTIAL VELOCITY
C      DISTRIBUTION AT THE ENTRANCE TO THE FIRST ROTOR AND A
C      PRESSURE LOSS ACROSS STATIONS 4 TO 5
    PG(5,J)= POCU -W(J)*POCO*(1.0 -EXP((THERM3(TSTAT(J)) -B)/DCP))
16  CONTINUE
    GO TO 60
20  CONTINUE
C      *** I EVEN SIGNIFIES A ROTOR EXIT AND I ODD SIGNIFIES A STATOR
22  IF (I-(I/2)*2.EQ.0) GO TO 30
25  DO 26 J=1,NLINES
    CP(I,J)= CP(I-1,J)
    GAMMA(I,J)= GAMMA(I-1,J)
    TO(I,J)=TO(I-1,J)
C      *** CALCULATE TOTAL PRESSURE AT STATOR EXIT
    T= TO(I-2,J)
    H= (THERM1(TO(I,J)) -THERM1(T))*ATAS(I,J)
    CALL ENTALP
26  PG(I,J)= PU(I-2,J)*EXP((THERM3(TSTAT(J))-THERM3(T))/DCP)
    GO TO 60
C      *** CALCULATE TOTAL TEMPERATURE RISE ACROSS ROTOR
30  DO 40 J=1,NLINES
31  H= 2.0*(CU(I,J)*U(I,J) -CU(I-1,J)*U(I-1,J))/GJ
C      *** CALCULATE TOTAL TEMPERATURE AT ROTOR EXIT
    T= TO(I-1,J)
    CALL ENTALP
    TO(I,J)= TSTAT(J)
C      *** THERMP YIELDS THE SPECIFIC HEAT CP(I,J) AND GAMMA(I,J)
C      FROM TO(I,J)
    CALL THERMP

```

PRF17. - EFN SOURCE STATEMENT - IFN(S) -

12/15/67

H= H*ATAR(I,J)
CALL ENTALP
40 PC(I,J)= PU(I-1,J)*EXP((THERM3(TSTAT(J)) -THERM3(T))/DCP)
60 RETURN
END

PRF13512
PRF13513
PRF13514
PRF13515
PRF13516

12/15/67

RDER1. - EFN SOURCE STATEMENT - IFN(S) -

C
C*** CALCULATES VALUES OF THE FIRST DERIVATIVE OF Y WITH
RESPECT TO R

```

SUBROUTINE RDERIV(Y,IAX)
DIMENSION Y(IAX,11)
REAL MACT, MAPR, MOLEWT, JOULE
DIMENSION ATAS(25,11), FLOW(32)
LOGICAL IERROR, YES
COMMON /MATRIX/ ALPHA(10,11), ATAR(29,11), B2(29),
X BETA(10,11), BH(32), BLADE(29), BT(32),
X CC(10,11), CP(32,11), CPCU(6), CR(32,11),
X CSLOPE(10,11), CU2(11), CU(32,11), CUCU(29,5),
X CX(32,11), CXM(10,11), CXNEW(10,11), CXRATU(29),
X CXS(10,11), DA(10), DELM(11), DEPV(10,11),
X DF(20), DFACT(25,11), DFL(25), DFLOW(32),
X EMACH(29,11), FOUNO(20,3,10), FRDEL(10,11), GAMMA(32,11),
X HMN(29), HUB(32), IKK(10), MACH(29,11),
X OEAR(29,11), PC(32,11), R(32,11), RCURVE(10,11),
X RH(32), RHO(32,11), RINT(11), RUSTAG(11),
X RS(32), RSLUPE(10,11), RTRAIL(11), SECU(29,5),
X SOLID(29,11), SSCU(29,5), TERM1(10,11), TERMA(11),
X TERMB(11), TERMC(11), TIP(32), TITLE(12),
X TU(32,11), TSTA(11), U(32,11), W(11),
X X(32)
COMMON /SCALER/ A, AA, A10A0, A202A0, A303A0, A404A0,
X A505A0, B, BB, CC, CM, CMEAN, CMEANP, CUINTG,
X CPI2, CPI3, CPI4, CPI5, CPI6, CPC2, CPO3, CPO4,
X CPO5, CAMP, DCP, DU, DIFCM, DT, DUMMY, ERAS1,
X G, GASK, GJ, GR, GR2, JOULE, MAPR, MOLEWT,
X PCCC, C, RPM, TCP, TERMD, TESTBH, TESTDS, TESTMS,
X TCCO, TUL, TCLAT, TGLB2, TOLMIN, TOLMS, TOLTIP, TOLUP,
X TOLCX, TOLR, TCTINT, TOTPR, V, VMI
COMMON /INTEGR/ I, IB, IB1, IDUMP, IERROR, IFIRST,
X IG, ICUTR, IPASS, IS, IT, J, JIN, JJ,
X JM, JMI, K, KI, KK, L, LIMIT, LSTAGE,
X MSTAGE, NLINES, NTUBES, NX, NX1, YES
EQUIVALENCE (ATAR(1,1),ATAS(1,1)), (FLOW(1),DFLOW(1))

JJ=L
IF (IAX.EQ.32) JJ=1
DO 100 J=2,NTUBES
100 CG(L,J)= (Y(JJ,J-1)-Y(JJ,J+1))/(R(I,J-1)-R(I,J+1))
CO(L,1)=(Y(JJ,1)-Y(JJ,2))/(R(I,1)-R(I,2))
CO(L,NLINES)=(Y(JJ,NLINES)-Y(JJ,NLINES-1))/(R(I,NLINES)-
1 R(I,NLINES-1))
RETURN
END

```

12/15/67

SUBROUTINE ROTOUT

C

*** COMPUTES ROTOR EXIT GEOMETRY

ROTOR3567
ROTOR3568
ROTOR3569
ROTOR3570
ROTOR3571
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ROTOR3616
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ROTOR3618
ROTOR3619
ROTOR3620

```

REAL MACH, MAPR, MOLENT, JOULE
DIMENSION ATAS(29,11), FLCW(32)
LOGICAL IERROR, YES
COMMON /MATRIX/ ALPHA(10,11), ATAR(29,11), B2(29),
X BETA(10,11), BH(32), BLADE(29), BT(32),
X CC(10,11), CP(32,11), CFCO(6), CR(32,11),
X CSLOPE(10,11), CU2(11), CU(32,11), CUCG(29,5),
X CX(32,11), CXM(10,11), CXNEW(10,11), CXRAT(29),
X CXS(10,11), CA(10), DELM(11), DEPV(10,11),
X DF(20), DFACT(29,11), DFL(29), DFLCW(32),
X EMACH(29,11), FCUND(20,3,10), FRDEL(10,11), GAMMA(32,11),
X HMN(29), HUB(32), IKK(10), MACH(29,11),
X OEAR(29,11), PO(32,11), R(32,11), RCURVE(10,11),
X RH(32), RHO(32,11), RINT(11), ROSTAG(11),
X RS(32), RSLOPE(10,11), RTRAIL(11), SUCO(29,5),
X SOLID(29,11), SSCC(29,5), TERM1(10,11), TERMA(11),
X TERMB(11), TERMC(11), TIP(32), TITLE(12),
X TC(32,11), TSTAT(11), U(32,11), W(11),
X X(32)
COMMON /SCALER/ A, AA, A10A0, A202A0, A303A0, A404A0,
X A505A0, B, BB, CC, CM, CMEAN, CMEANP, CUINTG,
X CPI2, CPI3, CPI4, CPI5, CPI6, CPC2, CPO3, CPD4,
X CPU5, CAMP, DCP, DD, DIFCM, DT, DUMMY, ERAS1,
X G, CASK, GJ, GR, GR2, JOULE, MAPR, MOLENT,
X POCO, C, RPM, TCP, TERMD, TESTBH, TESTDS, TESTMS,
X TCCO, TOL, TGLAT, TGLB2, TGLMIN, TGLMS, TGLTIP, TOLCP,
X TOLCX, TOLR, TCTINT, TUTPR, V, VMI
COMMON /INTEGR/ I, IB, IB1, IDUMP, IERROR, IFIRST,
X IG, ICUTTR, IPASS, IS, IT, J, JIN, JJ,
X JM, JML, K, KL, KK, L, LIMIT, LSTAGE,
X MSTAGE, NLINES, NTUBES, NX, NX1, YES
EQUIVALENCE (ATAR(1,1),ATAS(1,1)), (FLOW(1),DFLCW(1))
COMMON /ENERGY/ E, T, GAMMER

DO 5 J=1,NLINES
5 CP(I,J)= CP(I-1,J)
L=2
ISAVE= I
LC1=0
LC2=0
LC3=0
JC=0
IF (IPASS.NE.1) GO TO 15
IF (LSTAGE.EQ.7) GO TO 1
CALL COPY
RETURN
1 CONTINUE
CALL RSTART
IT=1
10 CALL PRFIT2

```

12/15/67

C	*** SUBROUTINE INEST TO BE USED ONLY FOR INITIAL GUESS.	ROTU3621
C	IT=1 INDICATES SUBROUTINE INEST HAS NOT BEEN USED	ROTU3622
		ROTU3623
	IF (IT.NE.1) GO TO 15	ROTU3624
	CALL INEST	ROTU3625
		ROTU3626
C	*** SUBROUTINE STREAM CALCULATES A SIMPLE RADIAL	ROTU3627
C	EQUILIBRIUM SOLUTION OF THE FLOW	ROTU3628
		ROTU3629
	CALL STREAM	ROTU3630
	IT=0	ROTU3631
	RETURN	ROTU3632
15	CONTINUE	ROTU3633
	CALL CAXIAL	ROTU3634
	L=2	ROTU3635
	I= ISAVE	ROTU3636
19	CONTINUE	ROTU3637
	JC=JC+1	ROTU3638
	SAFE=CUCO(I,2)	ROTU3639
		ROTU3640
C	*** STAGE OPTIMIZATION (40 ATTEMPTS ONLY)	ROTU3641
		ROTU3642
	IF (JC.LE.40.AND.LIMIT.EQ.0) CALL DRIVE	ROTU3643
		ROTU3644
C	*** ERROR PRINTS MESSAGE - OPTIMIZATION DISCONTINUED	ROTU3645
		ROTU3646
	IF (JC.EQ.41) CALL ERROR(14)	ROTU3647
	LC1=0	ROTU3648
	IF(SAFE.NE.CUCO(I,2)) GO TO 10	ROTU3649
		ROTU3650
		ROTU3651
	J= NLINES	ROTU3652
	A= (R(I-1,J)+R(I,J))*0.5	ROTU3653
	SOLID(I,J)= (SOCC(I,1)/A +SUCC(I,2))/A +SUCC(I,3)	ROTU3654
	X+(SUCC(I,4) +SOCC(I,5)*A)*A	ROTU3655
	TESTDS= 1.0 -SQRT(CX(I,J)**2 +CR(I,J)**2 +(CU(I,J)-U(I,J))**2)/	ROTU3656
	X SQRT(CX(I-1,J)**2 +CR(I-1,J)**2 +(CU(I-1,J)-U(I-1,J))**2)	ROTU3657
	X +(U(I-1,J) -CU(I-1,J) -U(I,J) +CU(I,J))/	ROTU3658
	X (2.0*SOLID(I,J)*SQRT(CX(I-1,J)**2 +CR(I-1,J)**2	ROTU3659
	X +(CU(I-1,J)-U(I-1,J))**2))	ROTU3660
	IF (TESTDS.LE.DFI(I)+TOLB2) GO TO 44	ROTU3661
	CALL B2CAL	ROTU3662
	WRITE (6,99) I	ROTU3663
99	FORMAT (1H036X44F) ROTOR TIP D-FACTOR LIMIT VIOLATED AT STATION(I)	ROTU3664
	IERROR= .TRUE.	ROTU3665
	GO TO 10	ROTU3666
44	CONTINUE	ROTU3667
		ROTU3668
		ROTU3669
C	*** TEST THE HUB MACH NUMBER. IF TOO HIGH, ALTER THE	ROTU3670
C	COEFFICIENT OF 1.0/R IN THE WHIRL VELOCITY POLYNOMIAL	ROTU3671
		ROTU3672
	H= -(CX(I,1)**2 +CR(I,1)**2 +CU(I,1)**2)/GJ	ROTU3673
	T= TO(I,1)	ROTU3674
	J= 1	ROTU3675
	CALL ENTALP	ROTU3676

12/15/67

ROTOU. - EFN SOURCE STATEMENT - IFN(S) -

CALL GAM	ROTO3677
TESTMS = -H*GJ/(32.174*GASK*GAMMER*ISTAT(1))	ROTO3678
TESTMS = HMN(I) - SQRT(TESTMS) +TOLMS	ROTO3679
IF (TESTMS.GE.0.) GO TO 48	ROTO3680
SAVE= CUC(I,2)	ROTO3681
	ROTO3682
C *** CALCULATE THE B-COEFFICIENT FROM THE ABSOLUTE MACH NUMBER	ROTO3683
C LIMIT	ROTO3684
	ROTO3685
45 CALL B2CAL1	ROTO3686
LC2=LC2+1	ROTO3687
	ROTO3688
C *** ERROR TRANSFER TO A NEW DATA SET	ROTO3689
	ROTO3690
IF (LC2.GT.50) CALL ERROR(15)	ROTO3691
WRITE (6,102) I	ROTO3692
102 FORMAT (1F037X39F*** MACH NO. LIMIT VIOLATED AT STATION 12,4H ***)	ROTO3693
IEROR=.TRUE.	ROTO3694
GO TO 10	ROTO3695
48 TESTBH=HMN(I+1)-ATAN((U(I,1)-CU(I,1))/SQRT(CX(I,1)**2+CR(I,1)**2))	ROTO3696
	ROTO3697
C *** TEST THE RELATIVE FLOW ANGLE AT THE HUB AND ALTER THE	ROTO3698
C COEFFICIENT OF L.C/R IN THE WHIRL VELOCITY POLYNOMIAL	ROTO3699
C IF NECESSARY	ROTO3700
	ROTO3701
IF (TESTBH.LE.0.) RETURN	ROTO3702
LC3=LC3+1	ROTO3703
	ROTO3704
C *** ERROR TRANSFER TO A NEW DATA SET	ROTO3705
	ROTO3706
IF (LC3.GT.50) CALL ERROR(16)	ROTO3707
WRITE (6,103) I	ROTO3708
103 FORMAT (1F022X50F*** RELATIVE FLOW ANGLE LIMIT VIOLATED AT STATION	ROTO3709
X 12,4H ***)	ROTO3710
	ROTO3711
C *** CALCULATE THE B-COEFFICIENT FROM THE RELATIVE FLOW ANGLE	ROTO3712
C LIMIT	ROTO3713
	ROTO3714
CALL B2CAL2	ROTO3715
IEROR=.TRUE.	ROTO3716
GO TO 10	ROTO3717
END	ROTO3718

RSTAR. - EFN SOURCE STATEMENT - IFN(S) -

SUBROUTINE RSTART

```

C      *** CALCULATES EQUAL AREA ESTIMATE OF STREAMLINE POSITION
C      AND WHEEL SPEED

REAL MACH, MAPR, MCLEWT, JOULE
DIMENSION ATAS(29,11), FLCW(32)
LOGICAL IERROR, YES
COMMON /MATRIX/ ALPHA(10,11), ATAR(29,11), B2(29),
X BETA(10,11), BH(32), BLADE(29), BT(32),
X CC(10,11), CF(32,11), CPCO(6), CR(32,11),
X CSLOPE(10,11), CU2(11), CU(32,11), CUCO(29,5),
X CX(32,11), CXM(10,11), CXNEW(10,11), CXRATU(29),
X CXS(10,11), DA(10), DELM(11), DEPV(10,11),
X DF(20), DFACT(29,11), DFL(29), DFLOW(32),
X EMACH(29,11), FOUNO(20,3,10), FRDEL(10,11), GAMMA(32,11),
X HMN(29), HUB(32), IKK(10), MACH(29,11),
X GEAR(29,11), PL(32,11), K(32,11), RCURVE(10,11),
X RH(32), RHO(32,11), RINT(11), RSTAG(11),
X RS(32), RSLOPE(10,11), RTRAIL(11), SCCO(29,5),
X SOLID(29,11), SSCO(29,5), TERM1(10,11), TERMA(11),
X TERMB(11), TERMC(11), TIP(32), TITLE(12),
X TO(32,11), TSTAT(11), U(32,11), W(11),
X X(32)
COMMON /SCALER/ A, AA, ALCAG, A202A0, A303A0, A404A0,
X AS05A0, B, BB, CC, CP, CMEAN, CMEANP, COINTG,
X CPI2, CPI3, CPI4, CPI5, CPI6, CPG2, CPO3, CPU4,
X CPU5, DAMP, DCP, DD, DIFCN, DT, DUMMY, ERAS1,
X G, GASK, GJ, GR, GR2, JOULE, MAPR, MCLEWT,
X POCO, Q, RPM, TCP, TERMD, TESTBH, TESTDS, TESTMS,
X TUCO, TOL, TCLAT, TOLB2, TCLMIN, TOLMS, TOLTIP, TOLCP,
X TOLCX, TOLR, TCTINT, TOTPR, V, VMI
COMMON /INTEGR/ I, IB, IB1, IOUMP, IERROR, IFIRST,
X IG, IOUTTR, IPASS, IS, IT, J, JIN, JJ,
X JM, JMI, K, KI, KK, L, LIMIT, LSTAGE,
X MSTAGE, NLINES, NTUBES, NX, NX1, YES
EQUIVALENCE (ATAR(1,1), ATAS(1,1)), (FLOW(1), DFLOW(1))

AA= RS(I)**2 -RH(I)**2
BB= RS(I)**2 -AA*BH(I)
CC= AA*(BH(I) +BT(I) -1.0)
DO 10 J=1,NLINES
ERAS1= BB+DELP(J)*CC

C      *** ERROR TRANSFER TO A NEW DATA SET

IF (ERAS1.LE.0.0) CALL ERROR(13)
R(I,J)= SQRT(ERAS1)
10 U(I,J)= R(I,J)*RFM
RETURN
END

```

RSTA3720
RSTA3721
RSTA3722
RSTA3723
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RSTA3770

12/15/67

SHOCK. - EFN SOURCE STATEMENT - IFN(5) -

FUNCTION SHOCK(Z,Y)

*** CALCULATES SUPERSONIC EXPANSION ANGLE MINUS PRANDTL-MEYER
ANGLE

REAL MACH, MAPR, MOLEWT, JOULE

DIMENSION ATAS(25,11), FLCW(32)

LOGICAL IEFROCK, YES

COMMON /MATRIX/ ALPHA(10,11), ATAR(29,11), B2(29),
 X BETA(10,11), BH(32), BLADE(29), BT(32),
 X CC(10,11), CF(32,11), CPCG(6), CR(32,11),
 X CSLOPE(10,11), CU2(11), CC(32,11), CUCG(29,5),
 X CX(32,11), CXM(10,11), CXNEW(10,11), CXRAT(29),
 X CXS(10,11), CA(10), DELM(11), DEPV(10,11),
 X DF(20), DFACT(29,11), DFL(29), DFLEW(32),
 X EMACH(29,11), FOUN(20,3,10), FROEL(10,11), GAMMA(32,11),
 X HMN(29), HUB(32), IKK(10), MACH(29,11),
 X OEAR(29,11), PC(32,11), R(32,11), RCURVC(10,11),
 X RH(32), RHU(32,11), RINT(11), RCTAG(11),
 X RS(32), RSLOPE(10,11), RTKAIL(11), SLCG(29,5),
 X SOLID(29,11), SSCG(29,5), TERM1(10,11), TERMA(11),
 X TERMB(11), TERMC(11), TIP(32), TITLE(12),
 X TL(32,11), TSTAT(11), U(32,11), w(11),
 X X(32)
 COMMON /SCALE/ A, AA, A10AC, A202AO, A303AO, A404AO,
 X A505AO, B, BB, CC, CM, CMEAN, CMEANP, COINFG,
 X CPI2, CPI3, CPI4, CPI5, CPI6, CPQ2, CPQ3, CPU4,
 X CPU5, CAMP, DCP, DD, DIFCM, DT, DUMMY, ERAS1,
 X G, GASK, GJ, GR, GR2, JOULE, MAPR, MOLEWT,
 X POCG, C, RPM, TCP, TERMD, TESTBH, TESTDS, TESTMS,
 X TUCG, TOL, TOLAT, TOLB2, TOLMIN, TOLMS, TOLTIP, TOLCP,
 X TOLCX, TOLR, TOTINT, TOTPR, V, VMI
 COMMON /INTEGR/ I, Ib, IB1, IDUMP, IERRUR, IFIRST,
 X IG, ICUTR, IPASS, IS, IT, J, JIN, JJ,
 X JM, JPI, K, KI, KK, L, LIMIT, LSTAGE,
 X MSTAGE, NLINES, NTUBES, NX, NX1, YES
 EQUIVALENCE (ATAR(1,1), ATAS(1,1)), (FLOW(1), DFLEW(1))
 SHOCK= Y - TERM1(L,J)*ATAN(SQRT((Z-1.0)*(Z+1.0)))/TERM1(L,J) +
 X ATAN(SQRT((Z-1.0)*(Z+1.0)))
 RETURN
 END

SLINE. - EFN SOURCE STATEMENT - IFN(S) -

12/15/67

SUBROUTINE SLINE (X,XT,YT,N,ANS)	SLIN3815
DIMENSION XT(500),YT(500)	SLIN3816
IF (N-1) 3,3,11	SLIN3817
11 IF (X-XT(1)) 3,3,4	SLIN3818
2 RETURN	SLIN3819
3 ANS=YT(1)	SLIN3820
GOTO 2	SLIN3821
4 IF (X-XT(N)) 7,5,5	SLIN3822
5 ANS=YT(N)	SLIN3823
GOTO 2	SLIN3824
6 ANS=(YT(N)-YT(N-1))*(X-XT(N-1))/(XT(N)-XT(N-1))+YT(N-1)	SLIN3825
GOTO 2	SLIN3826
7 K=N-1	SLIN3827
DO 8 I=2,K	SLIN3828
IF (X-XT(I)) 9,10,8	SLIN3829
8 CONTINUE	SLIN3830
GOTO 6	SLIN3831
9 ANS=(YT(I)-YT(I-1))*(X-XT(I-1))/(XT(I)-XT(I-1))+YT(I-1)	SLIN3832
GOTO 2	SLIN3833
10 ANS=YT(I)	SLIN3834
GOTO 2	SLIN3835
END	SLIN3836

12/15/67

```

SUBROUTINE STAOUT
C      *** COMPUTES STATOR EXIT
REAL MACH, MAPK, MLEWT, JOULE
DIMENSION ATAS(29,11), FLCW(32)
LOGICAL IERROR, YES
COMMON /MATRIX/ ALPHA(10,11), ATAR(29,11), B2(29),
X BETA(10,11), BH(32), BLADE(29), BT(32),
X CO(10,11), CP(32,11), CPG(6), CR(32,11),
X CSLUPE(10,11), CU2(11), CU(32,11), CUCU(29,5),
X CX(32,11), CXM(10,11), CXNEW(10,11), CXRATU(29),
X CXS(10,11), DA(10), DELM(11), DEPV(10,11),
X DF(20), DFACT(29,11), DFL(29), DFLCW(32),
X EMACH(29,11), FOUNO(20,3,10), FRDEL(10,11), GAMMA(32,11),
X HMN(29), HUB(32), IKK(10), MACH(29,11),
X OBAR(29,11), PU(32,11), R(32,11), RCURVE(10,11),
X RH(32), RHO(32,11), RINT(11), ROSTAG(11),
X RS(32), RSLUPE(10,11), RTRAIL(11), SCCU(29,5),
X SOLID(29,11), SSCU(29,5), TEFM1(10,11), TERMA(11),
X TERMB(11), TERMC(11), TIP(32), TITLE(12),
X TO(32,11), TSTAT(11), U(32,11), w(11),
X X(32)
COMMON /SCALER/ A, AA, A10A0, A202A0, A303A0, A404A0,
X A505A0, B, BB, CC, CM, CMEAN, CMEANP, CUINTG,
X CPI2, CPI3, CPI4, CPI5, CPI6, CPG2, CPU3, CPU4,
X CPO5, DAMP, DCP, DD, DIFCM, DT, DUMMY, ERAS1,
X G, GASK, GJ, GR, GR2, JOULE, MAPK, MLEWT,
X POCO, C, RFM, TCP, TERMO, TESTBH, TESTDS, TESTMS,
X TOCO, TOL, TCLAT, TCLB2, TOLMIN, TOLMS, TOLTP, TOLCP,
X TOLCX, TOLR, TCTINT, TOIPR, V, VMI
COMMON /INTEGR/ I, IB, IB1, IDUMP, IERROR, IFIRST,
X IG, ICUTTR, IPASS, IS, IT, J, JIN, JJ,
X JM, JM1, K, K1, KK, L, LIMIT, LSTAGE,
X MSTAGE, NLINES, NTUBES, NX, NX1, YES
EQUIVALENCE (ATAR(1,1), ATAS(1,1)), (FLOW(1), DFLCW(1))

DO 5 J=1, NLINES
5 CP(I,J)= CP(I-1,J)
L=2
ISAVE= I
LC5=0

C      *** IF IPASS=1 THE CALCULATION MUST BE INITIALIZED

IF (IPASS.NE.1) GO TO 19
IF (LSTAGE.EQ.7) GO TO 1
CALL COPY
RETURN
1 CONTINUE
8 CALL RSTART
IT=1

C      *** PRFIT2 YIELDS FLOW PARAMETERS AT STREAMLINE RADII

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12/15/67

STAGC. - EFN SOURCE STATEMENT - IFN(S) -

		STAG3892
		STAG3893
		STAG3894
		STAG3895
C	*** SUBROUTINE INEST TO BE USED ONLY FOR INITIAL GUESS.	STAG3896
C	IT=1 INDICATES SUBROUTINE INEST HAS NOT BEEN USED	STAG3897
C	FOR THIS STATION	STAG3898
		STAG3899
	IF (IT.NE.1) GO TO 15	STAG3900
	CALL INEST	STAG3901
	IT=0	STAG3902
C	*** SUBROUTINE STREAM CALCULATES A SIMPLE RADIAL EQUILIBRIUM	STAG3903
C	SOLUTION OF THE FLOW	STAG3904
		STAG3905
	RETURN	STAG3906
15	CONTINUE	STAG3907
	CALL STREAM	STAG3908
19	CONTINUE	STAG3909
		STAG3910
C	*** SOLVE FLOW EQUATIONS WITH CURVATURE EFFECTS	STAG3911
		STAG3912
	CALL CAXIAL	STAG3913
	L=2	STAG3914
	I= ISAVE	STAG3915
	CALL PKFIT2	STAG3916
C	*** TEST STATOR D-FACTOR	STAG3917
		STAG3918
	AA=(R(I,1)+R(I-1,1))*5	STAG3919
	SOLID(I,1)= (SUCC(I,1)/AA+SUCC(I,2))/AA + SUCC(I,3) + (SUCC(I,4) +	STAG3920
	X SUCC(I,5)*AA)*AA	STAG3921
	TESTDS= DFL(I)-1.0+ SQRT(CX(I,1)**2+CU(I,1)**2 + CR(I,1)**2)/ SQRT	STAG3922
	X (CX(I-1,1)**2 + CU(I-1,1)**2 + CR(I-1,1)**2) + (CU(I,1)-CU(I-1,1)	STAG3923
	X)/(SOLID(I,1))*2.*SQRT(CX(I-1,1)**2+CU(I-1,1)**2+CR(I-1,1)**2))	STAG3924
	IF (TESTDS.GE.0.) RETURN	STAG3925
	LC5=LC5+1	STAG3926
		STAG3927
C	*** ERROR TRANSFER TO A NEW DATA SET	STAG3928
		STAG3929
	IF (ERAS1.LE.0.0) CALL ERROR (24)	STAG3930
	WRITE (5,104) 1	STAG3931
104	FORMAT (1F037X35H*** D-FACTOR LIMIT VIOLATED AT STATION 12,4H ***)	STAG3932
	IERROE=.TRUE.	STAG3933
	I=I-1	STAG3934
		STAG3935
C	*** ALTER E-COEFFICIENT	STAG3936
		STAG3937
	CALL B2CAL3	STAG3938
		STAG3939
C	*** DETERMINE FLOW PARAMETERS	STAG3940
		STAG3941
	CALL PRFIT2	STAG3942
		STAG3943
C	*** SATISFY CONTINUITY EQUATION	STAG3944
		STAG3945
	CALL STREAM	STAG3946
		STAG3947

12/12/67

STAGU. - EFN SOURCE STATEMENT - IFN(S) -

C *** CHECK ROTOR CALCULATION

CALL ROTOUT
I=I+1
GO TO 15
END

STAG3948
STAG3949
STAG3950
STAG3951
STAG3952
STAG3953

12/15/67

STREAM. - EFN SOURCE STATEMENT - IFN(S) -

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C      *** COMPUTES AXIAL VELOCITY DISTRIBUTIONS WHICH SATISFY
C      RATIO OF SPECIFIC HEATS IS CALCULATED AS CP/(CP-R/J)
      SUBROUTINE STREAM
      REAL MACH, MAPR, MOLEWT, JOULE
      DIMENSION ATAS(29,11), FLOW(32)
      LOGICAL IERROR, YES
      COMMON /MATRIX/ ALPHA(10,11), ATAR(29,11), B2(29),
X BETA(10,11), BH(32), BLADE(29), BT(32),
X CU(10,11), CP(32,11), CPCU(6), CR(32,11),
X CSLOPE(10,11), CU2(11), CU(32,11), CUCC(29,5),
X CX(32,11), CXM(10,11), CXNEW(10,11), CXRATO(29),
X CXS(10,11), DA(10), DELM(11), DEPV(10,11),
X DF(20), DFACT(29,11), DFL(29), DFLOW(32),
X EMACH(29,11), FOUNO(20,3,10), FROEL(10,11), GAMMA(32,11),
X HMN(29), HUB(32), IKK(10), MACH(29,11),
X OBAR(29,11), PG(32,11), R(32,11), RCURVE(10,11),
X RH(32), RHO(32,11), RINT(11), RCSTAG(11),
X RS(32), RSLOPE(10,11), RTRAIL(11), SCCU(29,5),
X SCLID(29,11), SSCU(29,5), TERM1(10,11), TERMA(11),
X TERMB(11), TERMC(11), TIP(32), TITLE(12),
X TC(32,11), TSTAT(11), U(32,11), W(11),
X X(32)
      COMMON /SCALER/ A, AA, A10A0, A202A0, A303A0, A404A0,
X AS05A0, E, BB, CC, CM, CMEAN, CMEANP, CUINTG,
X CPI2, CPI3, CPI4, CPI5, CPI6, CPC2, CPU3, CPU4,
X CPU5, CAMP, DCP, DD, DIFCM, DT, DUMMY, ERAS1,
X G, GASK, GJ, GR, GR2, JOULE, MAPR, MOLEWT,
X PCCO, C, RPM, TCP, TERMD, TESTQH, TESTQS, TESTMS,
X TOCG, TOL, TOLAT, TOLB2, TOLMIN, TOLMS, TOLTIP, TOLCP,
X TOLCX, TOLR, TOTINT, TOTPR, V, VMI
      COMMON /INTEGR/ I, IB, IB1, IDUMP, IERROR, IFIRST,
X IG, ICUTTR, IPASS, IS, IT, J, JIN, JJ,
X JM, JM1, K, K1, KK, L, LIMIT, LSTAGE,
X MSTAGE, NLINES, NTUBES, NX, NX1, YES
      EQUIVALENCE (ATAR(1,1),ATAS(1,1)), (FLOW(1),DFLOW(1))
      COMMON /ENERGY/ H, T, GAMMER
      CMEAN=CX(I,JM)
C      *** COMPUTE VALUES OF CXM,ROSTAG,AND TERMA,(CU**2+CR**2)
      DO 150 J=1,NLINES
      CXM(I,J)=CX(I,J)/CMEAN
      ROSTAG(J)=PC(I,J)/(TC(I,J)*GASK)
150  TERMA(J)=CU(I,J)**2+CR(I,J)**2
      NCCOUNT=1
C      *** START OF LOOP ON CM CONVERGENCE
      INCIC=0
155  J = JM
      H= -(CMEAN**2 +TERMA(J))/GJ

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12/15/67

STREM. - EFN SOURCE STATEMENT - IFN(S) -

T= TO(1,J)	STRE4009
CALL ENTALP	STRE4010
CALL GAM	STRE4011
VMI= GR2*GAMMER*TSTAT(J)	STRE4012
C *** ERROR TRANSFER TO A NEW DATA SET	STRE4013
IF (VMI.LE.0.0) CALL ERRCLR(27)	STRE4014
VMI= SQRT(VMI)	STRE4015
IF(CMEAN-VMI)205,205,160	STRE4016
160 IF(INDIC)165,170,165	STRE4017
C *** PROGRAM NOT SUITABLE FOR SUPERSONIC FLOW, GO TO A	STRE4018
C NEW DATA SET	STRE4019
165 CALL ERROR(2)	STRE4020
170 INDIC=1	STRE4021
CMEAN= VMI*0.75	STRE4022
205 DO 260 J=1,NLINES	STRE4023
CX(I,J)=CMEAN*CXM(L,J)	STRE4024
C *** CALCULATE STATIC DENSITY	STRE4025
H= -(CX(I,J)**2 +TERMA(J))/GJ	STRE4026
T= TO(1,J)	STRE4027
CALL ENTALP	STRE4028
RHO(I,J)= PO(1,J)*EXP((THERM3(TSTAT(J)) -THERM3(T))/UCP)/TSTAT(J)	STRE4029
X /GASK	STRE4030
DEPV(L,J)=RHO(I,J)*CXM(L,J)	STRE4031
260 CONTINUE	STRE4032
C *** CALCULATE INTEGRAL OF RHO*CXM*R VS. R FROM HUB TO TIP,	STRE4033
C (TOTINT), AND NEW VALUE OF CMEAN	STRE4034
275 CALL INTEG (DEPV,1)	STRE4035
TOTINT=RINT(NLINES)-RINT(1)	STRE4036
CMEANP=FLCW(1)/6.2831853/TOTINT	STRE4037
C *** CHECK CONVERGENCE OF CM	STRE4038
DIFCM=ABS((CMEAN-CMEANP)/CMEAN)	STRE4039
IF (DIFCM-TOLR)300,300,280	STRE4040
280 IF (NCCUNT-30)290,290,285	STRE4041
C *** ERROR WILL CAUSE TRANSFER TO NEXT DATA SET	STRE4042
285 CALL ERROR(3)	STRE4043
290 NCCUNT=NCCUNT+1	STRE4044
CMEAN=CMEANP	STRE4045
GO TO 155	STRE4046
C *** SUCCESSFUL CONVERGENCE ON CM	STRE4047
C *** USE CONVERGED VALUES OF INTEGRAL OF RHO*CXM*R VS. R FROM	STRE4048
C R(J) TO R(J+1), (DA VALUES), TO CALCULATE VALUES OF - -	STRE4049
C DEPV(L,J)=(INTEGRAL RHO*CXM*R VS. R FROM RH TO R(J))/TOTINT	STRE4050
	STRE4051
	STRE4052
	STRE4053
	STRE4054
	STRE4055
	STRE4056
	STRE4057
	STRE4058
	STRE4059
	STRE4060
	STRE4061
	STRE4062
	STRE4063
	STRE4064

	STREM.	-	EFN	SOURCE STATEMENT	-	IFN(S)	-
300	CONTINUE						
	DO 400		J=1,NLINES				
400	CX(I,J)=CXM(L,J)*CMEANP						
700	RETURN						
	END						

12/15/67

STRE4065
 STRE4066
 STRE4067
 STRE4068
 STRE4069
 STRE4070
 STRE4071
 STRE4072

12/15/67

THER1. - EFN SOURCE STATEMENT - IFN(S) -

FUNCTION THERM1(T)

*** CALCULATES F = INTEGRAL FROM 0.0 TO T OF CP DT, WHERE CP IS
GIVEN AS A FIFTH DEGREE POLYNOMIAL

REAL MACH, MAPR, MOLEWT, JOULE

DIMENSION ATAS(25,11), FLOW(32)

LOGICAL IERROR, YES

COMMON /MATRIX/ ALPHA(10,11), ATAR(29,11), B2(29),

X BLTA(10,11), BH(32), BLADE(29), BT(32),

X CC(10,11), CP(32,11), CPCO(6), CK(32,11),

X CSLOPE(10,11), CU2(11), CU(32,11), CUCC(29,5),

X CX(32,11), CXM(10,11), CXNEW(10,11), CXRATD(29),

X CXS(10,11), DA(10), DELM(11), DEPV(10,11),

X DF(20), DFACT(29,11), DFL(29), DFLOW(32),

X EMACH(29,11), FOUNO(20,3,10), FRDEL(10,11), GAMMA(32,11),

X HMN(29), HUB(32), IKK(10), MACH(29,11),

X DEAR(29,11), PO(32,11), R(32,11), RCURVE(10,11),

X RH(32), RHO(32,11), RINT(11), RCTAG(11),

X RS(32), RSLOPE(10,11), RTRAIL(11), SCCO(29,5),

X SOLID(29,11), SSCO(29,5), TERM1(10,11), TERMA(11),

X TERMB(11), TERMC(11), TIP(32), TITLL(12),

X TO(32,11), TSIAT(11), U(32,11), W(11),

X X(32)

COMMON /SCALER/ A, AA, A10AG, A202AO, A303AO, A404AO,

X A505AO, B, BB, CC, CM, CMEAN, CMEANP, COUNIG,

X CPI2, CPI3, CPI4, CPI5, CPI6, CPO2, CPO3, CPU4,

X CPO5, CAMP, DCP, LD, DIFCM, DT, DUMMY, ERAS1,

X G, GASK, GJ, GR, GR2, JOULE, MAPR, MOLEWT,

X POCO, Q, KFM, TCP, TERMD, TESTBH, TESTDS, TESTMS,

X TCCG, TOL, TOLAT, TOLB2, TCLMIN, TOLMS, TCLTIP, TOLCP,

X TOLCX, TOLR, TCTINT, TOTPR, V, VMI,

COMMON /INTEGR/ I, IB, IB1, IDUMP, IERROR, IFIRST,

X IG, ICUTTR, IPASS, IS, IT, J, JIN, JJ,

X JM, JM1, K, K1, KK, L, LIMIT, LSTAGE,

X MSTAGE, NLINES, NTUBES, NX, NX1, YES

EQUIVALENCE (ATAR(1,1), ATAS(1,1)), (FLOW(1), DFLOW(1))

THERM1 = (CPCO(1) + (CPI2 + (CPI3 + (CPI4 + (CPI5 + CPI6 * T) * T) * T) * T) * T)

1T) * T) * T

RETURN

END

12/15/67

SUBROUTINE THERM2(POVER, TOP, T)

*** SOLVES FOR TOP IN GASK * ALOG(POVER) = INTEGRAL FROM T
TO TOP OF (CP/T) DT, WHERE CP IS GIVEN AS A FIFTH DEGREE
POLYNOMIAL. (SEE THERM1).

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REAL MACF, MAPR, MOLEWT, JOULE
DIMENSION ATAS(29,11), FLOW(32)
LOGICAL IEFNR, YES
COMMON /MATRIX/ ALPHA(10,11), ATAR(29,11), B2(29),
X BETA(10,11), BH(32), BLADE(29), BT(32),
X CG(10,11), CP(32,11), CPCO(6), CR(32,11),
X CSLOPE(10,11), CU2(11), CU(32,11), CUCO(29,5),
X CX(32,11), CXM(10,11), CXNEW(10,11), CXRATC(29),
X CXS(10,11), CA(10), DELM(11), DEPV(10,11),
X DF(20), CFACT(29,11), DFL(29), DFLOW(32),
X EMACH(29,11), FOUNO(20,3,10), FKDEL(10,11), GAMMA(32,11),
X HMN(29), HUB(32), IKK(10), MACH(29,11),
X QBAR(29,11), PC(32,11), K(32,11), RCURVE(10,11),
X RH(32), RHO(32,11), RINT(11), ROSTAG(11),
X RS(32), RSLOPE(10,11), RTRAIL(11), SOCU(29,5),
X SOLID(29,11), SSCU(29,5), TERM1(10,11), TERMA(11),

X TERMB(11), TERMC(11), TIP(32), TITLE(12),
X TO(32,11), TSTAT(11), U(32,11), W(11),
X X(32)
COMMON /SCALER/ A, AA, A10A0, A202A0, A303A0, A404A0,
X A505A0, B, BB, CC, CM, CMEAN, CMEANP, COINTG,
X CPI2, CPI3, CPI4, CPI5, CPI6, CPU2, CPC3, CPU4,
X CPU5, CAMP, DCP, DD, DIFCM, DT, DUMMY, ERAS1,
X G, GASK, GJ, GR, GR2, JOULE, MAPR, MOLEWT,
X PUCO, C, RPM, TCP, TERMO, TESTBH, TESTOS, TESTMS,
X TCCO, TOL, TOLAT, TOLB2, TOLMIN, TOLMS, TOLTIP, TOLCP,
X TOLCX, TOLR, TOTINT, TOTPR, V, VMI
COMMON /INTEGR/ I, IB, IB1, IDUMP, IERROR, IFIRST,
X IG, ICUTR, IPASS, IS, IT, J, JIN, JJ,
X JM, JMI, K, KI, KK, L, LIMIT, LSTAGE,
X MSTAGE, NLINES, NTUBES, NX, NX1, YES
EQUIVALENCE (ATAR(1,1), ATAS(1,1)), (FLOW(1), DFLOW(1))

F(X)=ALOG(X)+(A10A0+(A202A0+(A303A0+(A404A0+A505A0*X)*X)*X)*X)*X
IF (POVER.LT.1.0.OR.TOP.LE.0.0.OR.T.LE.0.0) CALL ERRUR (32)
DUMMY=GASK/CPCO(1)*ALOG(POVER)/JOULE +F(T)
DO 10 JA =1,50
XA= -500.C*(F(TOP)-DUMMY)
TOP= TOP+XA
IF (ABS(XA/TOP).LE.TOLR) GO TO 15
10 CONTINUE

*** ERROR TRANSFER TO A NEW DATA SET

CALL ERROR(26)
15 RETURN
END

```

THER3. - EFN SOURCE STATEMENT - IFN(S) -

12/15/67

C

```

FUNCTION THERM3(T)
*** CALCULATE THE INTEGRAL OF CP/T DT FROM 0.0 TO T
REAL MACH, MAPR, MOLEWT, JOULE
DIMENSION ATAS(29,11), FLOW(32)
LOGICAL IERRCR, YES
COMMON /MATRIX/ ALPHA(10,11), ATAR(29,11), 32(29),
X BETA(10,11), BH(32), BLADE(29), BT(32),
X CG(10,11), CP(32,11), CPCU(6), CR(32,11),
X CSLCPE(10,11), CU2(11), CU(32,11), CUCC(29,5),
X CX(32,11), CXM(10,11), CXNEW(10,11), CXRATU(29),
X CXS(10,11), CA(10), DELM(11), DEPV(10,11),
X DF(20), DFACT(29,11), DFL(29), DFLOW(32),
X EMACH(29,11), FOUNO(20,3,10), FRDEL(10,11), GAMMA(32,11),
X HMN(29), HUB(32), IKK(10), MACH(29,11),
X UEAR(29,11), PC(32,11), R(32,11), RCURVE(10,11),
X RH(32), RHU(32,11), RINT(11), RCSTAG(11),
X RS(32), RSLOPE(10,11), RTRAIL(11), SCCU(29,5),
X SOLID(29,11), SSCC(29,5), TERM1(10,11), TERMA(11),
X TERMB(11), TERMC(11), TIP(32), TITLE(12),
X TC(32,11), TSTAT(11), U(32,11), W(11),
X X(32)
COMMON /SCALER/ A, AA, A10A0, A202A0, A3C3A0, A404A0,
X A505A0, B, BB, CC, CF, CMEAN, CMEANP, CUINTG,
X CPI2, CPI3, CPI4, CPI5, CPI6, CPO2, CPC3, CPO4,
X CPO5, CAMP, DCP, DD, DIFCM, DT, DUMMY, CRAS1,
X G, GASK, GJ, GR, GR2, JOULE, MAPR, MOLEWT,
X PCCO, C, RFM, TCP, TERMD, TESTBH, TESTOS, TESTMS,
X TCCO, TOL, TOLAT, TOLB2, TOLMIN, TOLMS, TOLTIP, TULCP,
X TOLCX, TOLR, TCTINT, TOTPR, V, VMI
COMMON /INTEGR/ I, IB, IB1, IDUMP, IERRCR, IFIRST,
X IG, ICUTTR, IPASS, IS, IT, J, JIN, JJ,
X JM, JMI, K, K1, KK, L, LIMIT, LSTAGE,
X MSTAGE, NLINES, NTUBES, NX, NX1, YES
EQUIVALENCE (ATAR(1,1), ATAS(1,1)), (FLOW(1), DFLOW(1))
THERM3= CFCG(1)*ALOG(T)+(CPCO(2)+(CPO2+(CPO3+(CPL4+CPO5*T)*T)*T)
X *T)*T
RETURN
END

```

12/15/67

THERP. - EFN SOURCE STATEMENT - IFN(S) -

SUBROUTINE THERMP

C
C
C

*** CALCULATE SPECIFIC HEAT AT CONSTANT PRESSURE (CP) AS A
FUNCTION BEING A FIFTH DEGREE POLYNOMIAL. THEN THE
CONTINUITY

REAL MACH, MAPR, MOLEWT, JOULE
DIMENSION ATAS(29,11), FLOW(32)
LOGICAL IERROR, YES

COMMON /MATRIX/ ALPHA(10,11), ATAR(29,11), B2(29),
X BETA(10,11), BH(32), BLADE(29), BT(32),
X CC(10,11), CP(32,11), CPCO(6), CR(32,11),
X CSLOPE(10,11), CU2(11), CU(32,11), CUCO(29,5),
X CX(32,11), CXM(10,11), CXNEW(10,11), CXRATU(29),
X CXS(10,11), DA(10), DELM(11), DEPV(10,11),
X DF(20), DFACT(29,11), DFL(29), DFLOW(32),
X EMACH(29,11), FOUNO(20,3,10), FRDEL(10,11), GAMMA(32,11),
X HMN(29), HUB(32), IKK(10), MACH(29,11),
X OEAR(29,11), PO(32,11), R(32,11), RCURVE(10,11),
X RH(32), RHO(32,11), RINT(11), RCSTAG(11),
X KS(32), RSLOPE(10,11), RTRAIL(11), SCCO(29,5),
X SOLID(29,11), SSCO(29,5), TERM1(10,11), TERMA(11),
X TERMB(11), TERMC(11), TIP(32), TITLE(12),
X TO(32,11), TSTAT(11), U(32,11), W(11),
X X(32)
COMMON /SCALER/ A, AA, A10A0, A202A0, A303A0, A404A0,
X A505A0, B, BB, CC, CM, CMEAN, CMEANP, CUINTG,
X CPI2, CPI3, CPI4, CPI5, CPI6, CPC2, CPO3, CPO4,
X CPO5, DAMP, DCP, DD, DIFCM, DT, DUMMY, ERAS1,
X G, GASK, GJ, GR, GR2, JOULE, MAPR, MOLEWT,
X PUCO, Q, RPM, TLP, TERMD, TESTBH, TESTDS, TESTMS,
X TGOO, TOL, TOLAT, TOLB2, TOLMIN, TOLMS, TOLTIP, TULCP,
X TOLCX, TOLR, TOTINT, TOTPR, V, VMI
COMMON /INTEGR/ I, IB, IB1, IDUMP, IERROR, IFIRST,
X IG, ICUTTR, IPASS, IS, IT, J, JIN, JJ,
X JM, JPI, K, KI, KK, L, LIMIT, LSTAGE,
X MSTAGE, NLINES, NTUBES, NX, NX1, YES
EQUIVALENCE (ATAR(1,1), ATAS(1,1)), (FLOW(1), DFLOW(1))
CP(I,J)= CPCO(1)+(CPCO(2)+(CPCO(3)+(CPCO(4)+(CPCO(5)+CPCO(6)*
X TC(I,J))*TO(I,J))*TC(I,J))*TO(I,J))*TO(I,J)
CV= CP(I,J) - DCP
GAMMA(I,J)=CP(I,J)/CV
RETURN
END

THER4213
THER4214
THER4215
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THER4256
THER4257

12/15/67

SUBROUTINE XDERIV(Y,DYDX,D2YD2X)

*** CALCULATE THE FIRST AND SECOND DERIVATIVE OF Y
WITH RESPECT TO X (AXIAL LENGTH)

DIMENSION Y(32,11),DYDX(10,11),D2YD2X(10,11)

REAL MACH, MAPR, MOLEWT, JOULE

DIMENSION ATAS(25,11), FLOW(32)

LOGICAL IERROR, YES

COMMON /MATRIX/	ALPHA(10,11),	ATAR(29,11),	B2(29),
X BETA(10,11),	BH(32),	BLADE(29),	BT(32),
X CD(10,11),	CP(32,11),	CPCG(6),	CR(32,11),
X CSLGPE(10,11),	CU2(11),	CU(32,11),	CUCO(29,5),
X CX(32,11),	CXM(10,11),	CXNEW(10,11),	CXRATG(29),
X CXS(10,11),	DA(10),	DELM(11),	DEPV(10,11),
X DF(20),	DFACT(29,11),	DFL(29),	DFLOW(32),
X EMACH(29,11),	FDOUD(20,3,10),	FROEL(10,11),	GAMMA(32,11),
X HMN(29),	HUB(32),	IKK(10),	MACH(29,11),
X GEAR(29,11),	PC(32,11),	R(32,11),	RCURVE(10,11),
X RH(32),	RHO(32,11),	RINT(11),	RESTAG(11),
X RS(32),	RSLOPE(10,11),	RTRAIL(11),	SCCO(29,5),
X SOLID(29,11),	SSCO(29,5),	TERM1(10,11),	TERMA(11),
X TERMB(11),	TERMC(11),	TIP(32),	TITLE(12),
X TO(32,11),	TSTAT(11),	U(32,11),	W(11),
X X(32)			

COMMON /SCALER/	A,	AA,	A1CA0,	A202A0,	A303A0,	A404A0,
X A505A0,	B,	BB,	CC,	CM,	CMEAN,	CMEANP,
X CPI2,	CPI3,	CPI4,	CPI5,	CPI6,	CPO2,	CPO3,
X CPO5,	DAMP,	DCP,	DD,	DIFCM,	DT,	DUMMY,
X G,	GASK,	GJ,	GR,	GR2,	JOULE,	MAPR,
X POCO,	C,	KPM,	TCP,	TERMD,	TESTBH,	TESTUS,
X TOCO,	TOL,	TOLAT,	TOLB2,	TOLMIN,	TOLMS,	TOLCIP,
X TOLCX,	TOLR,	TOTINT,	TOTPR,	V,	VMI	
COMMON /INTEGR/	I,	IB,	IB1,	IDUMP,	IERROR,	IFIRST,
X IG,	IOUTTR,	IPASS,	IS,	IT,	J,	JIN,
X JM,	JM1,	K,	K1,	KK,	L,	LIMIT,
X MSTAGE,	NLINES,	NTUBES,	NX,	NX1,	YES	

EQUIVALENCE (ATAR(1,1), ATAS(1,1)), (FLOW(1), DFLOW(1))

DYDX(10,J)=0.0

D2YD2X(10,J)=0.0

L=1

3 DO 5 I=1B1,NX1

L=L+1

AA=(Y(I-1,J)-Y(I,J))/(X(I-1)-X(I))

BB=(Y(I+1,J)-Y(I,J))/(X(I+1)-X(I))

DYDX(L,J)=(Y(I+1,J)-Y(I-1,J))/(X(I+1)-X(I-1))

5 D2YD2X(L,J)=(AA-BB)/(X(I-1)-X(I+1))*2.0

6 RETURN

END

APPENDIX C

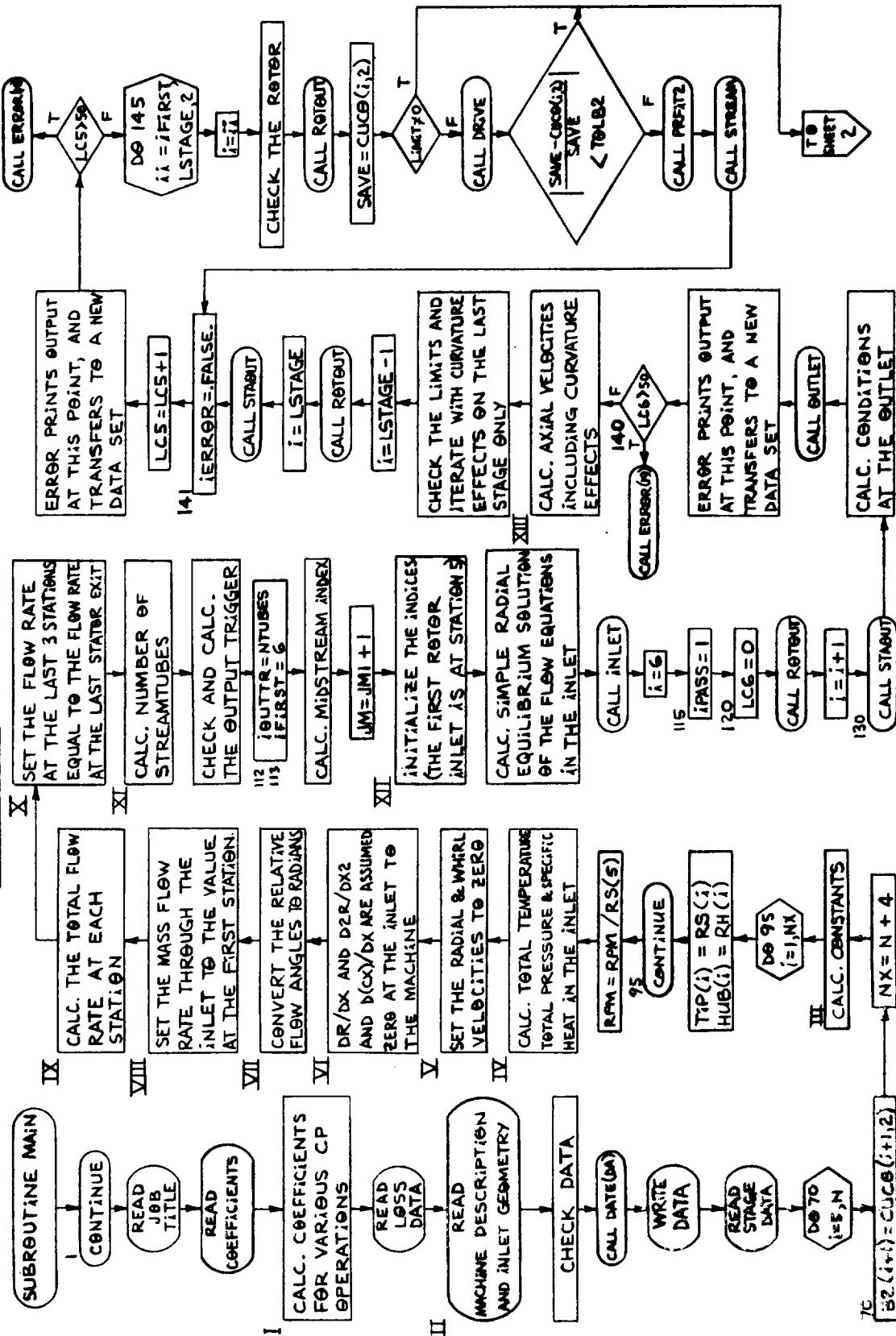
PROGRAM FLOW CHARTS

INDEX

<u>Subroutine</u>	<u>Page</u>
MAIN	C-1
ANEXIT	C-6
B2CAL	C-7
B2CAL1	C-8
B2CAL2	C-9
B2CAL3	C-10
CAXIAL	C-11
COPY	C-15
DATA	C-16
DATAL	C-17
DRIVE	C-18
ENTALP	C-19
GAM	C-20
INEST	C-21
INLET	C-23
INTEG	C-24
LOSE	C-25
LOSS	C-27
MOVE	C-34
OUTLET	C-35
OUTPUT	C-36
PRFIT2	C-43
ROTOU	C-44
RSTART	C-46
SHOCK	C-47
SLINE	C-48
STAOUT	C-49
STREAM	C-50
THERM1	C-51
THERM2	C-52
THERM3	C-53
THERMP	C-54
XDERIV	C-55

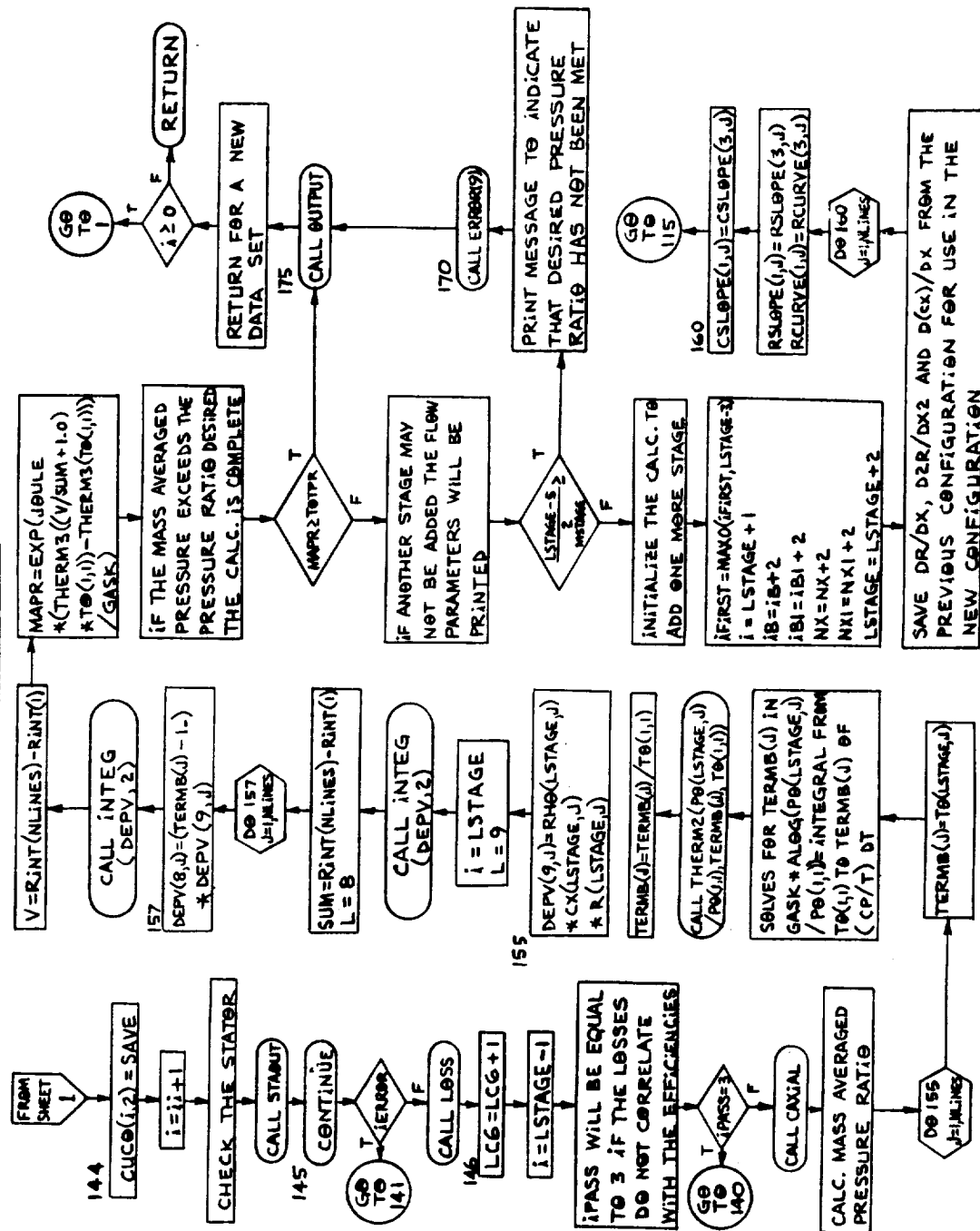
N 35 MAIN S.R.

SHEET 1 OF 5



N 35 MAIN S.R.

SHEET 2 OF 5



N 35 MAIN S.R.

SHEET 3 OF 5

- I
- $$\begin{aligned} CP02 &= CPC0(3)/2. \\ CP03 &= CPC0(4)/3. \\ CP04 &= CPC0(5)/4. \\ CP05 &= CPC0(6)/5. \\ A10A0 &= CPC0(2)/CPC0(1) \\ A202A0 &= CP02/CPC0(1) \\ A303A0 &= CP03/CPC0(1) \\ A404A0 &= CP04/CPC0(1) \\ A505A0 &= CP05/CPC0(1) \\ C0INTG &= THERM3(518.688) \\ CPi2 &= CPC0(2)/2. \\ CPi3 &= CPC0(3)/3. \\ CPi4 &= CPC0(4)/4. \\ CPi5 &= CPC0(5)/5. \\ CPi6 &= CPC0(6)/6. \end{aligned}$$
- II SEE SAMPLE DATA SHEETS FOR INPUT
- III
- $$\begin{aligned} GASK &= G/MOLEWT \\ DCP &= GASK/J0ULE \\ GR &= 64.348 * GASK \\ GR2 &= GR * .5 \end{aligned}$$
- IV
- $$\begin{aligned} i &= 1 \\ j &= 1 \\ T0(i,j) &= T0C0 \\ CALL THERMP \\ DO 101 j=1,NLINES \\ DO 99 i=1,5 \\ Te(i,j) &= T0C0 \\ P0(i,j) &= P0C0 \\ CP(i,j) &= CP(1,1) \\ 99 \text{ GAMMA}(i,j) &= \text{GAMMA}(1,1) \end{aligned}$$

N 35 MAIN S.R.
SHEET 4 OF 5

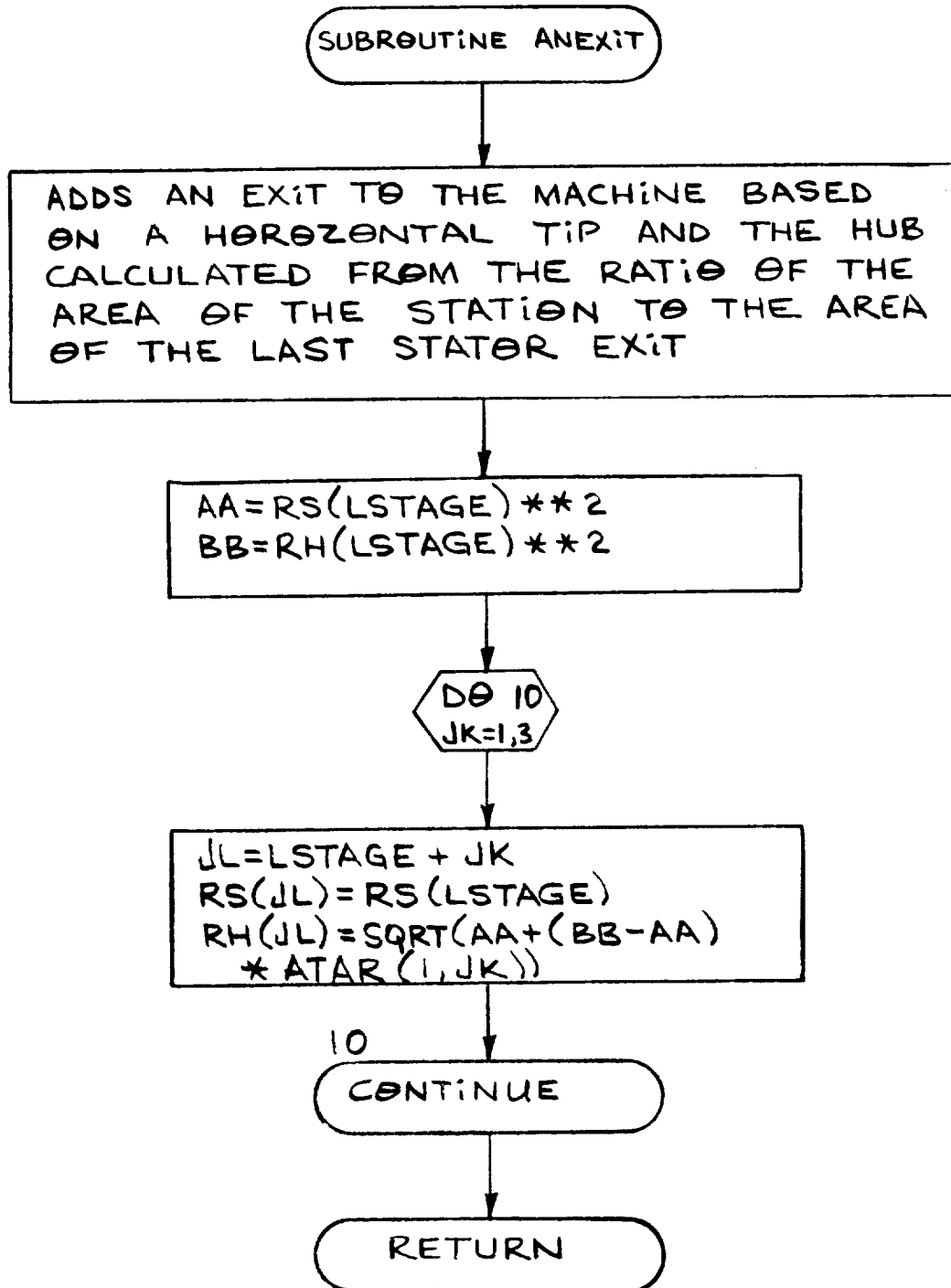
- V DO 100 I=1,NX
 CU(I,J)=0.0
100 CR(I,J)=0.0
 ATAR(6,J)=0.9
 ATAR(7,J)=0.89
- VI RSLØPE(I,J)=0.0
 RCURVE(I,J)=0.0
101 CSLØPE(I,J)=0.0
- VII DO 106 I=7,NX,2
106 HMN(I)=HMN(I)/57.2957795
- VIII FLOW(2)=FLOW(I)
 FLOW(3)=FLOW(I)
 FLOW(4)=FLOW(I)
 FLOW(5)=FLOW(I)
- IX DO 110 I=5,N
110 FLOW(I+1)=FLOW(I)+DFLOW(I+1)
- X FLOW(N+2)=FLOW(N+1)
 FLOW(N+3)=FLOW(N+1)
 FLOW(N+4)=FLOW(N+1)
- XI NTUBES=NLINES-1
 JMI=NLINES/2
- XII L=1
 IB=1
 IPASS=1
 IB1=2
 LSTAGE=7
 NX1=9
 NX=10

N 35 MAIN S.R.

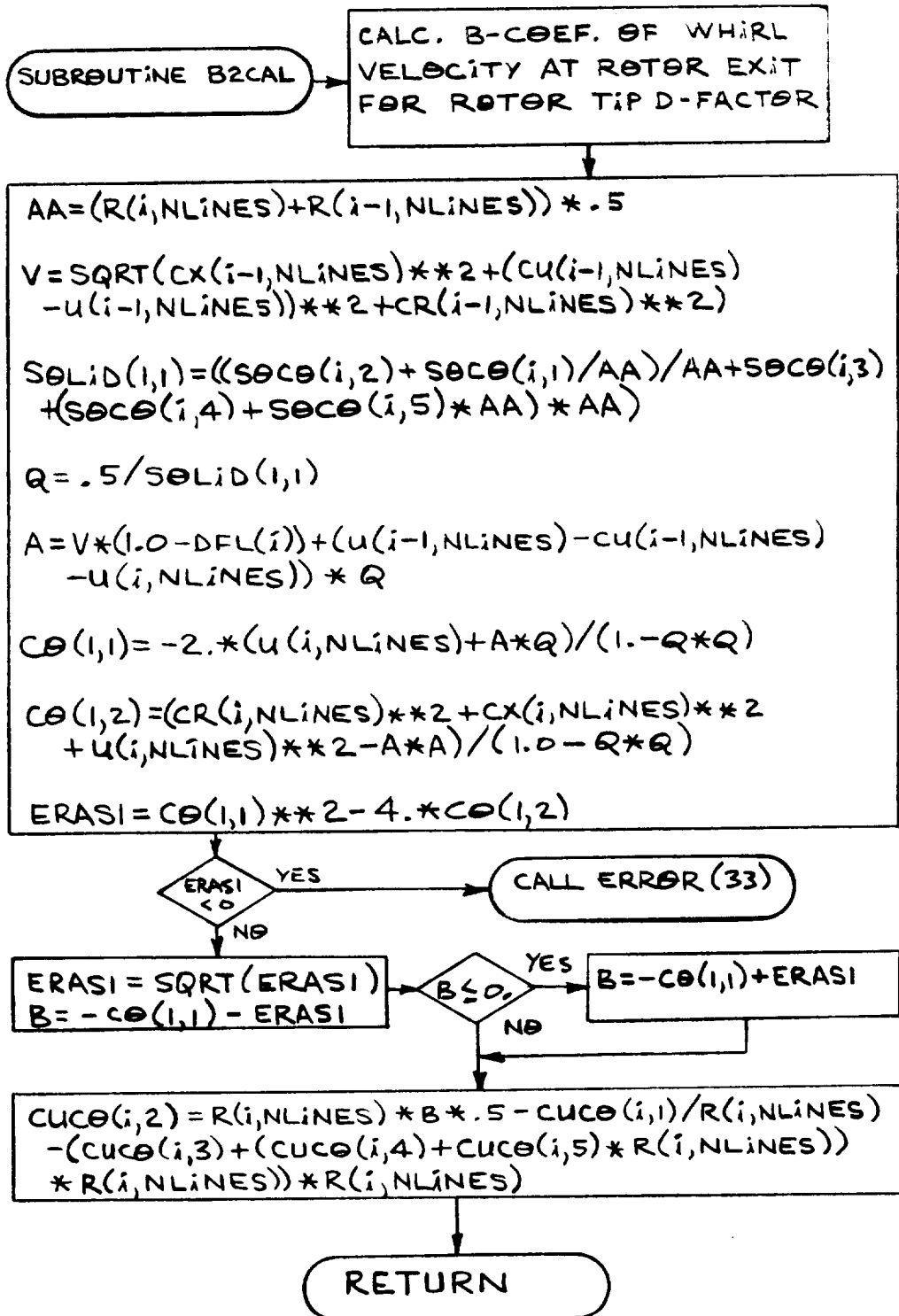
SHEET 5 OF 5

XIII 142 CALL CAXIAL
LC5 = 0
iPASS = 2
L = 1

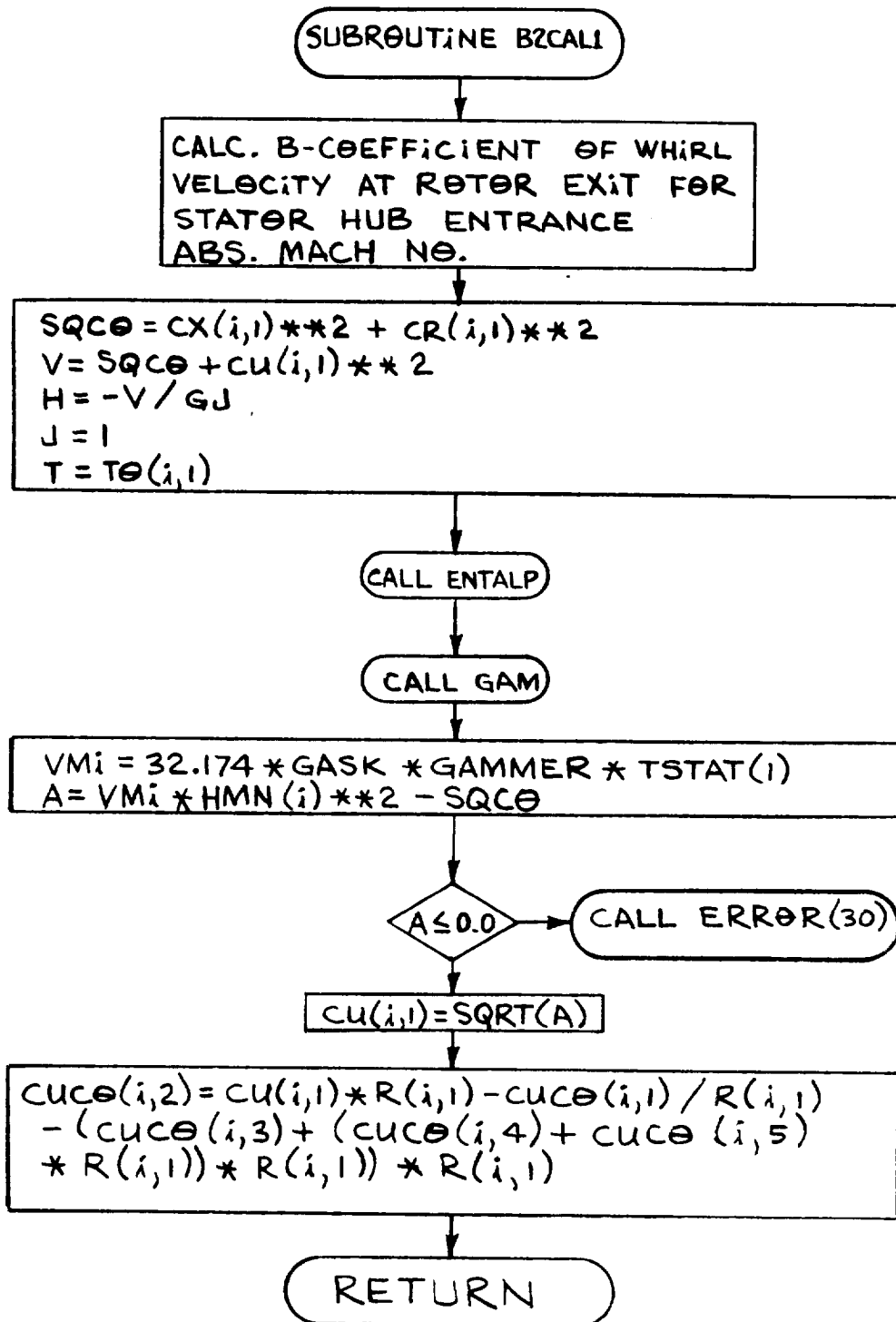
N35 AN EXIT S.R.



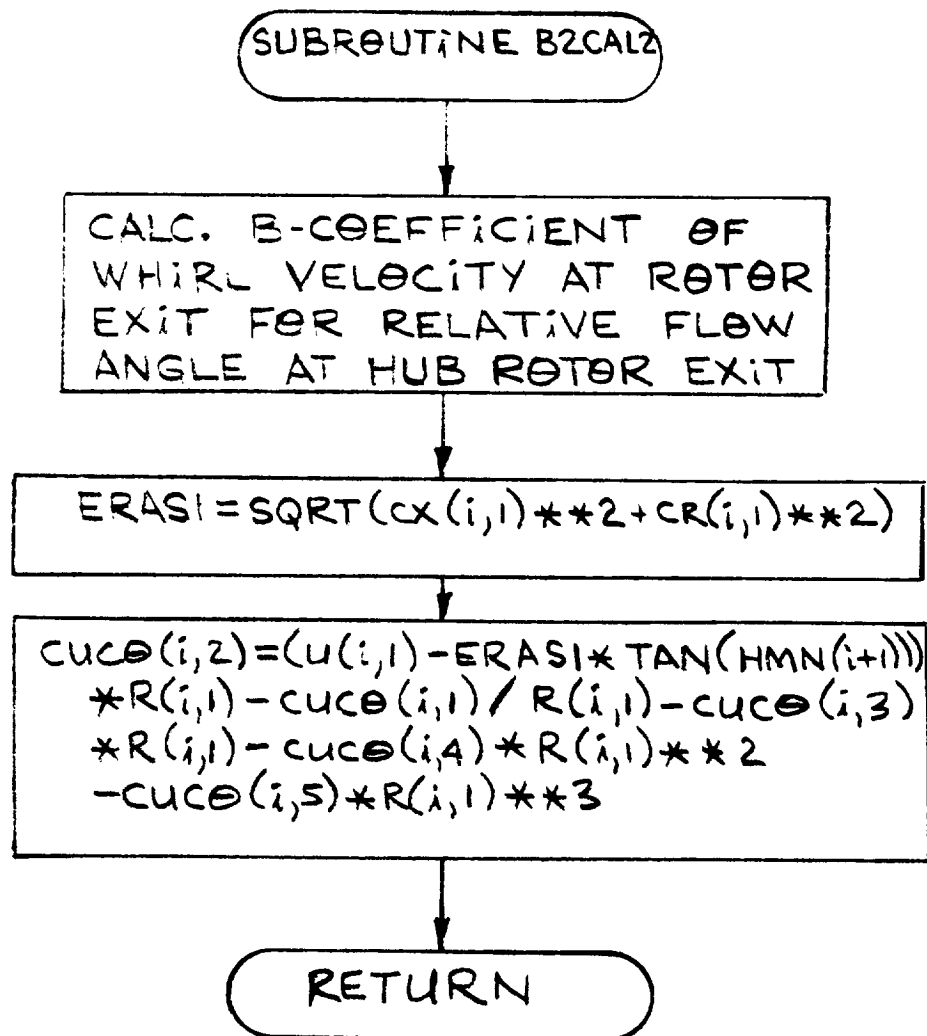
N 35 B2CAL S.R.



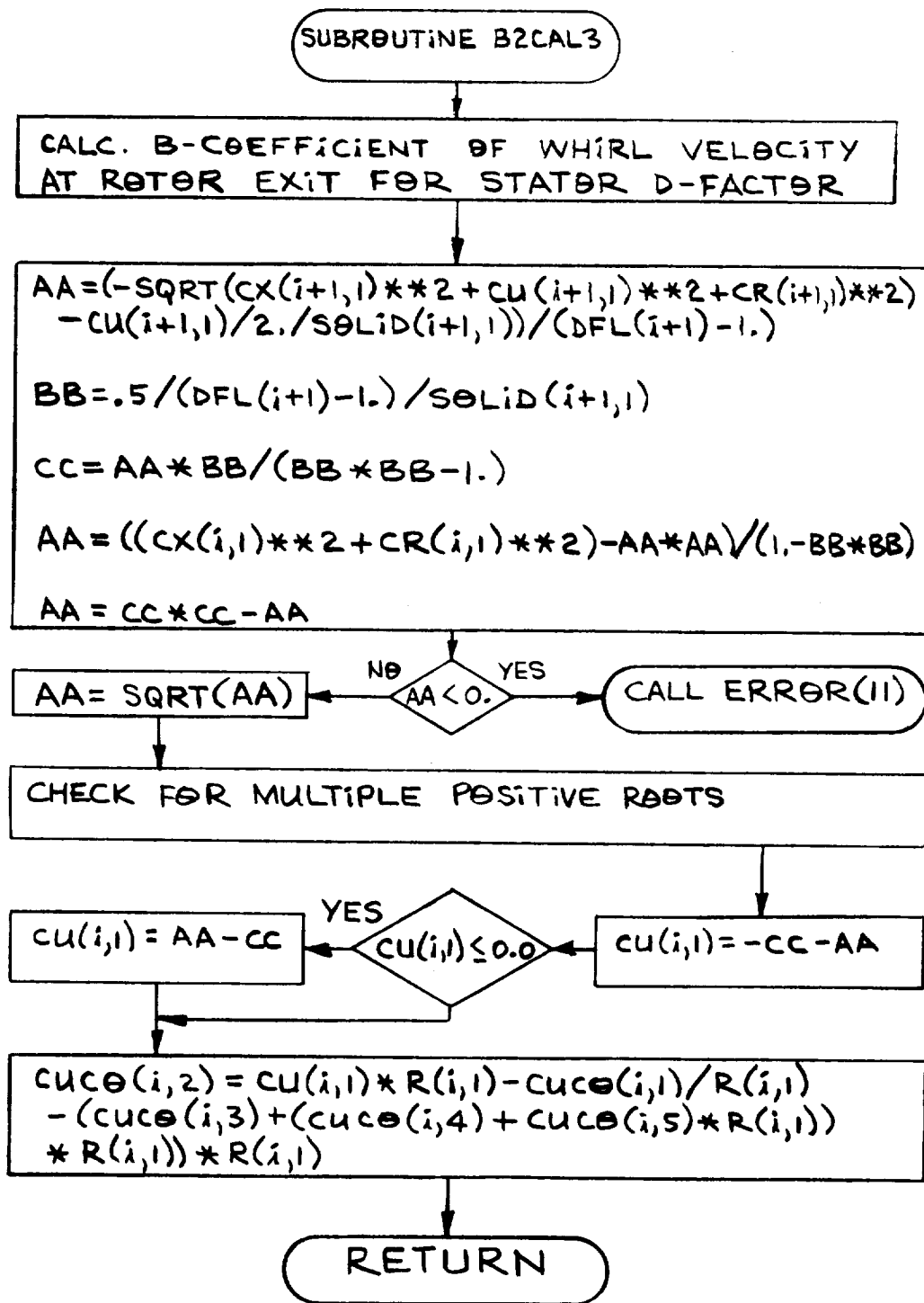
N35 B2CAL1 S.R.



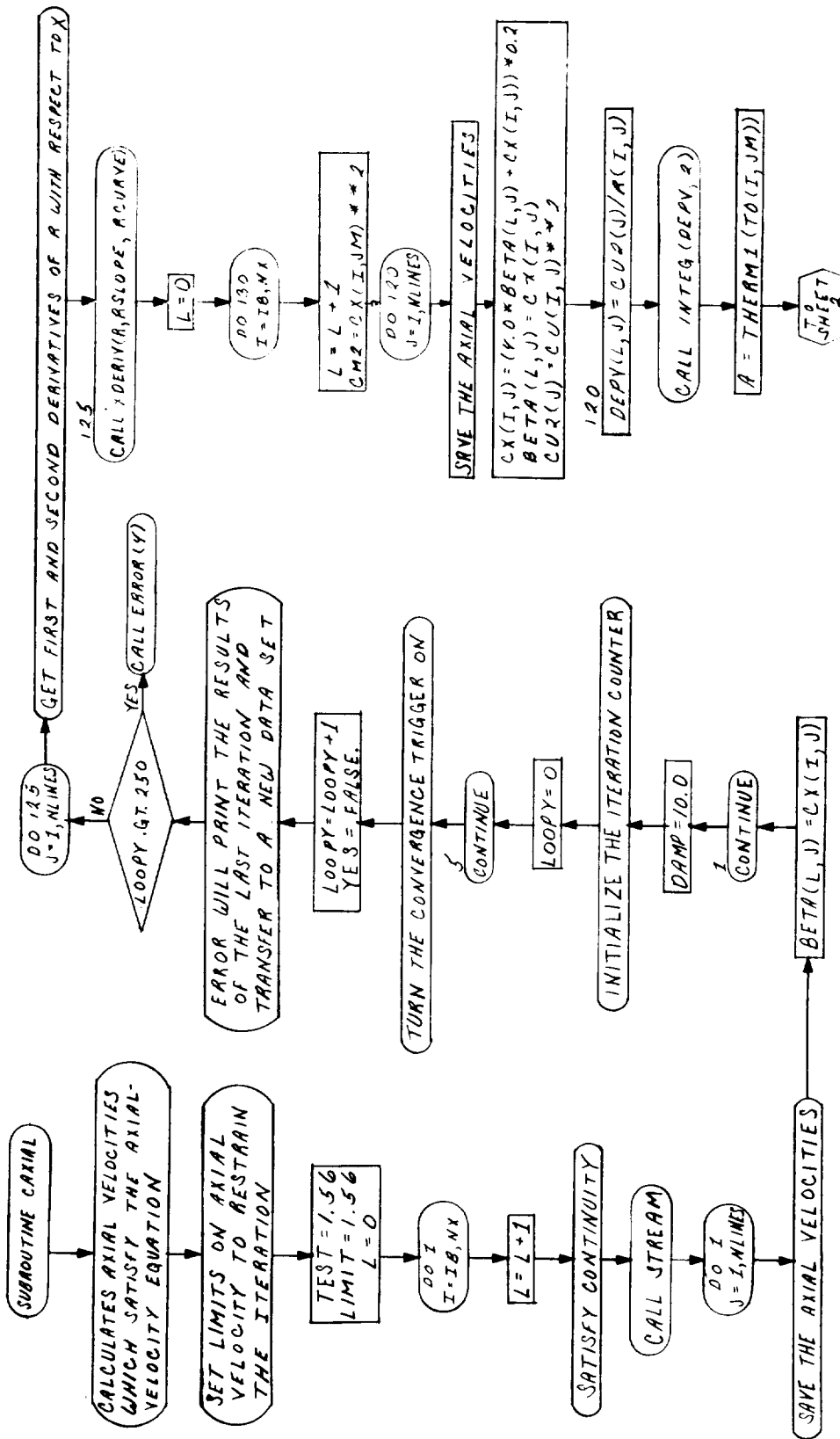
N 35 B2CAL2 S.R.



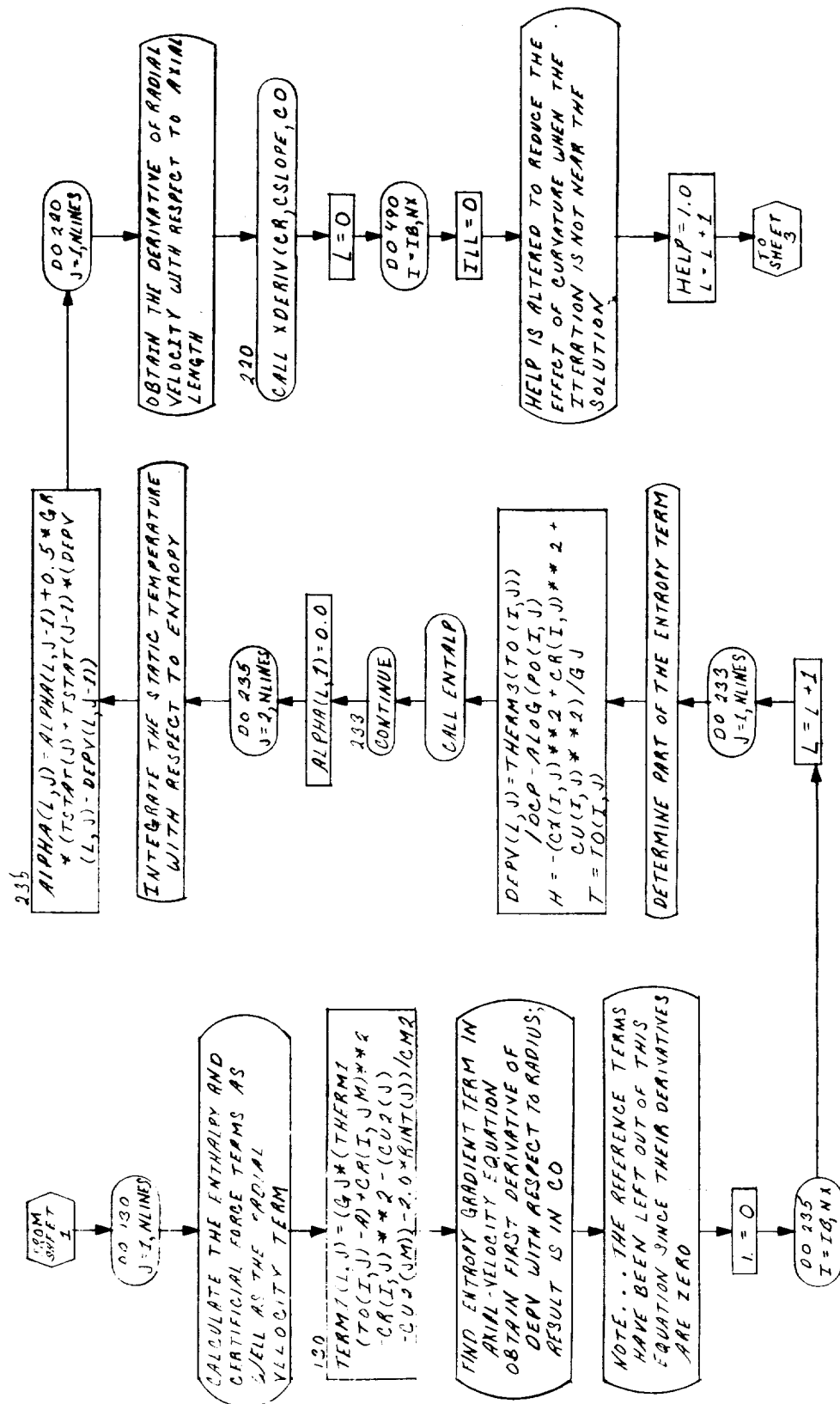
N 35 B2CAL3 S.R.

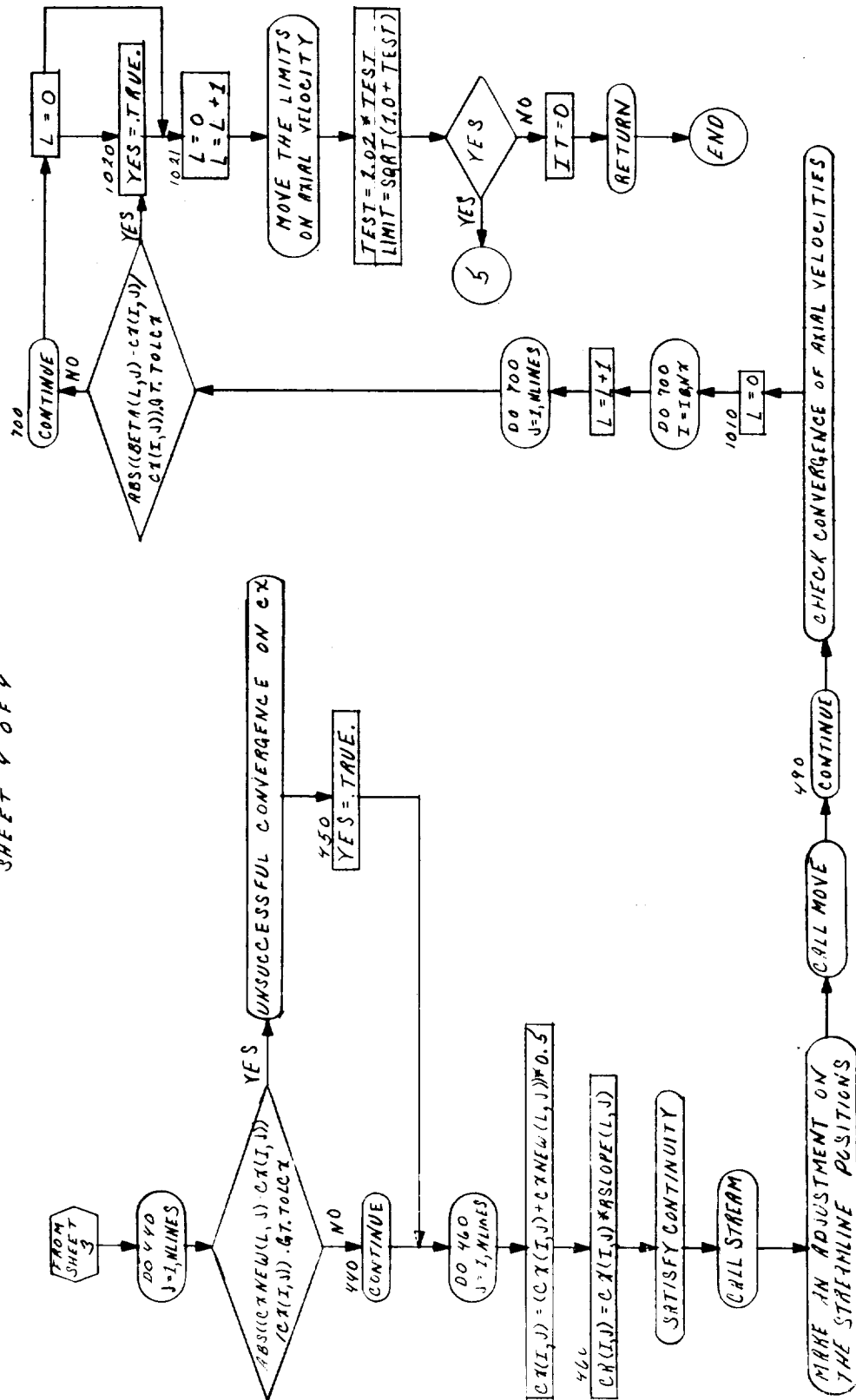


CAXIAL
SHEET 1 OF 4

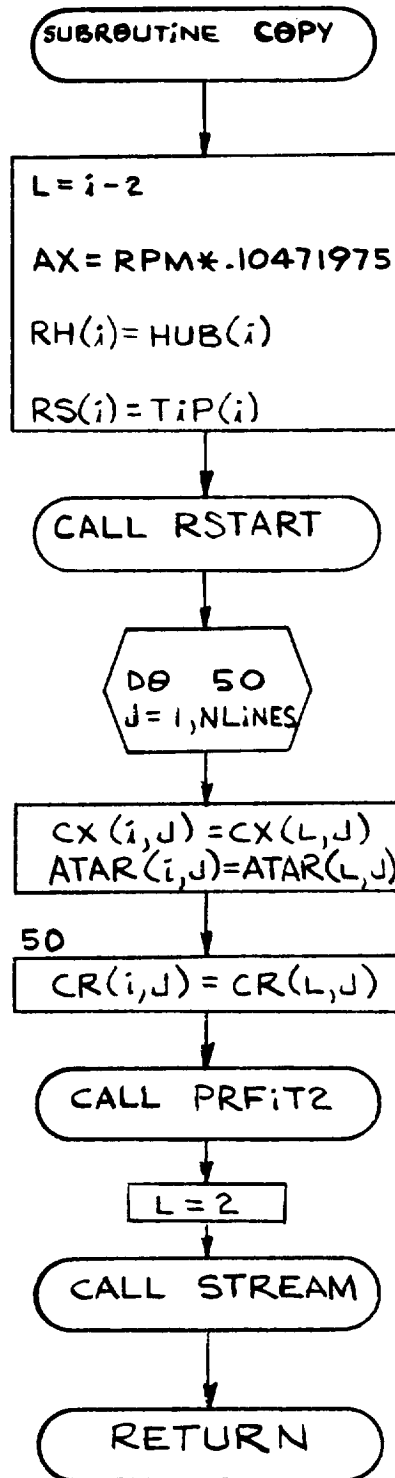


CAXIAL
SHEET 2 OF 4





N 35 COPY S.R.

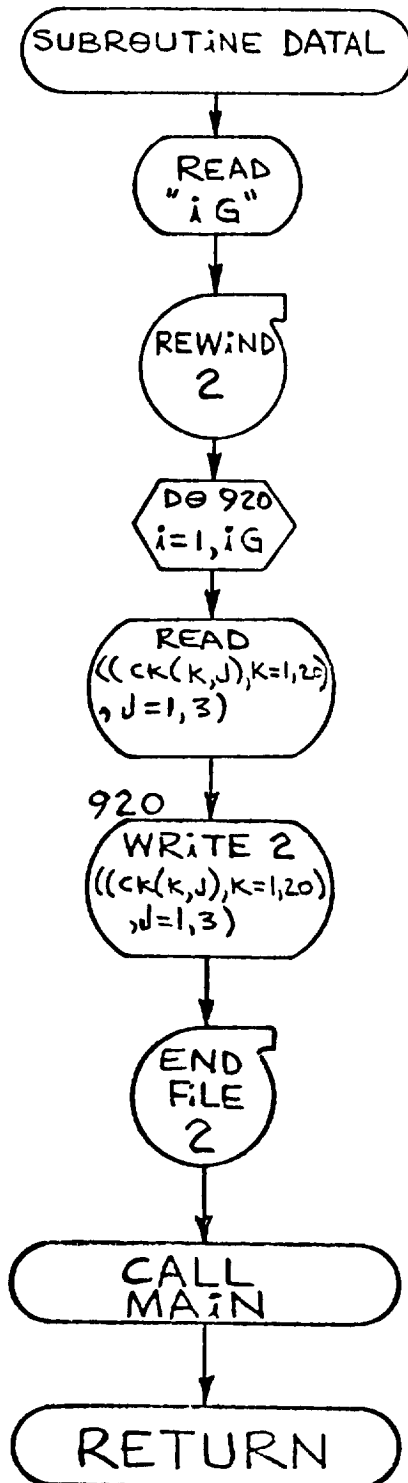


N 35 DATA S.R.

BLOCK DATA

DATA G, GJ, JOULE / 1545.44, 50070.466, 778.12 /
DATA (DF(i), i=1,20) / 0.0, .1, .15, .2, .25, .3, .35, .4,
.45, .5, .55, .6, .65, .7, .75, .8, .85, .9, .95, 1.0 /

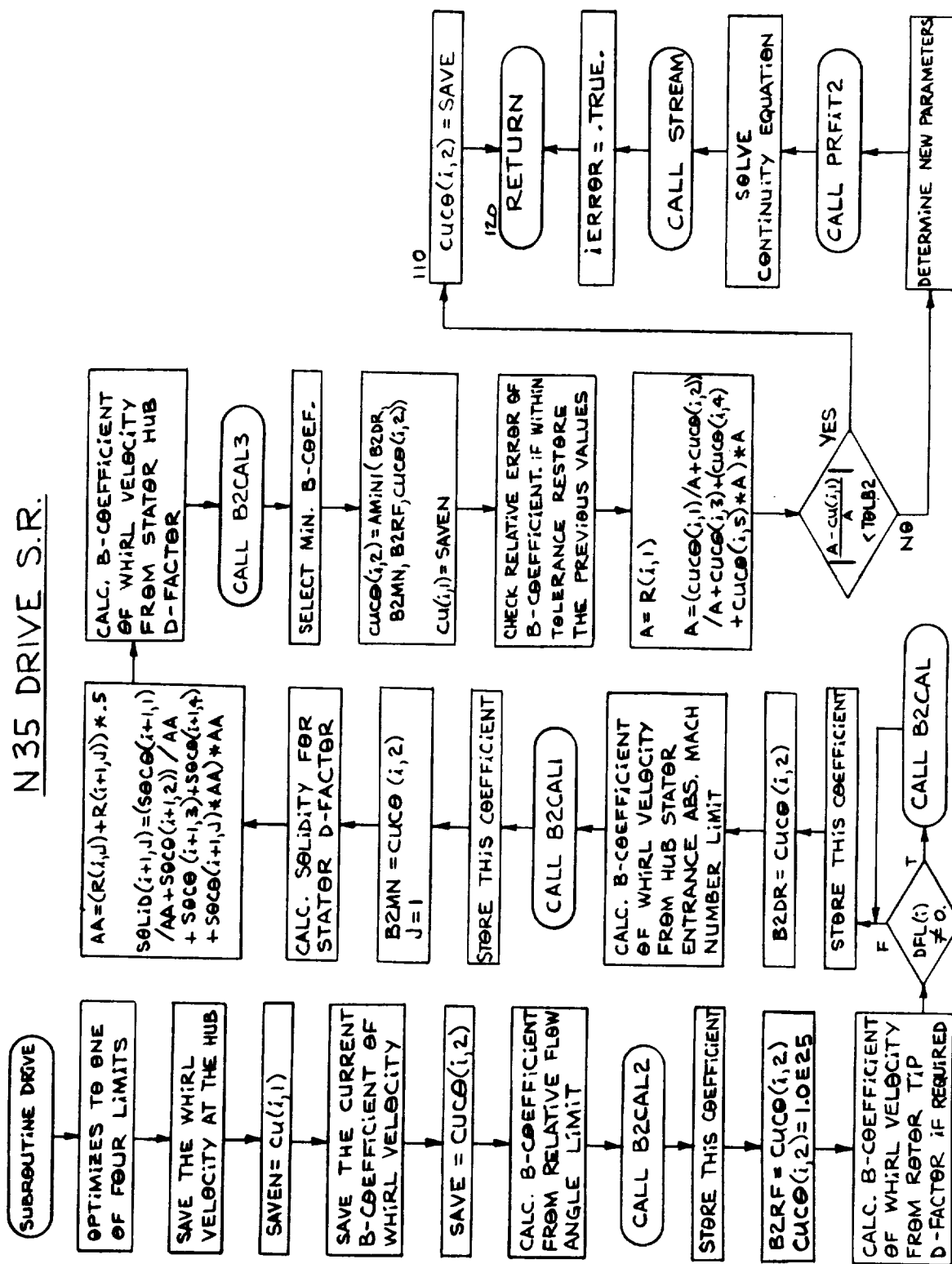
N 35 DATAL S.R.



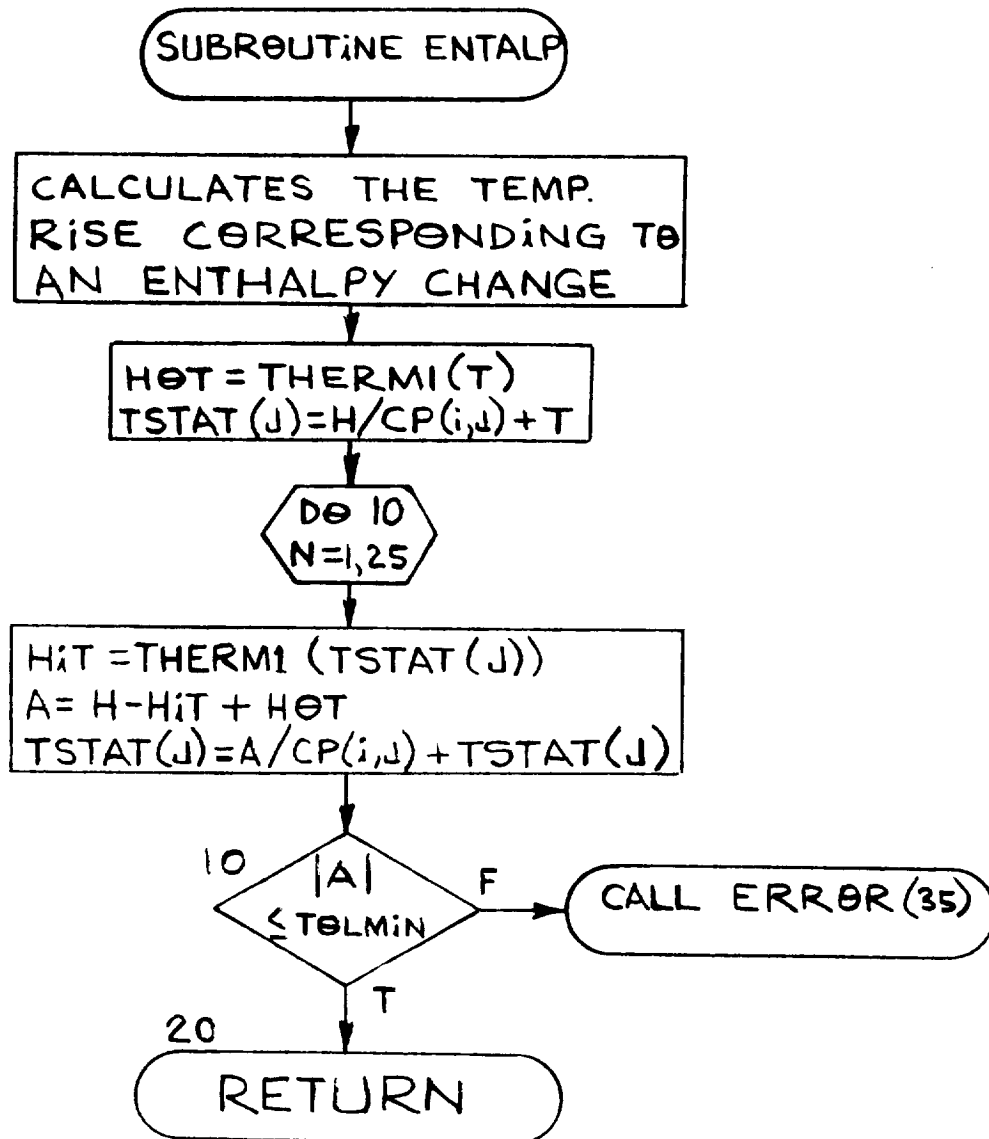
PREPARES A MASTER TAPE
OF LOSS DATA.

IF A PERMANENT FILE IS
USED, THIS ROUTINE IS TO
BE DISCARDED (THE
\$ENTRY MUST ALSO BE
CHANGED.)

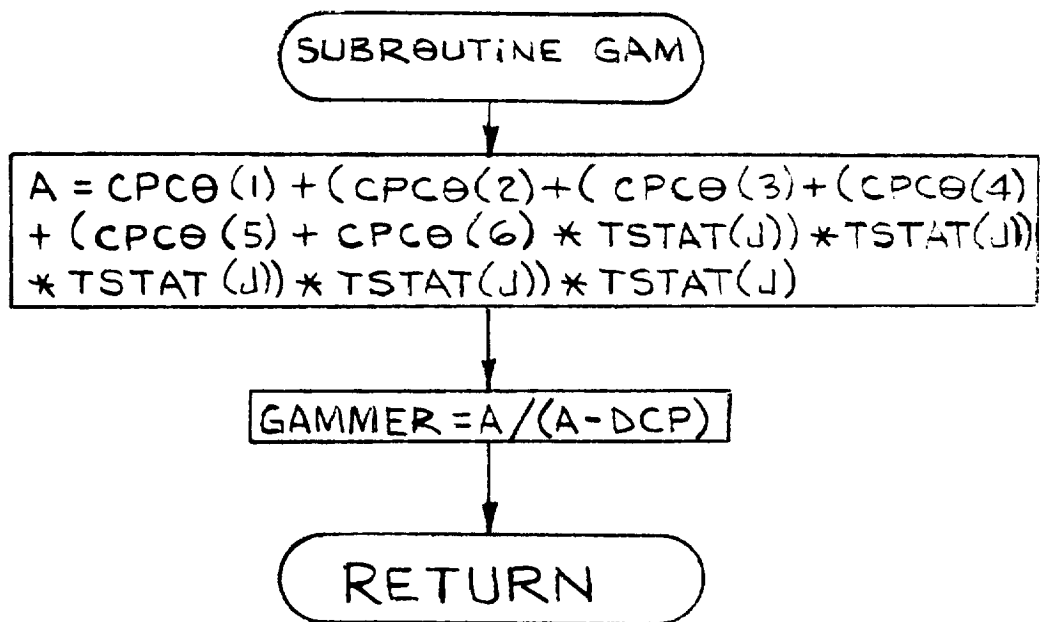
N35 DRIVE S.R.



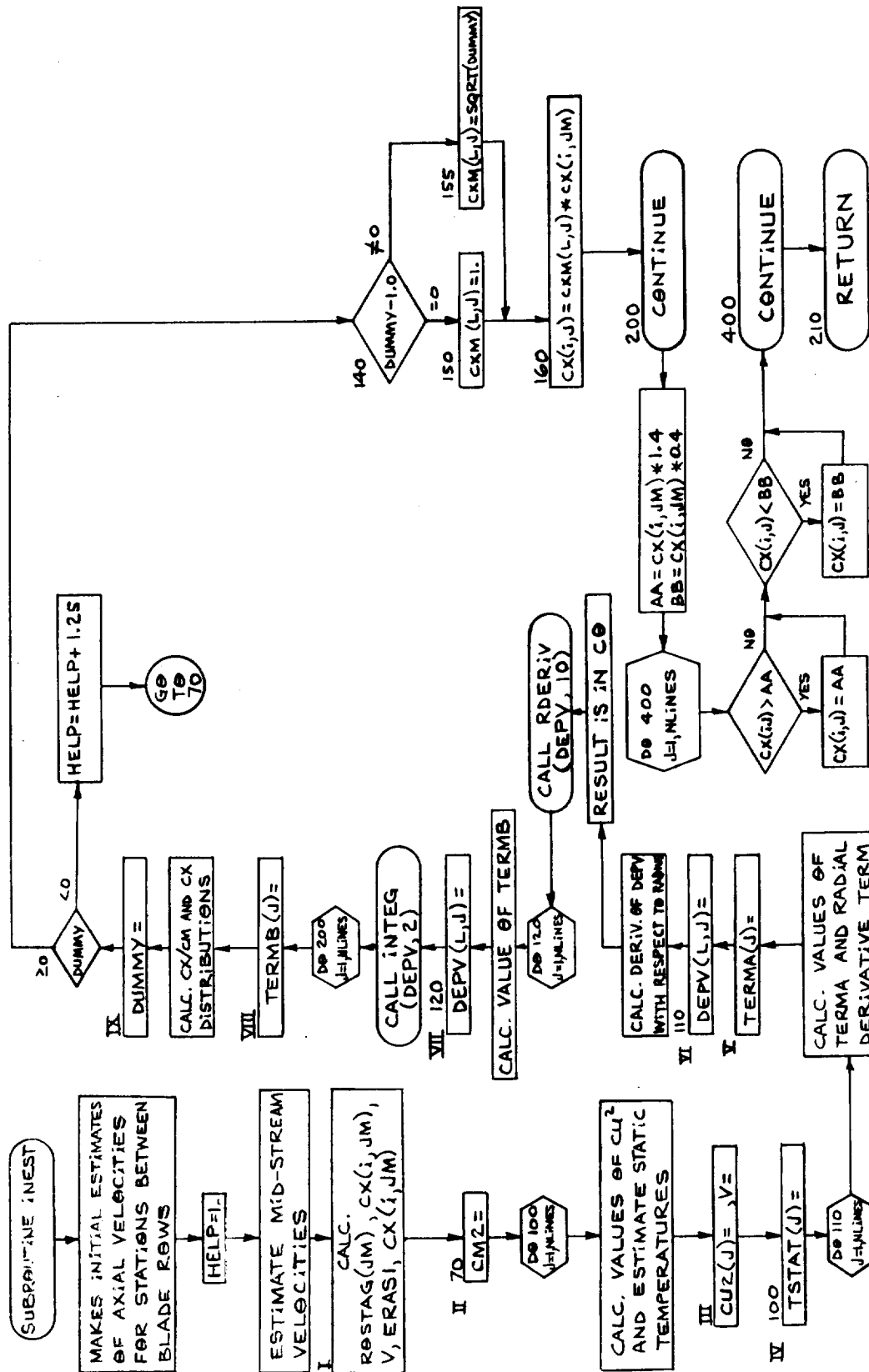
N 35 ENTALP S.R.



N 35 GAM S.R.



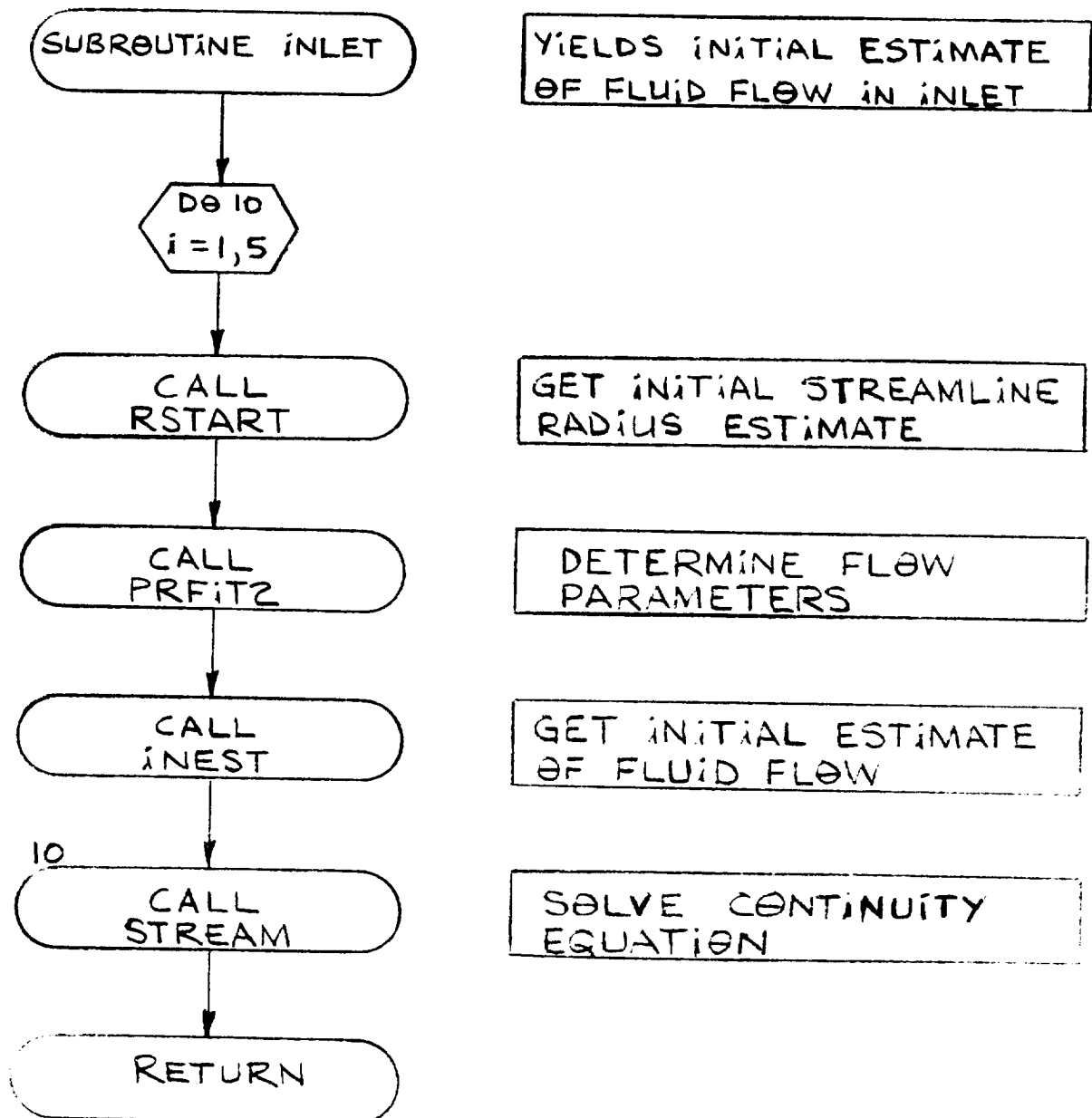
N 35 INEST S.R.
SHEET 1 OF 2



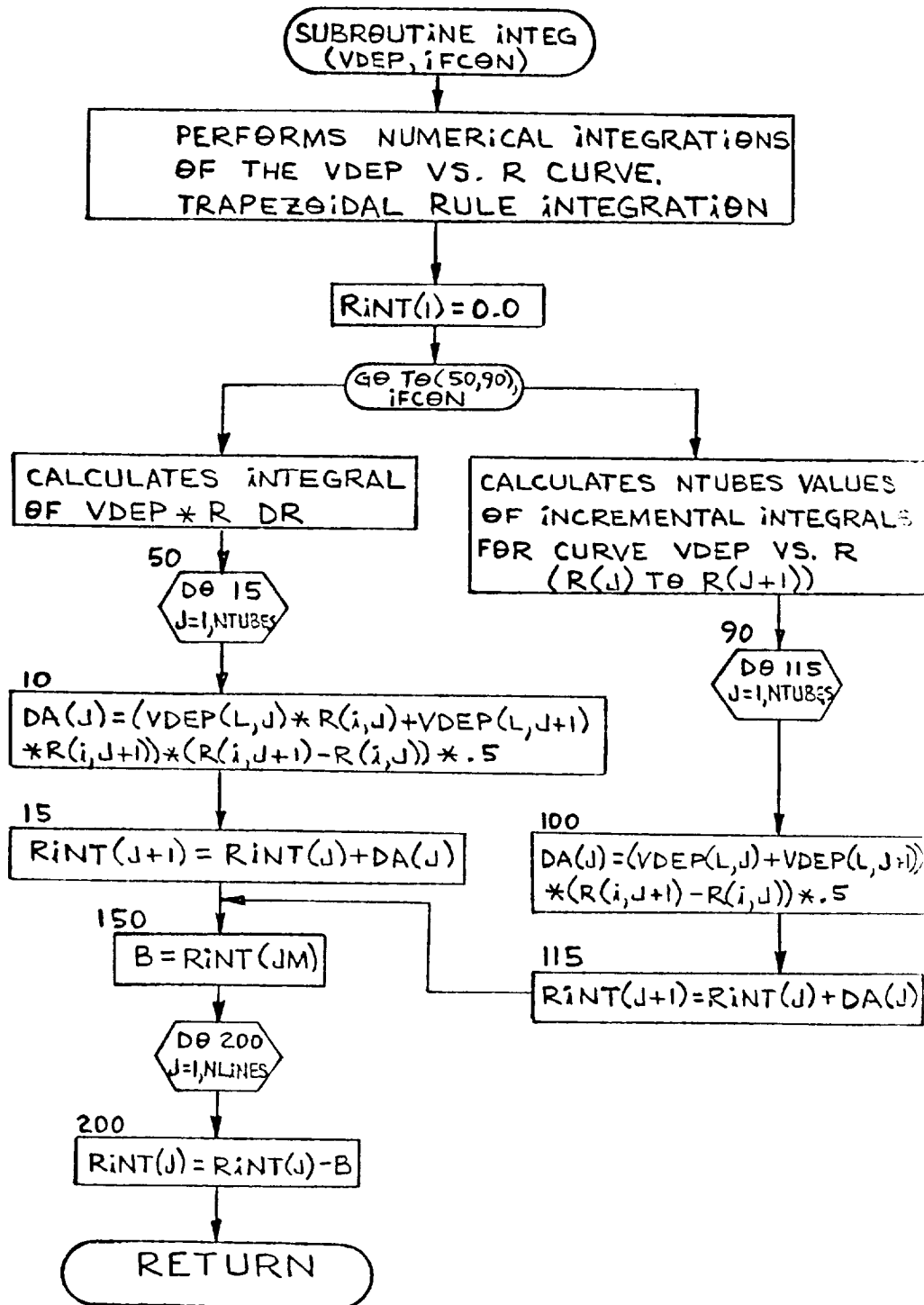
N 35 INEST S.R.
SHEET 2 OF 2

- I $R\theta STAG(JM) = P\theta(i, JM) / (T\theta(i, JM) * GASK)$
 $CX(i, JM) = FLOW(i) / (R\theta STAG(JM) * (RS(i) ** 2 - RH(i) ** 2)) / 3.1415927$
 $V = (CX(i, JM) ** 2 + CU(i, JM) ** 2) / GJ / CP(i, JM)$
 $ERASI = 1.0 - V / T\theta(i, JM)$
 $CX(i, JM) = CX(i, JM) / (ERASI ** (1. / (GAMMA(i, JM) - 1.)))$
- II $CM2 = CX(i, JM) ** 2 * HELP$
- III $CU2(J) = CU(i, J) ** 2$
 $V = (CM2 + CU2(J)) / GJ / CP(i, J)$
- IV $TSTAT(J) = T\theta(i, J) - V$
- V $TERMA(J) = GJ * (CP(i, J) * T\theta(i, J) - CP(i, JM) * T\theta(i, JM)) - (CU2(J) - CU2(JM))$
- VI $DEPV(L, J) = ALOG((T\theta(i, J) ** (GAMMA(i, J) / (GAMMA(i, J) - 1.))) / P\theta(i, J))$
- VII $DEPV(L, J) = CU2(J) / R(i, J) + GR2 * TSTAT(J) * C\theta(L, J)$
- VIII $TERMB(J) = 2.0 * RINT(J)$
- IX $DUMMY = ((TERMA(J) - TERMB(J)) / CM2) + 1.0$
- X $CX(i, JM) = CX(i, JM) * 1.1$
 $JJK = JJK + 1$

N 35 INLET S.R.

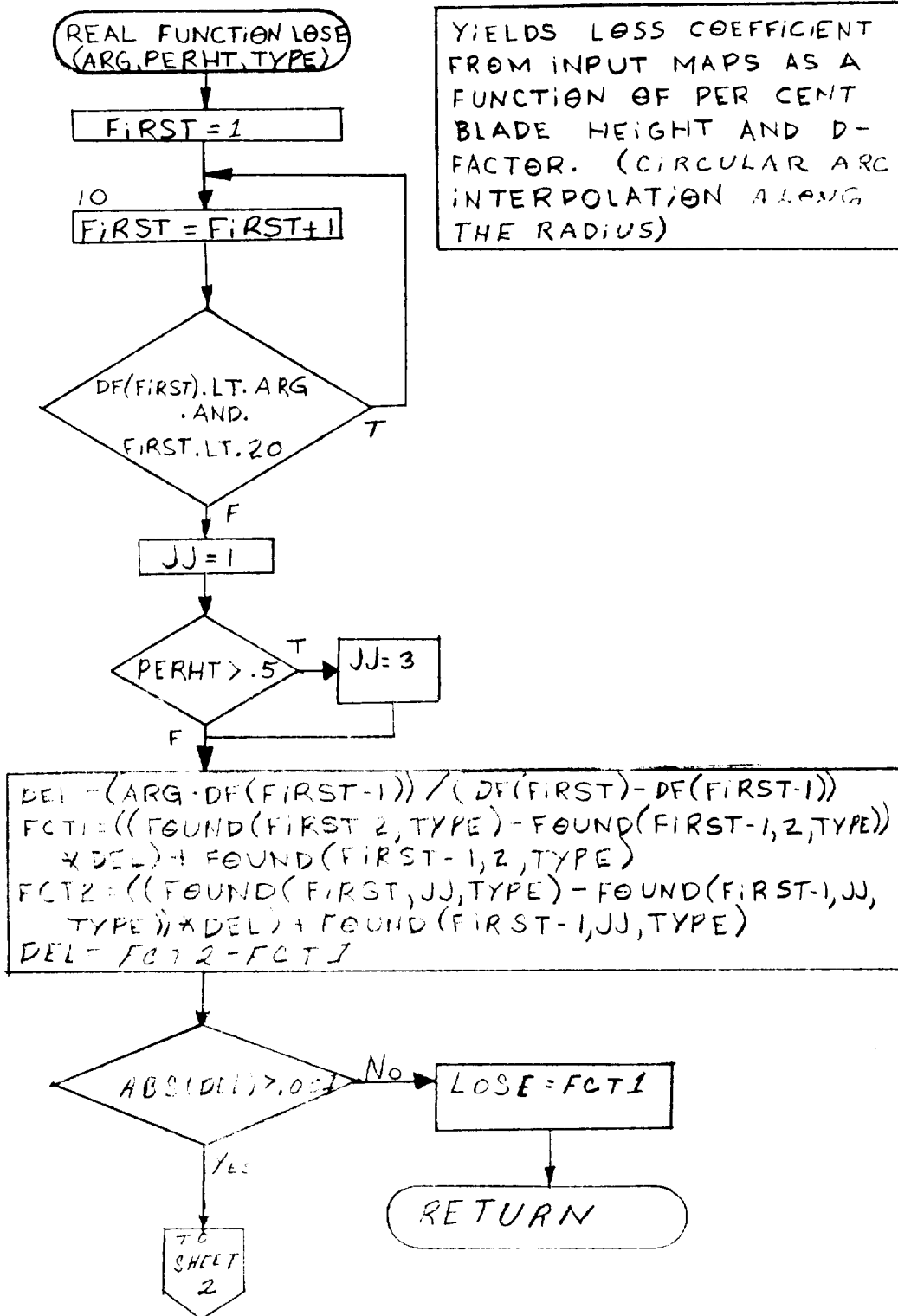


N35 INTEG S.R.



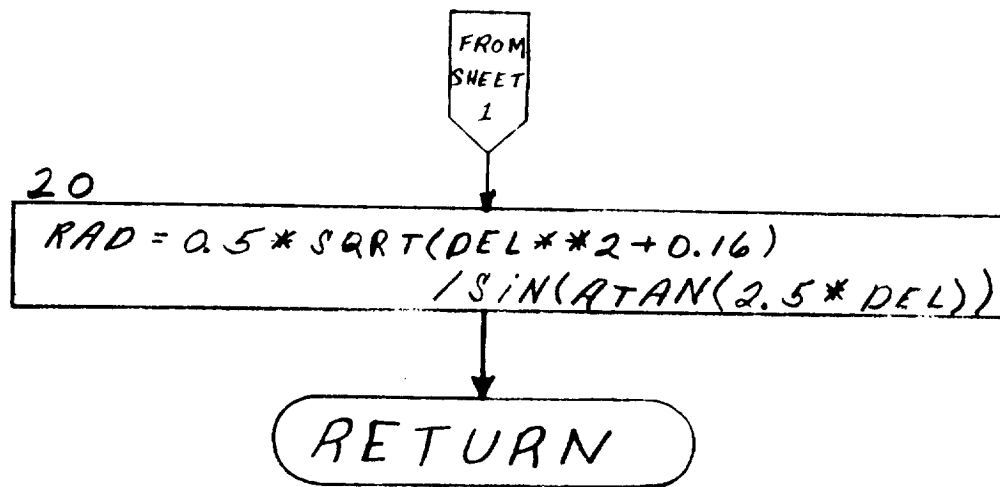
LOSE FUNCTION

PAGE 1 OF 2

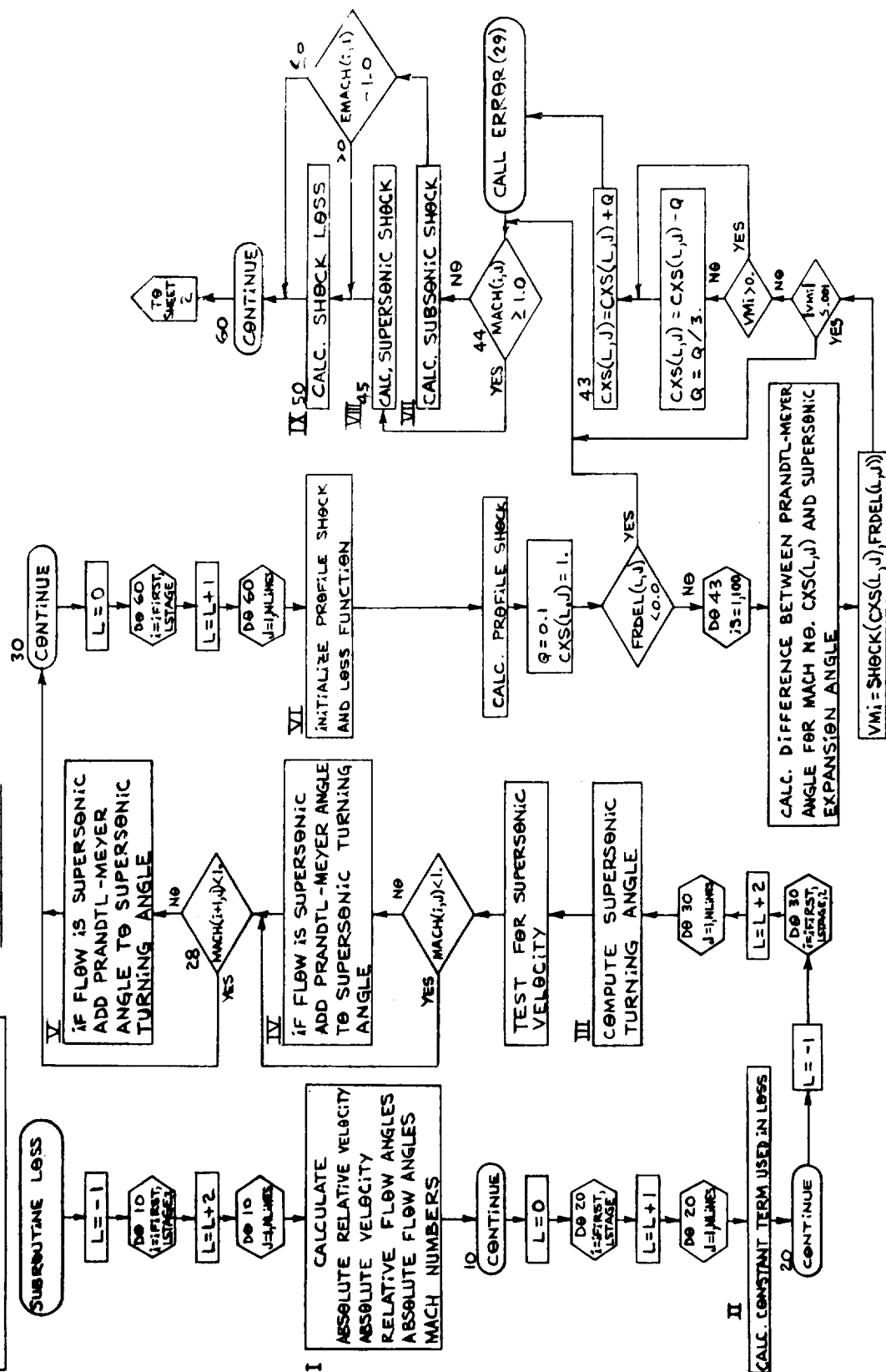


LOSE FUNCTION

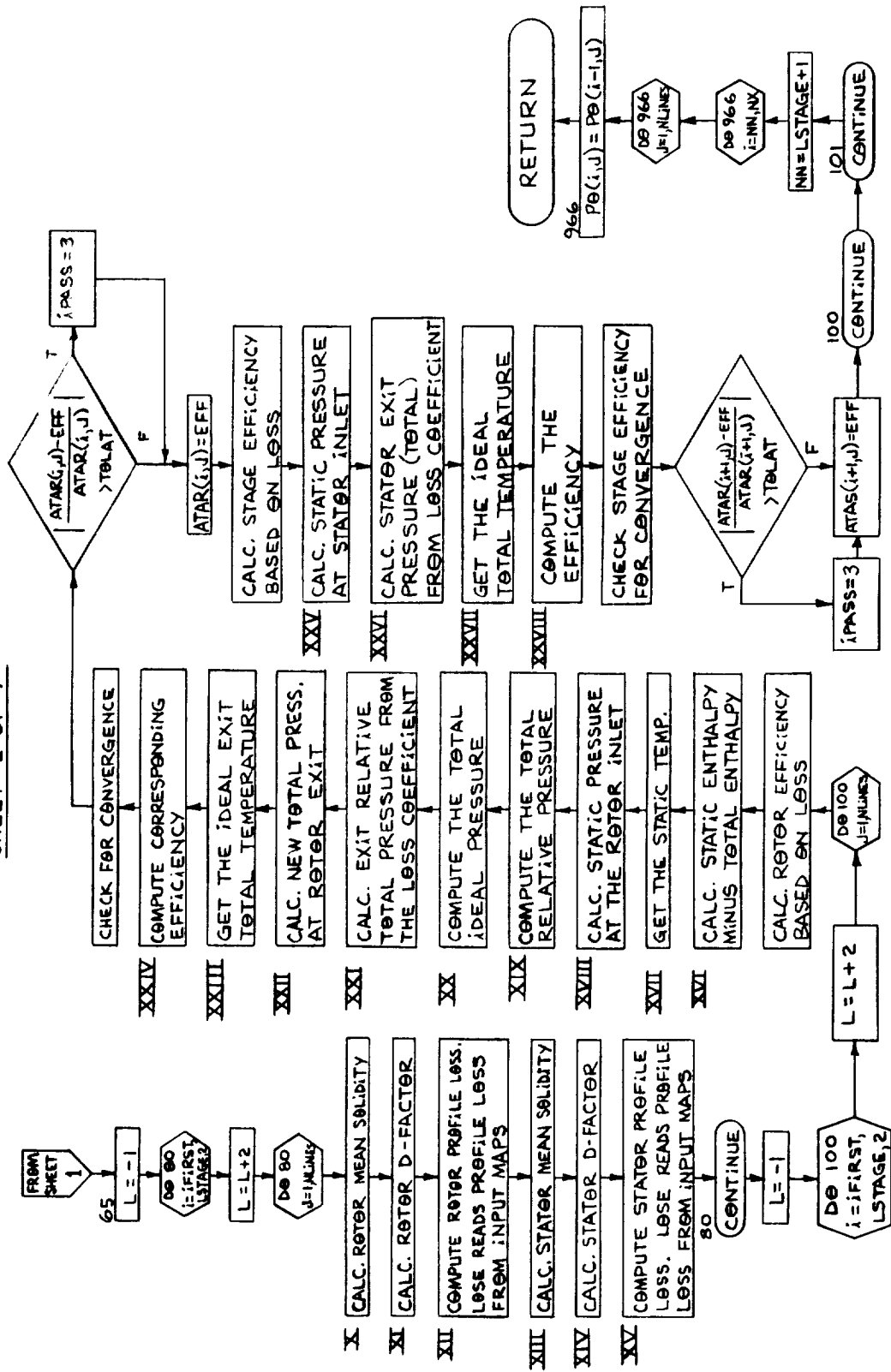
PAGE 2 OF 2



**MATCHES LOSS WITH ADIABATIC EFFICIENCY
BEAR CONTAINS THE LOSS FUNCTION**



N 35 LOSS S.R.
SHEET 2 OF 7



N35 LOSS S.R.
SHEET 3 OF 7

I

$$CXM(L,J) = CX(I-1,J)**2 + (CU(I-1,J) - U(I-1,J))**2 + CR(I-1,J)**2$$

$$CXM(L+1,J) = CX(I,J)**2 + CU(I,J)**2 + CR(I,J)**2$$

$$BETA(L,J) = ATAN((U(I-1,J) - CU(I-1,J)) / SQRT(CX(I-1,J)**2 + CR(I-1,J)**2))$$

$$BETA(L+1,J) = ATAN((U(I,J) - CU(I,J)) / SQRT(CX(I,J)**2 + CR(I,J)**2))$$

$$ALPHA(L+1,J) = ATAN(CU(I,J) / SQRT(CX(I,J)**2 + CR(I,J)**2))$$

$$ALPHA(L+2,J) = ATAN(CU(I+1,J) / SQRT(CX(I+1,J)**2 + CR(I+1,J)**2))$$

$$CXS(L,J) = CX(I-1,J)**2 + CU(I-1,J)**2 + CR(I-1,J)**2$$

$$H = -CXS(L,J) / GJ$$

$$T = T\theta(I-1,J)$$

CALL ENTALP

CALL GAM

$$MACH(I,J) = SQRT(CXM(L,J) / (GR2 * GAMMER * TSTAT(J)))$$

$$H = -CXM(L+1,J) / GJ$$

$$T = T\theta(I,J)$$

CALL ENTALP

CALL GAM

$$MACH(I+1,J) = SQRT(CXM(L+1,J) / (GR2 * GAMMER * TSTAT(J)))$$

II

$$TERM1(L,J) = SQRT((GAMMA(I-1,J) + 1.) / (GAMMA(I-1,J) - 1.))$$

III

$$A = (R(I,J) + R(I-1,J)) * .5$$

$$B = (R(I,J) + R(I+1,J)) * .5$$

$$FRDEL(L,J) = ((SSC\theta(I,1) / A + SSC\theta(I,2) / A + SSC\theta(I,3) + (SSC\theta(I,4) + SSC\theta(I,5) * A) * A) * (BETA(L,J) - BETA(L+1,J)))$$

$$FRDEL(L+1,J) = ((SSC\theta(I+1,1) / B + SSC\theta(I+1,2) / B + SSC\theta(I+1,3) + (SSC\theta(I+1,4) + SSC\theta(I+1,5) * B) * B) * (ALPHA(L+1,J) - ALPHA(L+2,J)))$$

N 35 LOSS S.R.
SHEET 4 OF 7

- IV $A = (MACH(i, J) - 1.) * (MACH(i, J) + 1.)$
 $FRDEL(L, J) = FRDEL(L, J) + TERM1(L, J)$
 $* ATAN(SQRT(A) / TERM1(L, J)) - ATAN(SQRT(A))$
- V $A = (MACH(i+1, J) - 1.) * (MACH(i+1, J) + 1.)$
 $FRDEL(L+1, J) = FRDEL(L+1, J) + TERM1(L+1, J)$
 $* ATAN(SQRT(A) / TERM1(L+1, J)) - ATAN(SQRT(A))$
- VI $\theta BAR(i, J) = 0.0$
- VII $EMACH(i, J) = MACH(i, J) * (1.0 + CXS(L, J)) * .5$
- VIII $EMACH(i, J) = (MACH(i, J) + CXS(L, J)) * .5$
- IX $\theta BAR(i, J) = (1.0 - (((GAMMA(i-1, J) + 1.0) * .5 * EMACH(i, J) ** 2)$
 $/ (1.0 + .5 * (GAMMA(i-1, J) - 1.0) * EMACH(i, J) ** 2))) **$
 $(GAMMA(i-1, J) / (GAMMA(i-1, J) - 1.0)) * (GAMMA(i-1, J) * 2.0$
 $/ ((GAMMA(i-1, J) + 1.0) * EMACH(i, J) ** 2 - (GAMMA(i-1, J)$
 $- 1.0) / (GAMMA(i-1, J) + 1.0))) * (1.0 / (1.0 - GAMMA(i-1, J))))$
 $/ (1.0 - 1.0 / (1.0 + (GAMMA(i-1, J) - 1.0) * MACH(i, J) ** 2$
 $* .5)) * (GAMMA(i-1, J) / (GAMMA(i-1, J) - 1.0)))$

N35 LOSS S.R.
SHEET 5 OF 7

X $A = (R(i,j) + R(i-1,j)) * .5$

$$SOLiD(i,j) = (S\theta C\theta(i,1)/A + S\theta C\theta(i,2))/A + S\theta C\theta(i,3) + (S\theta C\theta(i,4) + S\theta C\theta(i,5) * A) * A$$

XI $AA = \text{SQRT}((CX(i-1,j)**2 + (u(i-1,j) - cu(i-1,j))**2 + CR(i-1,j)**2))$

$$DFACT(i,j) = 1. - \text{SQRT}((CX(i,j)**2 + (u(i,j) - cu(i,j))**2 + CR(i,j)**2)) / AA + (u(i-1,j) - cu(i-1,j) - u(i,j) + cu(i,j)) / 2. / SOLiD(i,j) / AA$$

XII $A = RS(i-1) - RH(i-1)$

$$\theta BAR(i,j) = \theta BAR(i,j) + L\theta SE(DFACT(i,j), (R(i-1,j) - RH(i-1)) / A, BLADE(i)) * 2. * SOLiD(i,j) / \cos(AMiNI(BETA(L+1,j), 1.2217))$$

XIII $A = (R(i+1,j) + R(i,j)) * .5$

$$SOLiD(i+1,j) = (S\theta C\theta(i+1,1)/A + S\theta C\theta(i+1,2))/A + S\theta C\theta(i+1,3) + (S\theta C\theta(i+1,4) + S\theta C\theta(i+1,5) * A) * A$$

XIV $AA = \text{SQRT}((CX(i,j)**2 + cu(i,j)**2 + CR(i,j)**2))$

$$DFACT(i+1,j) = 1. - \text{SQRT}((CX(i+1,j)**2 + cu(i+1,j)**2 + CR(i+1,j)**2)) / AA + (cu(i,j) - cu(i+1,j)) / 2. / SOLiD(i+1,j) / AA$$

XV $A = RS(i) - RH(i)$

$$\theta BAR(i+1,j) = \theta BAR(i+1,j) + L\theta SE(DFACT(i+1,j), (R(i,j) - RH(i)) / A, BLADE(i+1)) * 2. * SOLiD(i+1,j) / \cos(AMiNI(ALPHA(L+2,j), 1.2217))$$

N35 LOSS S.R.
SHEET 6 OF 7

```

XVI  H = -(CX(I-1,J)**2 + CR(I-1,J)**2 + CU(I-1,J)**2)/GJ

XVII  T = T0(I-1,J)
      CALL ENTALP
      B = THERM3(T)

XVIII  PSTAT = P0(I-1,J)*EXP((THERM3(TSTAT(J))-B)/DCP)

XIX  H = U(I-1,J)*(U(I-1,J)-2.*CU(I-1,J))/GJ
      CALL ENTALP
      PREL = P0(I-1,J)*EXP((THERM3(TSTAT(J))-B)/DCP)

XX  H = (U(I,J)-U(I-1,J))*(U(I,J)+U(I-1,J))/GJ
     T = TSTAT(J)
     CALL ENTALP
     B = THERM3(T)
     PiDEAL = PREL*EXP((THERM3(TSTAT(J))-B)/DCP)

XXI  P = PiDEAL - 0BAR(I,J)*(PREL-PSTAT)

XXII  H = -U(I,J)*(2.*CU(I,J)-U(I,J))/GJ
      T = T0(I,J)
      CALL ENTALP
      P = P*EXP((THERM3(T)-THERM3(TSTAT(J)))/DCP)

XXIII  CALL THERM2(P/P0(I-1,J),T,T0(I-1,J))

XXIV  EFF = (THERMI(T)-THERMI(T0(I-1,J)))/(THERMI(T0(I,J))
      -THERMI(T0(I-1,J)))

      P0(I,J) = P

```

N35 LOSS S.R.
SHEET 7 OF 7

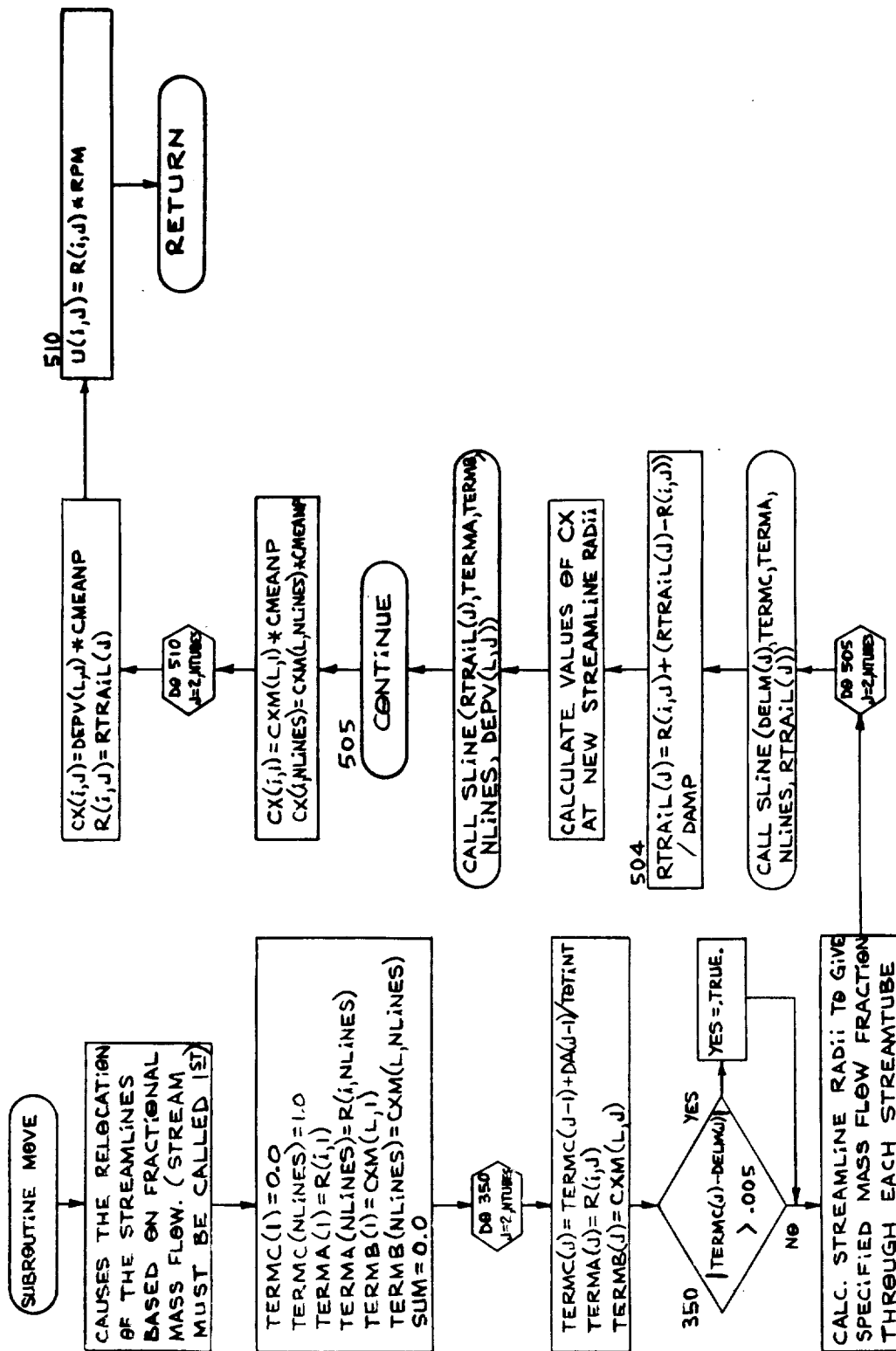
XXV $H = -(C_X(i,J)**2 + C_R(i,J)**2 + C_U(i,J)**2)/GJ$
 $T = T\theta(i,J)$
 CALL ENTALP
 $PSTAT = P\theta(i,J) * \exp((THERM3(TSTAT(J)) - THERM3(T)) / DCP)$

XXVI $P = P\theta(i,J) - \theta BAR(i+1,J) * (P\theta(i,J) - PSTAT)$
 $P\theta(i+1,J) = P$

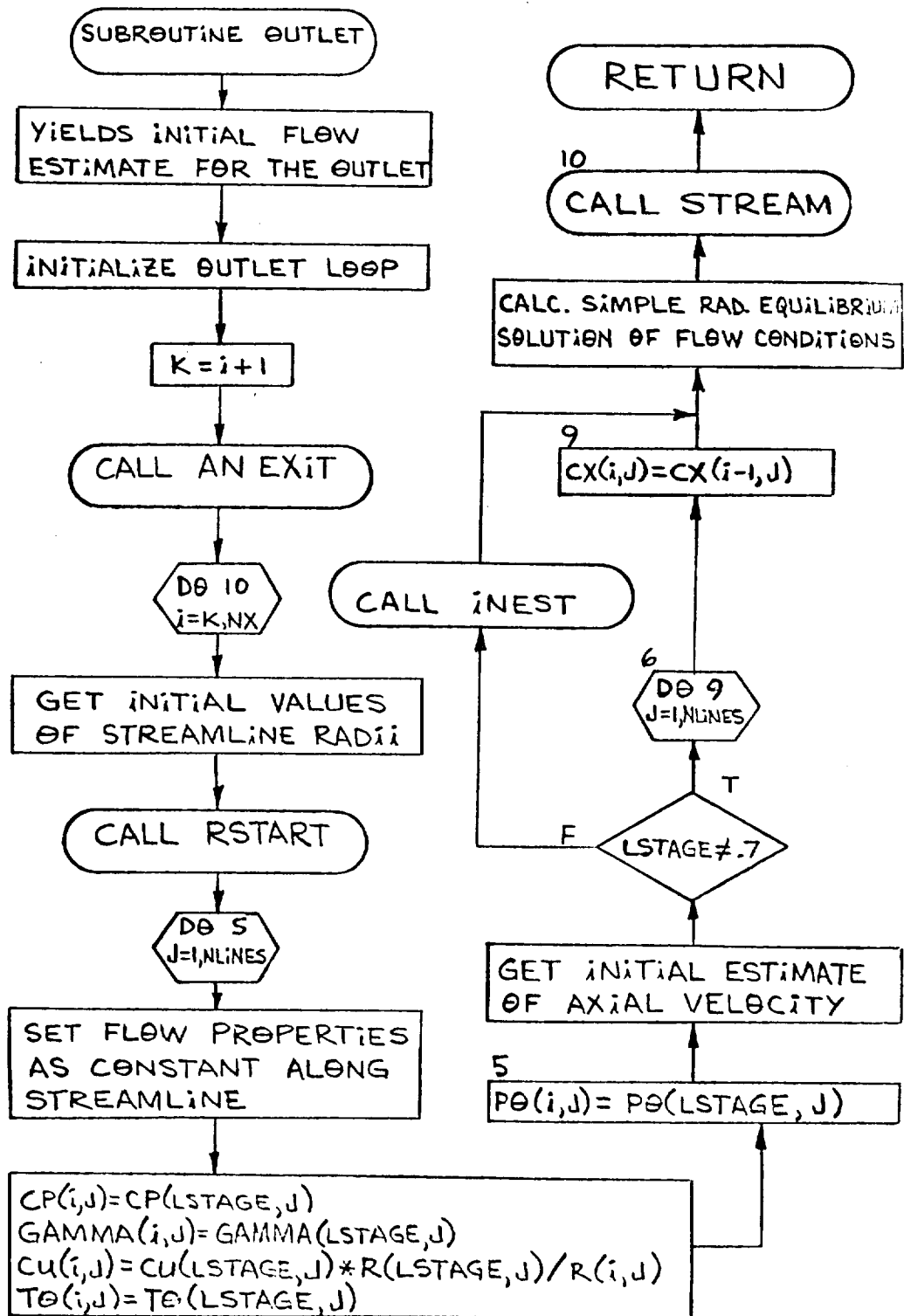
XXVII CALL THERM2(P/P $\theta(i-1,J)$, T, T $\theta(i-1,J)$)

XXVIII $EFF = (THERM1(T) - THERM1(T\theta(i-1,J)))$
 $/ (THERM1(T\theta(i,J)) - THERM1(T\theta(i-1,J)))$

N35 MOVE S.R.

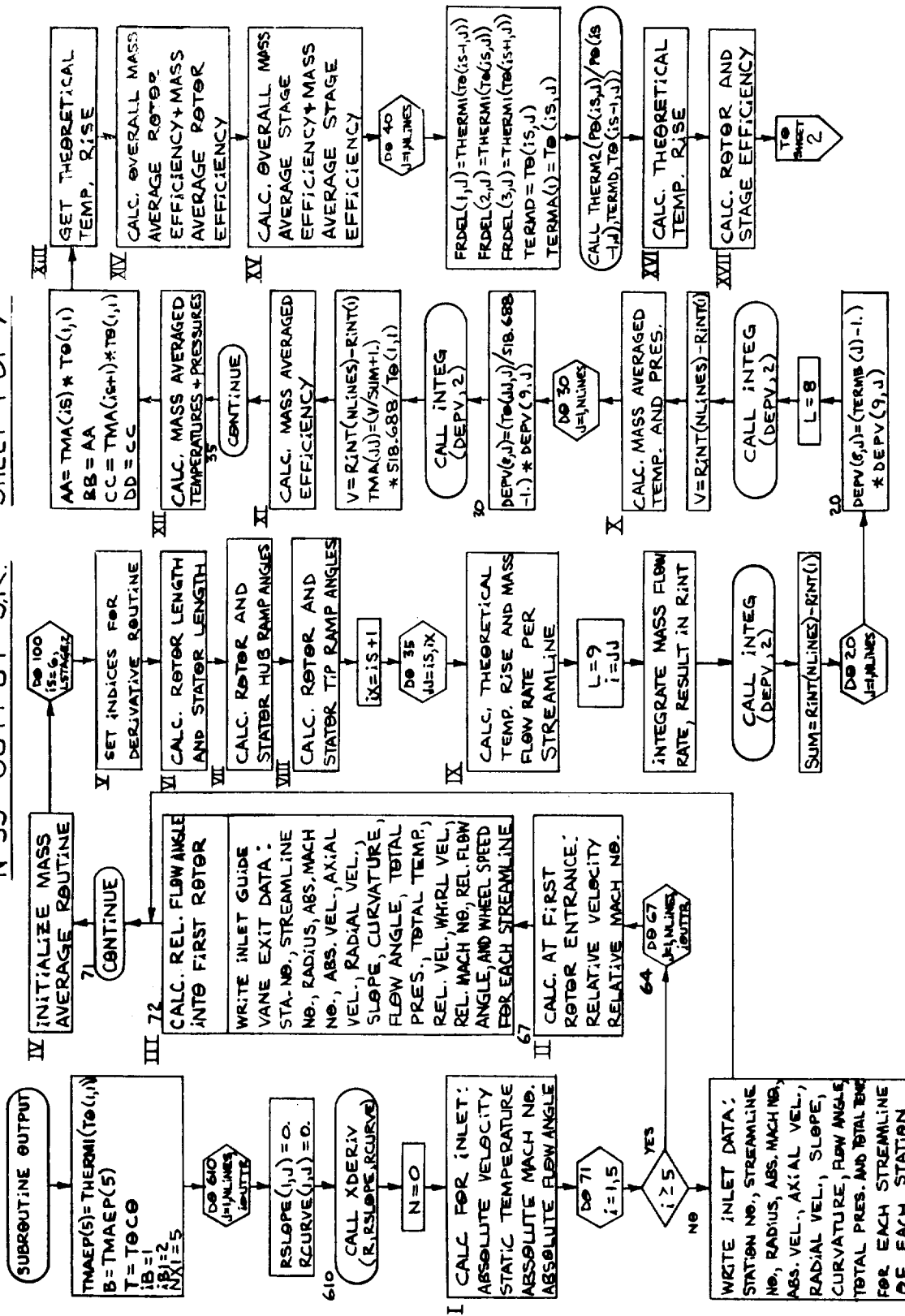


N 35 OUTLET S.R.



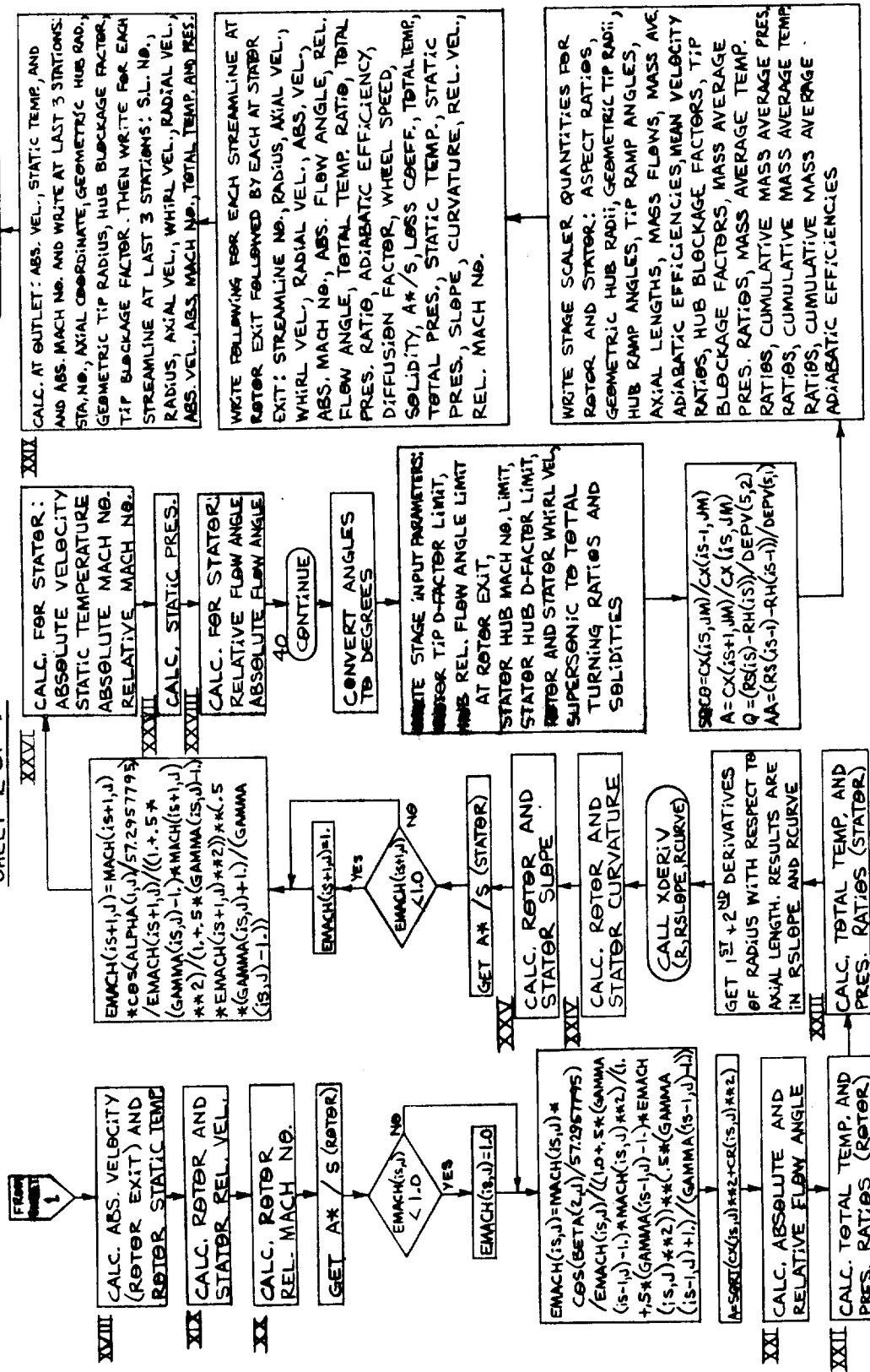
N 35 OUTPUT S.R.

SHEET 1 OF 7



N 35 OUTPUT S.R.

SHEET 2 OF 7



N 35 OUTPUT
SHEET 3 OF 7

```
I      DO 58 I=1,5
      DO 58 J=1,NLINES,IOUTTR
      CXM(I,J)=SQRT(CX(I,J)**2+CU(I,J)**2+CR(I,J)**2)
      H=-CXM(I,J)**2/GJ
      CALL ENTALP
      CALL GAM
      CXNEW(I,J)=TSTAT(J)
      CXS(I,J)=CXM(I,J)/SQRT(GR2*GAMMER*TSTAT(J))
      A=SQRT(CX(I,J)**2+CR(I,J)**2)
      ALPHA(I,J)=ATAN(CU(I,J)/A)*57.2957795
      RCURVE(I,J)=RCURVE(I,J)/(SQRT(1.+RSLOPE(I,J)
      **2)**3)
58     RSLOPE(I,J)=ATAN(RSLOPE(I,J))*57.2957795

II     CALL GAM
      ERASI = GR2*GAMMER*TSTAT(J)
      CΘ(5,J)=CX(5,J)**2+(CU(5,J)-u(5,J))**2+CR(5,J)**2
      CΘ(5,J)=SQRT(CΘ(5,J))
67     CXS(5,J)=CΘ(5,J)/SQRT(ERASI)
```

N 35 OUTPUT S.R.
SHEET 4 OF 7

- III DO 273 J=1,NLINES,iOUTTR
72 BETA(2,J)=ATAN((U(5,J)-CU(5,J))/SQRT(CX(5,J)**2
+ CR(5,J)**2))*57.2957795
273 CONTINUE
- IV TMA(5) = 1.0
PMA(5) = 1.0
- V IB=IS-1
IBI=IS
NXI=IS+1
N=N+1
- VI DEPV(5,1)=X(IS)-X(IS-1)
DEPV(5,2)=X(IS+1)-X(IS)
- VII ALPHA(3,1)=ATAN((RH(IS)-RH(IS-1))/DEPV(5,1))*57.2957795
ALPHA(4,1)=ATAN((RH(IS+1)-RH(IS))/DEPV(5,2))*57.2957795
- VIII ALPHA(3,2)=ATAN((RS(IS)-RS(IS-1))/DEPV(5,1))*57.2957795
ALPHA(4,2)=ATAN((RS(IS+1)-RS(IS))/DEPV(5,2))*57.2957795

N 35 OUTPUT S.R.
SHEET 5 OF 7

- IX** $DO\ 10\ J=1,NLINES$
 $TERMB(J)=T\theta(JJ,J)$
 $CALL\ THERM2(P\theta(JJ,J)/14.6966,TERMB(J),518.688)$
 $TERMB(J)=TERMB(J)/518.688$
 10 $DEPV(9,J)=RH\theta(JJ,J)*CX(JJ,J)*R(JJ,J)$
- X** $TMA(JJ)=(V/SUM+1.)*518.688$
 $PMA(JJ)=EXP((THERM3(TMA(JJ))-C\theta INTG)/DCP)$
 $\quad *14.6966/P\theta(1,1)$
- XI** $TMAEP(JJ)=THERMI(TMA(JJ)*T\theta C\theta)$
- XII** $TMAB(is)=TMA(is)/TMA(is-1)$
 $TMAB(is+1)=TMA(is+1)/TMA(is-1)$
 $PMAB(is)=PMA(is)/PMA(is-1)$
- XIII** $CALL\ THERM2(PMA(is),AA,T\theta(1,1))$
 $CALL\ THERM2(PMA(is)/PMA(is-1),BB,TMA(is-1)$
 $\quad *T\theta(1,1))$
 $CALL\ THERM2(PMA(is+1),CC,T\theta(1,1))$
 $CALL\ THERM2(PMA(is+1)/PMA(is-1),DD,TMA(is-1)$
 $\quad *T\theta C\theta)$
- XIV** $CXS(6,1)=(THERMI(AA)-TMAEP(5))/(TMAEP(is)$
 $\quad -TMAEP(5))$
 $PMAB(is+1)=PMA(is+1)/PMA(is-1)$
 $CXS(6,2)=(THERMI(BB)-TMAEP(is-1))/(TMAEP(is)$
 $\quad -TMAEP(is-1))$
- XV** $CXS(7,1)=(THERMI(CC)-TMAEP(5))/(TMAEP(is+1)$
 $\quad -TMAEP(5))$
 $CXS(7,2)=(THERMI(DD)-TMAEP(is-1))/(TMAEP(is+1)$
 $\quad -TMAEP(is-1))$
- XVI** $CALL\ THERM2(P\theta(is+1,J)/P\theta(is-1,J),TERMA(1),T\theta(is-1,J))$

N 35 OUTPUT S.R.
SHEET 6 OF 7

- XVII** $ATAR(iS,J) = (THERMI(TERMD) - FRDEL(1,J)) / (FRDEL(2,J) - FRDEL(1,J))$
 $ATAS(iS+1,J) = (THERMI(TERMA(1)) - FRDEL(1,J)) / (FRDEL(3,J) - FRDEL(1,J))$
- XVIII** $CXM(1,J) = \sqrt{CX(iS,J)**2 + CU(iS,J)**2 + CR(iS,J)**2}$
 $H = -CXM(1,J)**2 / GJ$
 $T = T\theta(iS,J)$
 CALL ENTALP
 $CXNEW(1,J) = TSTAT(J)$
 CALL GAM
 $ERASI = GR2 * GAMMER * TSTAT(J)$
 $C\theta(8,J) = P\theta(iS,J) * \exp((THERM3(TSTAT(J)) - THERM3(T)) / DCP)$
- XIX** $C\theta(5,J) = CX(iS,J)**2 + (CU(iS,J) - U(iS,J))**2 + CR(iS,J)**2$
 $C\theta(5,J) = \sqrt{C\theta(5,J)}$
 $C\theta(6,J) = CX(iS+1,J)**2 + (CU(iS+1,J) - U(iS+1,J))**2 + CR(iS+1,J)**2$
 $C\theta(6,J) = \sqrt{C\theta(6,J)}$
- XX** $CXS(1,J) = C\theta(5,J) / \sqrt{ERASI}$
- XXI** $ALPHA(1,J) = ATAN(CU(iS,J)/A) * 57.2957795$
 $BETA(1,J) = ATAN((U(iS,J) - CU(iS,J))/A) * 57.2957795$
- XXII** $C\theta(1,J) = T\theta(iS,J) / T\theta(iS-1,J)$
 $C\theta(3,J) = P\theta(iS,J) / P\theta(iS-1,J)$
- XXIII** $C\theta(2,J) = T\theta(iS+1,J) / T\theta(iS,J)$
 $C\theta(4,J) = P\theta(iS+1,J) / P\theta(iS,J)$
- XXIV** $RCURVE(2,J) = RCURVE(2,J) / (\sqrt{1 + RSLOPE(2,J)**2})**3$
 $RCURVE(3,J) = RCURVE(3,J) / (\sqrt{1 + RSLOPE(3,J)**2})**3$

N35 OUTPUT S.R.
SHEET 7 OF 7

XXV RSLOPE(2,J)=ATAN(RSLOPE(2,J))*57.2957795
RSLOPE(3,J)=ATAN(RSLOPE(3,J))*57.2957795

XXVI CXM(2,J)=SQRT(CX(1S+1,J)**2+CU(1S+1,J)**2
+ CR(1S+1,J)**2)
H=-CXM(2,J)**2/GJ
T=T0(1S+1,J)
CALL ENTALP
CXNEW(2,J)=TSTAT(J)
CALL GAM
ERASI=GR2*GAMMER*TSTAT(J)
CXS(2,J)=CXM(2,J)/SQRT(ERASI)
C0(7,J)=C0(6,J)/SQRT(ERASI)

XXVII C0(9,J)=P0(1S+1,J)*EXP((THERM3(TSTAT(J))
-THERM3(T))/DCP)

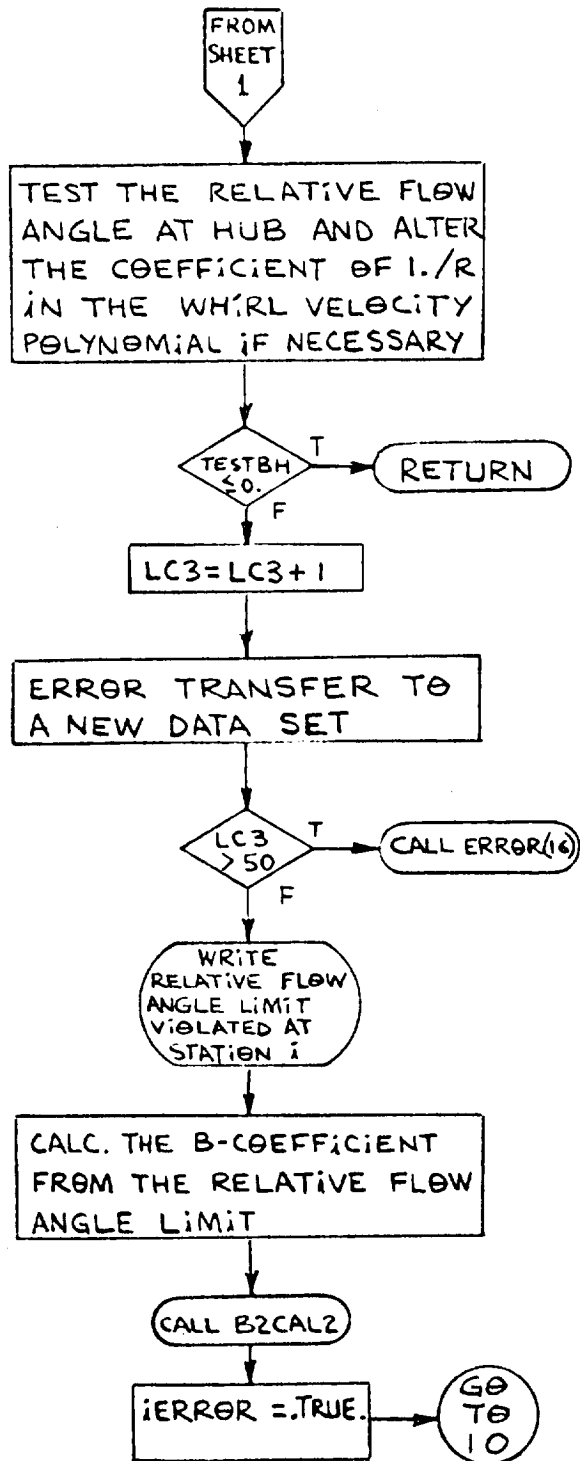
XXVIII BETA(2,J)=-ATAN((CU(1S+1,J)-U(1S+1,J))
/SQRT(CX(1S+1,J)**2+CR(1S+1,J)**2))*57.2957795
ALPHA(2,J)=ATAN(CU(1S+1,J)/SQRT(CX(1S+1,J)**2
+ CR(1S+1,J)**2))*57.2957795

XXIX JJ=LSTAGE+1
KJ=0
DO 140 iJ=JJ,NX
KJ=KJ+1
DO 140 J=1,NLINES
CXM(KJ,J)=SQRT(CX(iJ,J)**2+CU(iJ,J)**2
+ CR(iJ,J)**2)
H=-CXM(KJ,J)**2/GJ
T=T0(iJ,J)
CALL ENTALP
CALL GAM
CXNEW(KJ,J)=TSTAT(J)
ERASI=GR2*GAMMER*TSTAT(J)
140 CXS(KJ,J)=CXM(KJ,J)/SQRT(ERASI)

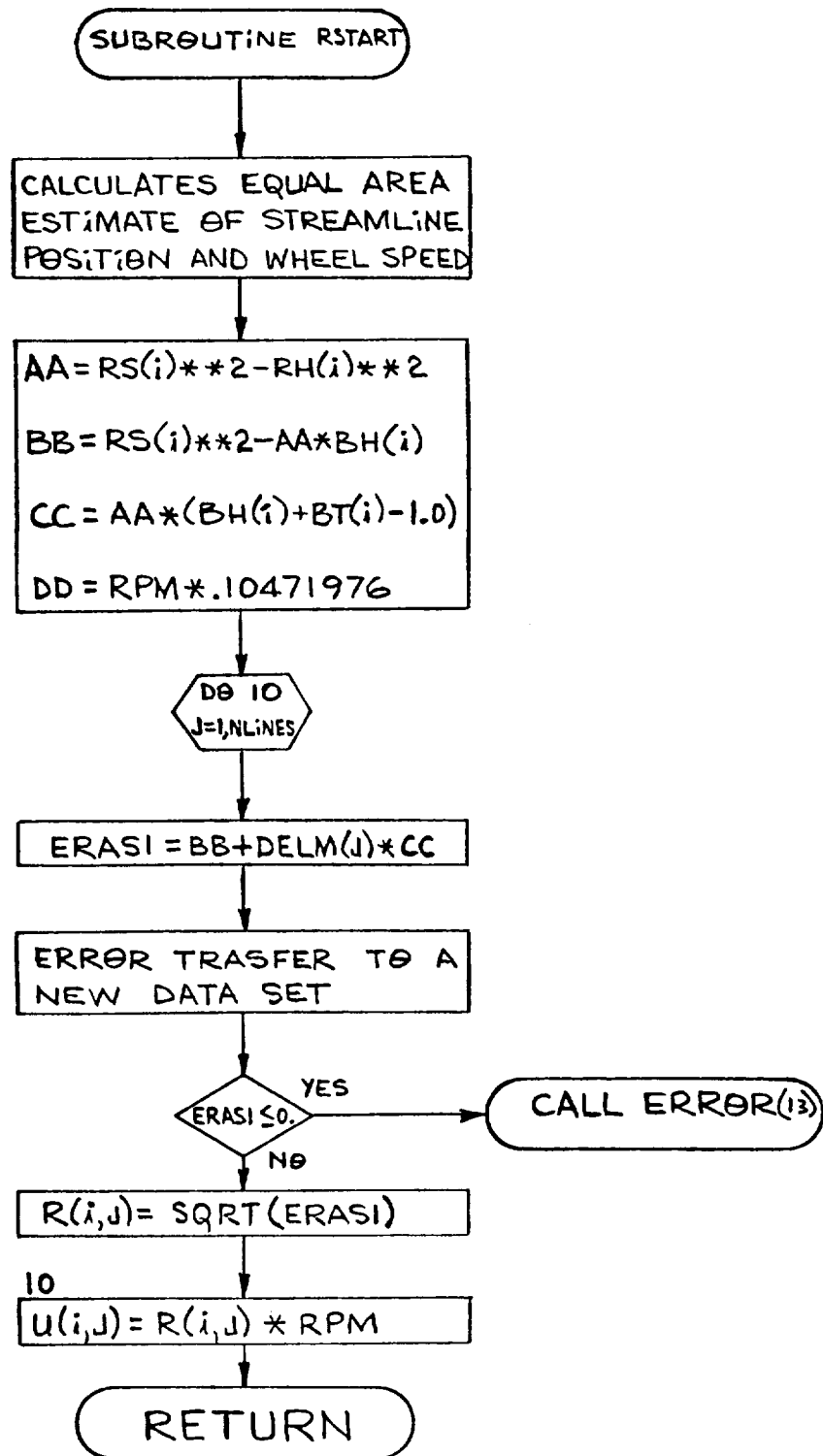
```

    graph TD
        Start([GO TO 60]) --> 16
        16: PO(5,J) = POCE - W(J) * POCE * (1.0 - EXP((THERM3(TSTAT(J)-B)/DCP)))
        16 --> 18
        18: CALC. PRESSURE LOSS ACROSS INLET GUIDE VANE. AN INLET GUIDE VANE IS SIMULATED BY SPECIFYING A TANGENTIAL VELOCITY DISTIBUTION AT THE ENTRANCE TO THE 1ST ROTOR AND A PRESSURE LOSS ACROSS STATIONS 4 TO 5
        18 --> 20
        20: H = -(CX(5,J)**2 + CR(5,J)**2) / GJ
        20 --> 22
        22: CALL ENTPALP
        22 --> 24
        24: PO(5,J) = POCE - W(J) * POCE * (1.0 - EXP((THERM3(TSTAT(J)-B)/DCP)))
        24 --> 26
        26: CALC. TOTAL TEMPERATURE RISE ACROSS THE ROTOR
        26 --> 28
        28: PO(i,j) = PO(i-2,j) * EXP((THERM3(TSTAT(j)) - THERM3(T)) / DCP)
        28 --> 30
        30: CALL ENTPALP
        30 --> 32
        32: T = TO(i-2,j)
        32 --> 34
        34: H = (THERM1(TO(i,j)) - THERM1(T)) * ATAS(i,j)
        34 --> 36
        36: CALC. TOTAL PRESSURE AT STATOR EXIT
        36 --> 38
        38: CP(i,j) = CP(i-1,j)
        38: GAMMA(i,j) = GAMMA(i-1,j)
        38: TO(i,j) = TO(i-1,j)
        38 --> 40
        40: DO 26 J=1,NLINES
        40 --> 42
        42: IF 1-G/2 * X2 = 0 THEN T
        42 --> 44
        44: T = TOCE
        44: B = THERM3(TOCE)
        44 --> 46
        46: CALC. WHIRL VELOCITY AT EACH STREAMLINE
        46 --> 48
        48: DO 8 I=1,LSTAGE
        48 --> 50
        50: GAMMA(i,j) = GAMMA(i-1,j)
        50: CP(i,j) = CP(i-1,j)
        50: CU(i,j) = R(i-1,j) * CU(i-1,j) / R(i,j)
        50: TO(i,j) = TO(LSTAGE,j)
        50 --> 52
        52: PO(i,j) = PO(LSTAGE,j)
        52 --> 54
        54: GO TO 60
        54 --> 56
        56: IF I < LSTAGE THEN T
        56 --> 58
        58: DO 8 J=1,NLINES
        58 --> 60
        60: GO TO 60
        60 --> 62
        62: IF I < 5 THEN T
        62 --> 64
        64: CU(i,j) = (CUCE(i,j) / R(i,j) + CUCE(i,j) + CUCE(i,j) * R(i,j) + CUCE(i,j) * R(i,j)) / R(i,j)
        64 --> 66
        66: DO 12 J=1,NLINES
        66 --> 68
        68: T = TOCE
        68: B = THERM3(TOCE)
        68 --> 70
        70: CALC. WHIRL VELOCITY AT EACH STREAMLINE
        70 --> 72
        72: DO 10 T = TOCE
        72: B = THERM3(TOCE)
        72 --> 74
        74: H = -(CX(5,J)**2 + CR(5,J)**2) / GJ
        74 --> 76
        76: CALL ENTPALP
        76 --> 78
        78: PO(5,J) = POCE - W(J) * POCE * (1.0 - EXP((THERM3(TSTAT(J)-B)/DCP)))
        78 --> 80
        80: CALC. PRESSURE LOSS ACROSS INLET GUIDE VANE. AN INLET GUIDE VANE IS SIMULATED BY SPECIFYING A TANGENTIAL VELOCITY DISTIBUTION AT THE ENTRANCE TO THE 1ST ROTOR AND A PRESSURE LOSS ACROSS STATIONS 4 TO 5
        80 --> 82
        82: H = -(CX(5,J)**2 + CR(5,J)**2) / GJ
        82 --> 84
        84: CALL ENTPALP
        84 --> 86
        86: PO(5,J) = POCE - W(J) * POCE * (1.0 - EXP((THERM3(TSTAT(J)-B)/DCP)))
        86 --> 88
        88: CALC. TOTAL TEMPERATURE RISE ACROSS THE ROTOR
        88 --> 90
        90: PO(i,j) = PO(i-2,j) * EXP((THERM3(TSTAT(j)) - THERM3(T)) / DCP)
        90 --> 92
        92: CALL ENTPALP
        92 --> 94
        94: T = TO(i-2,j)
        94 --> 96
        96: H = (THERM1(TO(i,j)) - THERM1(T)) * ATAS(i,j)
        96 --> 98
        98: CALC. TOTAL PRESSURE AT STATOR EXIT
        98 --> 100
        100: CP(i,j) = CP(i-1,j)
        100: GAMMA(i,j) = GAMMA(i-1,j)
        100: TO(i,j) = TO(i-1,j)
        100 --> 102
        102: DO 26 J=1,NLINES
        102 --> 104
        104: IF 1-G/2 * X2 = 0 THEN T
        104 --> 106
        106: T = TOCE
        106: B = THERM3(TOCE)
        106 --> 108
        108: CALC. WHIRL VELOCITY AT EACH STREAMLINE
        108 --> 110
        110: DO 8 I=1,LSTAGE
        110 --> 112
        112: GAMMA(i,j) = GAMMA(i-1,j)
        112: CP(i,j) = CP(i-1,j)
        112: CU(i,j) = R(i-1,j) * CU(i-1,j) / R(i,j)
        112: TO(i,j) = TO(LSTAGE,j)
        112 --> 114
        114: PO(i,j) = PO(LSTAGE,j)
        114 --> 116
        116: GO TO 60
        116 --> 118
        118: IF I < LSTAGE THEN T
        118 --> 120
        120: DO 8 J=1,NLINES
        120 --> 122
        122: GO TO 60
        122 --> 124
        124: IF I < 5 THEN T
        124 --> 126
        126: CU(i,j) = (CUCE(i,j) / R(i,j) + CUCE(i,j) + CUCE(i,j) * R(i,j) + CUCE(i,j) * R(i,j)) / R(i,j)
        126 --> 128
        128: DO 12 J=1,NLINES
        128 --> 130
        130: T = TOCE
        130: B = THERM3(TOCE)
        130 --> 132
        132: CALC. WHIRL VELOCITY AT EACH STREAMLINE
        132 --> 134
        134: DO 10 T = TOCE
        134: B = THERM3(TOCE)
        134 --> 136
        136: H = -(CX(5,J)**2 + CR(5,J)**2) / GJ
        136 --> 138
        138: CALL ENTPALP
        138 --> 140
        140: PO(5,J) = POCE - W(J) * POCE * (1.0 - EXP((THERM3(TSTAT(J)-B)/DCP)))
        140 --> 142
        142: CALC. PRESSURE LOSS ACROSS INLET GUIDE VANE. AN INLET GUIDE VANE IS SIMULATED BY SPECIFYING A TANGENTIAL VELOCITY DISTIBUTION AT THE ENTRANCE TO THE 1ST ROTOR AND A PRESSURE LOSS ACROSS STATIONS 4 TO 5
        142 --> 144
        144: H = -(CX(5,J)**2 + CR(5,J)**2) / GJ
        144 --> 146
        146: CALL ENTPALP
        146 --> 148
        148: PO(5,J) = POCE - W(J) * POCE * (1.0 - EXP((THERM3(TSTAT(J)-B)/DCP)))
        148 --> 150
        150: CALC. TOTAL TEMPERATURE RISE ACROSS THE ROTOR
        150 --> 152
        152: PO(i,j) = PO(i-2,j) * EXP((THERM3(TSTAT(j)) - THERM3(T)) / DCP)
        152 --> 154
        154: CALL ENTPALP
        154 --> 156
        156: T = TO(i-2,j)
        156 --> 158
        158: H = (THERM1(TO(i,j)) - THERM1(T)) * ATAS(i,j)
        158 --> 160
        160: CALC. TOTAL PRESSURE AT STATOR EXIT
        160 --> 162
        162: CP(i,j) = CP(i-1,j)
        162: GAMMA(i,j) = GAMMA(i-1,j)
        162: TO(i,j) = TO(i-1,j)
        162 --> 164
        164: DO 26 J=1,NLINES
        164 --> 166
        166: IF 1-G/2 * X2 = 0 THEN T
        166 --> 168
        168: T = TOCE
        168: B = THERM3(TOCE)
        168 --> 170
        170: CALC. WHIRL VELOCITY AT EACH STREAMLINE
        170 --> 172
        172: DO 8 I=1,LSTAGE
        172 --> 174
        174: GAMMA(i,j) = GAMMA(i-1,j)
        174: CP(i,j) = CP(i-1,j)
        174: CU(i,j) = R(i-1,j) * CU(i-1,j) / R(i,j)
        174: TO(i,j) = TO(LSTAGE,j)
        174 --> 176
        176: PO(i,j) = PO(LSTAGE,j)
        176 --> 178
        178: GO TO 60
        178 --> 180
        180: IF I < LSTAGE THEN T
        180 --> 182
        182: DO 8 J=1,NLINES
        182 --> 184
        184: GO TO 60
        184 --> 186
        186: IF I < 5 THEN T
        186 --> 188
        188: CU(i,j) = (CUCE(i,j) / R(i,j) + CUCE(i,j) + CUCE(i,j) * R(i,j) + CUCE(i,j) * R(i,j)) / R(i,j)
        188 --> 190
        190: DO 12 J=1,NLINES
        190 --> 192
        192: T = TOCE
        192: B = THERM3(TOCE)
        192 --> 194
        194: CALC. WHIRL VELOCITY AT EACH STREAMLINE
        194 --> 196
        196: DO 10 T = TOCE
        196: B = THERM3(TOCE)
        196 --> 198
        198: H = -(CX(5,J)**2 + CR(5,J)**2) / GJ
        198 --> 200
        200: CALL ENTPALP
        200 --> 202
        202: PO(5,J) = POCE - W(J) * POCE * (1.0 - EXP((THERM3(TSTAT(J)-B)/DCP)))
        202 --> 204
        204: CALC. PRESSURE LOSS ACROSS INLET GUIDE VANE. AN INLET GUIDE VANE IS SIMULATED BY SPECIFYING A TANGENTIAL VELOCITY DISTIBUTION AT THE ENTRANCE TO THE 1ST ROTOR AND A PRESSURE LOSS ACROSS STATIONS 4 TO 5
        204 --> 206
        206: H = -(CX(5,J)**2 + CR(5,J)**2) / GJ
        206 --> 208
        208: CALL ENTPALP
        208 --> 210
        210: PO(5,J) = POCE - W(J) * POCE * (1.0 - EXP((THERM3(TSTAT(J)-B)/DCP)))
        210 --> 212
        212: CALC. TOTAL TEMPERATURE RISE ACROSS THE ROTOR
        212 --> 214
        214: PO(i,j) = PO(i-2,j) * EXP((THERM3(TSTAT(j)) - THERM3(T)) / DCP)
        214 --> 216
        2
```

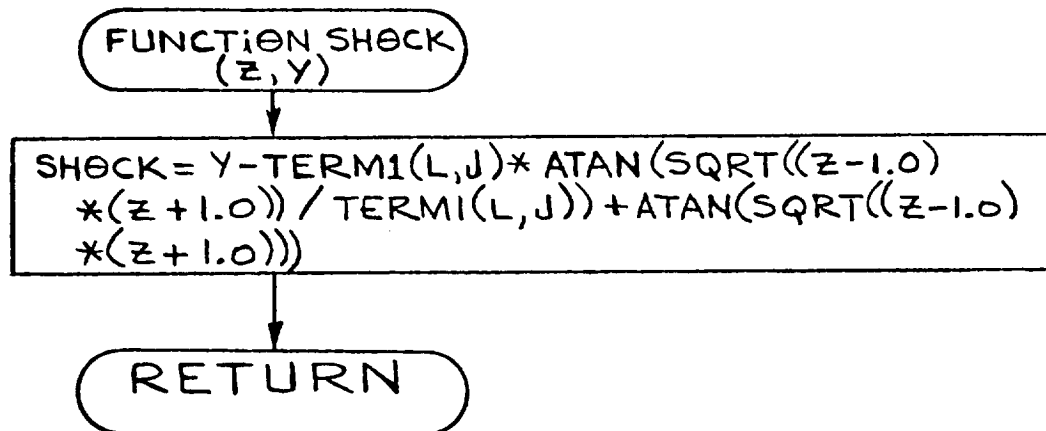

N 35 ROTOUT S.R.
SHEET 2 OF 2



N 35 RSTART S.R.

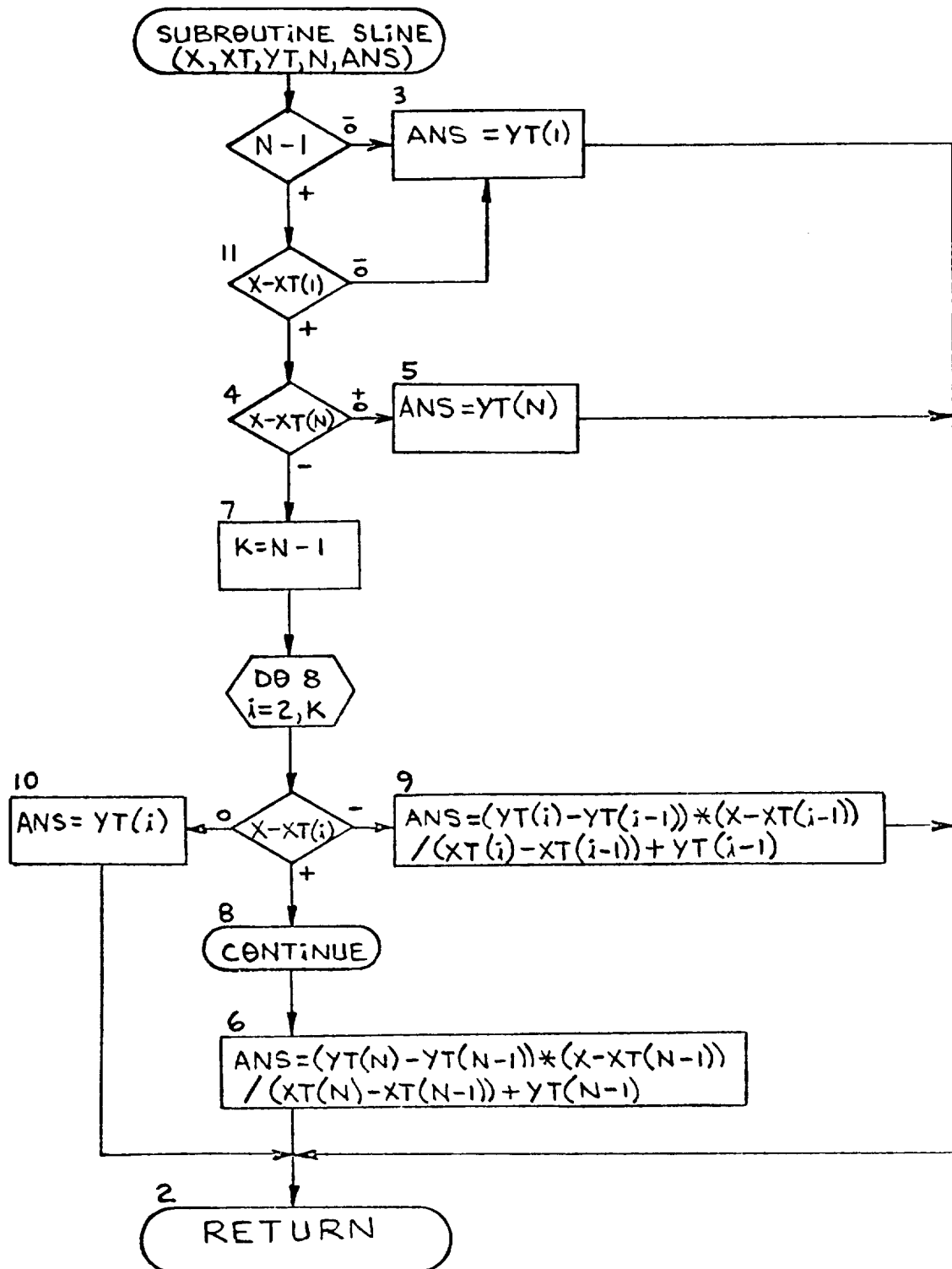


N 35 SHOCK FUNCTION



CALCULATES SUPERSONIC EXPANSION
ANGLE MINUS PRANDTL-MEYER ANGLE

N 35 SLINE S.R.

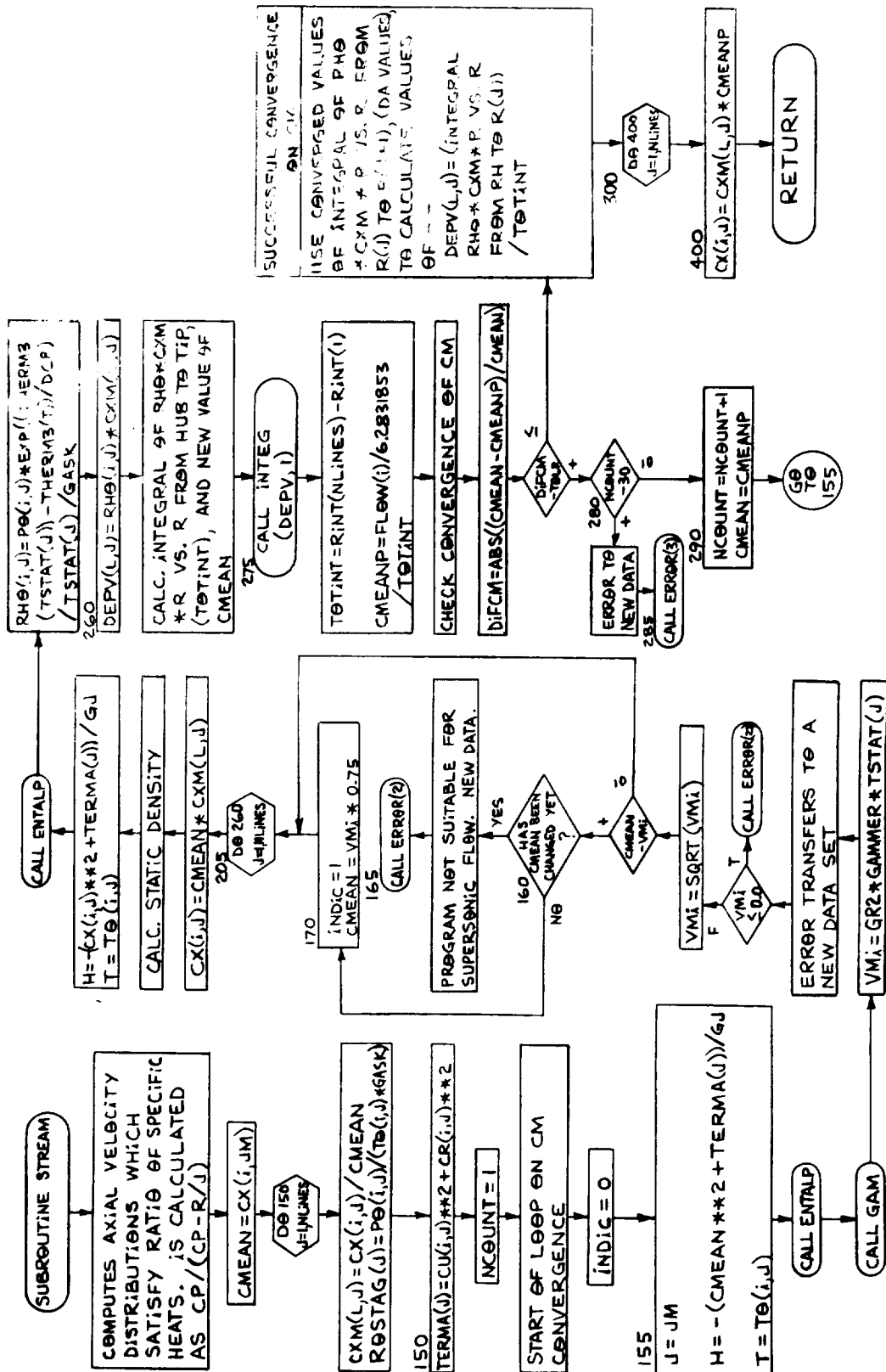


```

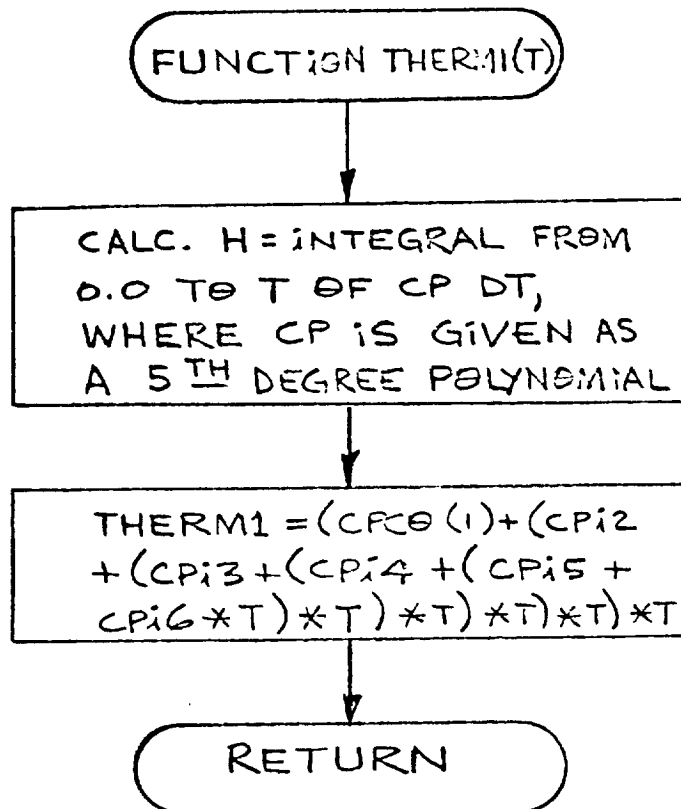
graph TD
    Start([SUBROUTINE STABOUT]) --> Exit[COMPUTES STATOR EXIT]
    Exit --> LoopStart((DO 5  
J=JMINEX))
    LoopStart --> CP[CP(I,J)=CP(I-1,J)]
    CP --> L2[L=2]
    L2 --> L5[LC5=0]
    L5 --> ISAVE[ISAVE=1]
    ISAVE --> Init[IF IPASS=1 THE CALC.  
MUST BE INITIALIZED]
    Init --> IPASS{IPASS=1}
    IPASS -- T --> STAGE{STAGE=7}
    STAGE -- T --> RSTART[CALL RSTART]
    RSTART --> IT1[IT=1]
    IT1 --> Prefit2[PRFIT2 YIELDS FLOW  
PARAMETERS AT STREAM-  
LINE RADII]
    Prefit2 --> Prefit2Call[CALL PRFIT2]
    Prefit2Call --> InitGuess[INITEST TO BE USED ONLY  
FOR INITIAL GUESS.  
IT=1 INDICATES SUBROUTINE  
INITEST HAS NOT BEEN USED  
FOR THIS STATION]
    InitGuess --> ITNE1{IT#1}
    ITNE1 -- T --> StreamCalc[STREAM CALCULATES A  
SIMPLE RADIAL EQUILIBRIUM  
SOLUTION OF THE FLOW]
    ITNE1 -- F --> ANEST[CALL ANEST]
    ANEST --> IT0[IT=0]
    IT0 --> Return1([RETURN])
    StreamCalc --> SolveEq[SOLVE FLOW EQUATIONS  
WITH CURVATURE EFFECTS]
    SolveEq --> L2Save[L=2  
ISAVE]
    L2Save --> CAXAL[CALL CAXAL]
    CAXAL --> TestD[TEST STATOR D-FACTOR]
    TestD --> TESTDS[TESTDS=DFL(I)-1+SQRT(CX(I,1)**2+CU(I,1)**2+CR(I,1)**2)  
/SQRT(CX(I-1,1)**2+CU(I-1,1)**2+CR(I-1,1)**2)+(CU(I,1)  
-CU(I-1,1))/(SOLID(I)*2.*SQRT(CX(I-1,1)**2+CU(I-1,1)**2  
+CR(I-1,1)**2))  
+SOCO(I,5)*AA) * AA  
SOLID(I,1)=(SOCO(I,1)/AA+SOCO(I,2))/AA+SOCO(I,3)+(SOCO(I,4)  
+SOCO(I,5)*AA)*AA  
AA=(R(I,1)+R(I-1,1))*5]
    TESTDS --> TESTDS0{TESTDS<0.}
    TESTDS0 -- T --> Return2([RETURN])
    TESTDS0 -- F --> LC5[LC5=LC5+1]
    LC5 --> ErrorTrans[ERROR TRANSFER TO A  
NEW DATA SET]
    ErrorTrans --> ERASI{ERASI}
    ERASI -- T --> ErrorCall[CALL ERROR(20)]
    ERASI -- F --> WriteD[WRITE  
D-FACTOR LIMIT  
VIOLATED AT  
STATION I]
    WriteD --> ErrorTrue[iERROR=.TRUE.  
i=i-1]
    ErrorTrue --> AlterB[ALTER B-COEFFICIENT]
    AlterB --> B2CAL[CALL B2CAL3]
    B2CAL --> DetermineFlow[DETERMINE FLOW PARAMETERS]
    DetermineFlow --> Prefit2Call2[CALL PRFIT2]
    Prefit2Call2 --> SatisfyEq[SATISFY CONTINUITY EQUATION]
    SatisfyEq --> CheckRotor[CHECK ROTOR CALCULATION]
    CheckRotor --> RotorCall[CALL ROTOB]
    RotorCall --> Iplus1[i=i+1]
    Iplus1 --> GoTo15((GO  
TO  
15))
    GoTo15 --> LoopStart

```

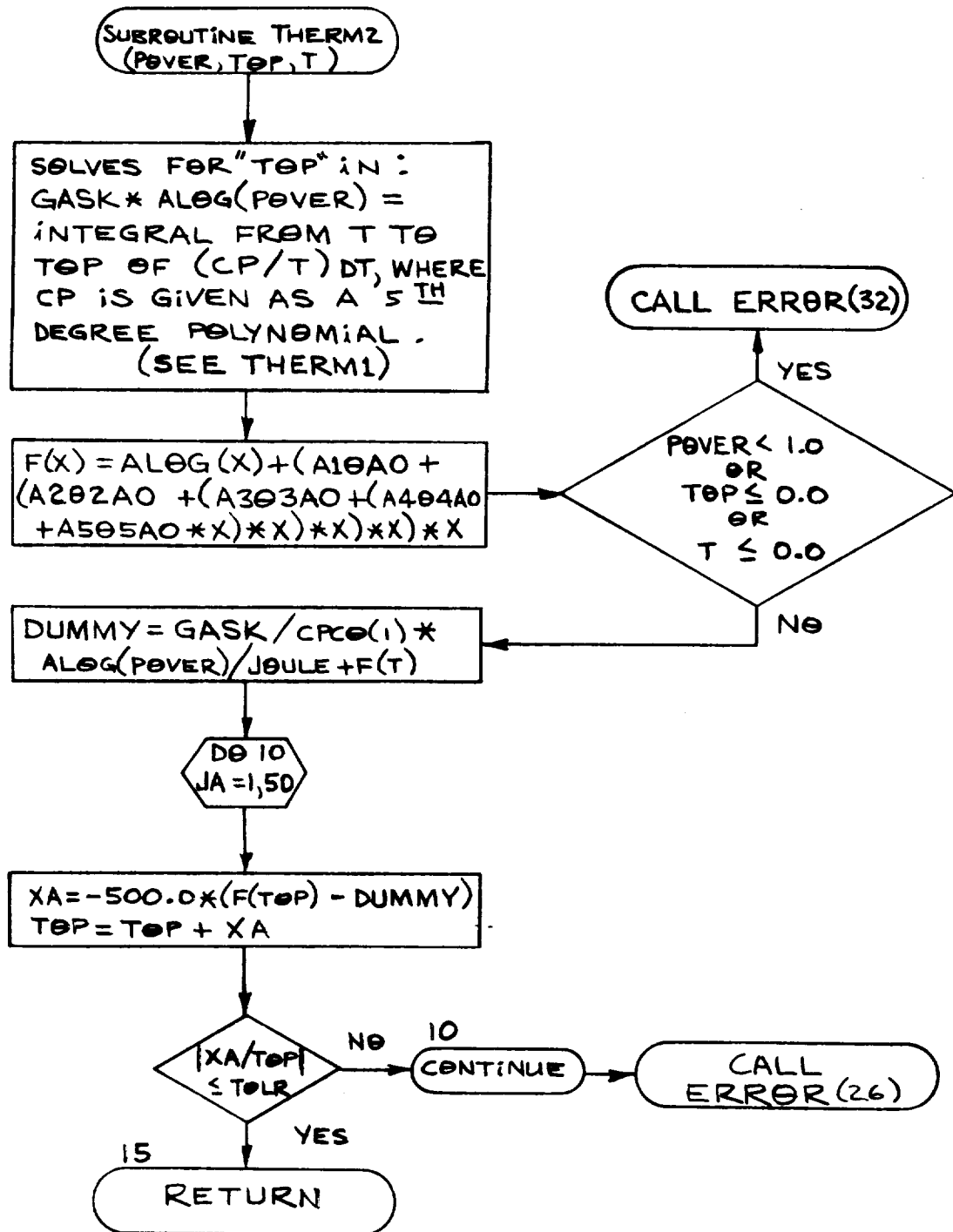
N 35 STREAM S.R.



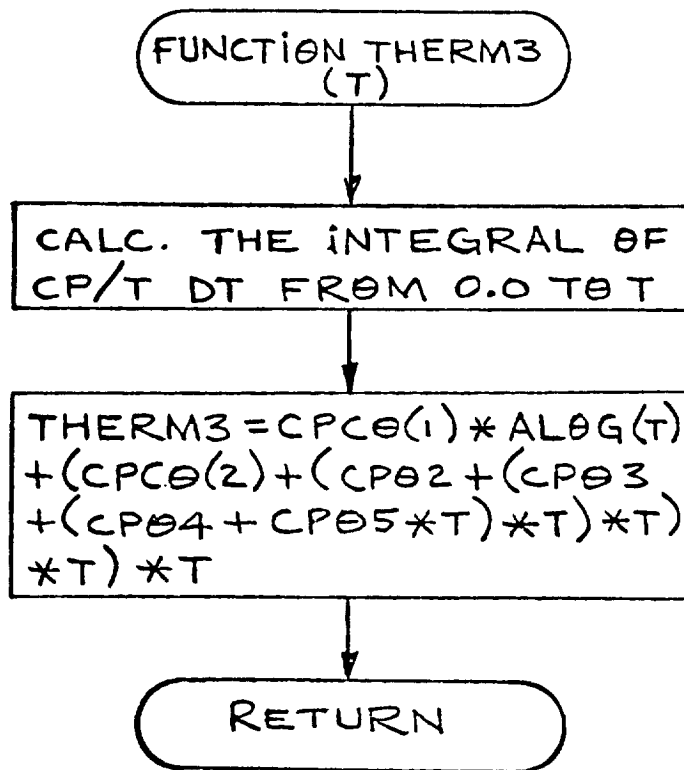
N 35 THERM1 FUNCTION



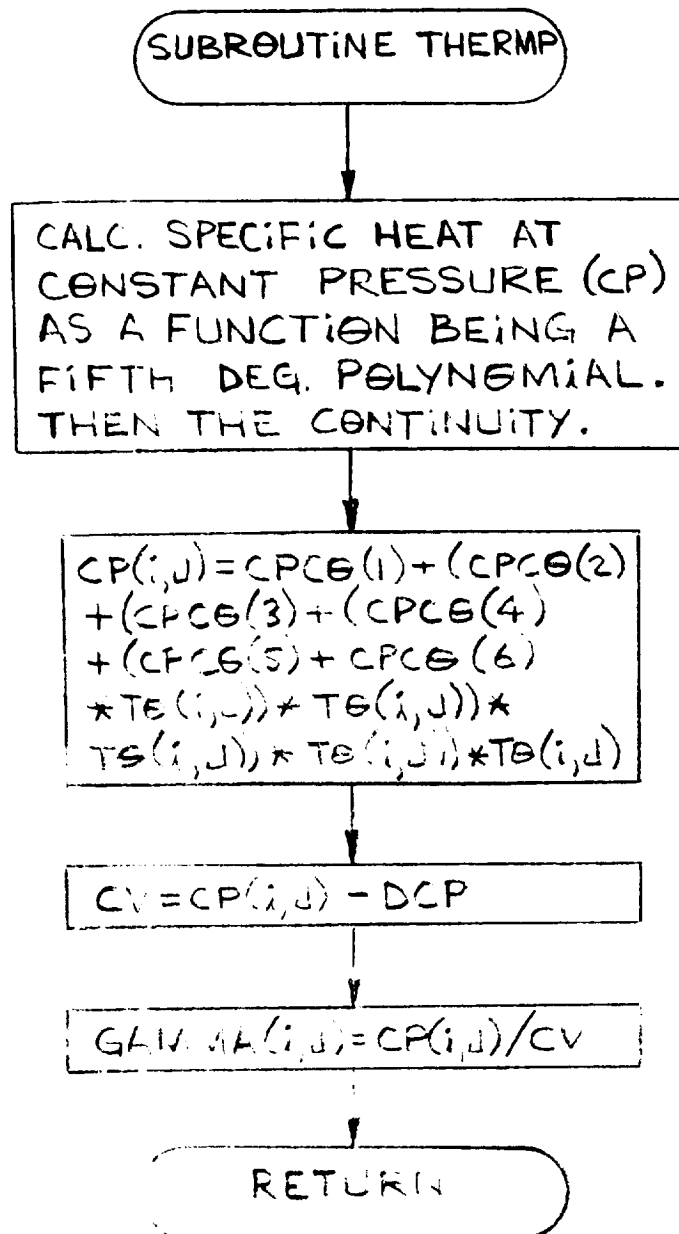
N35 THERM2 S.R.



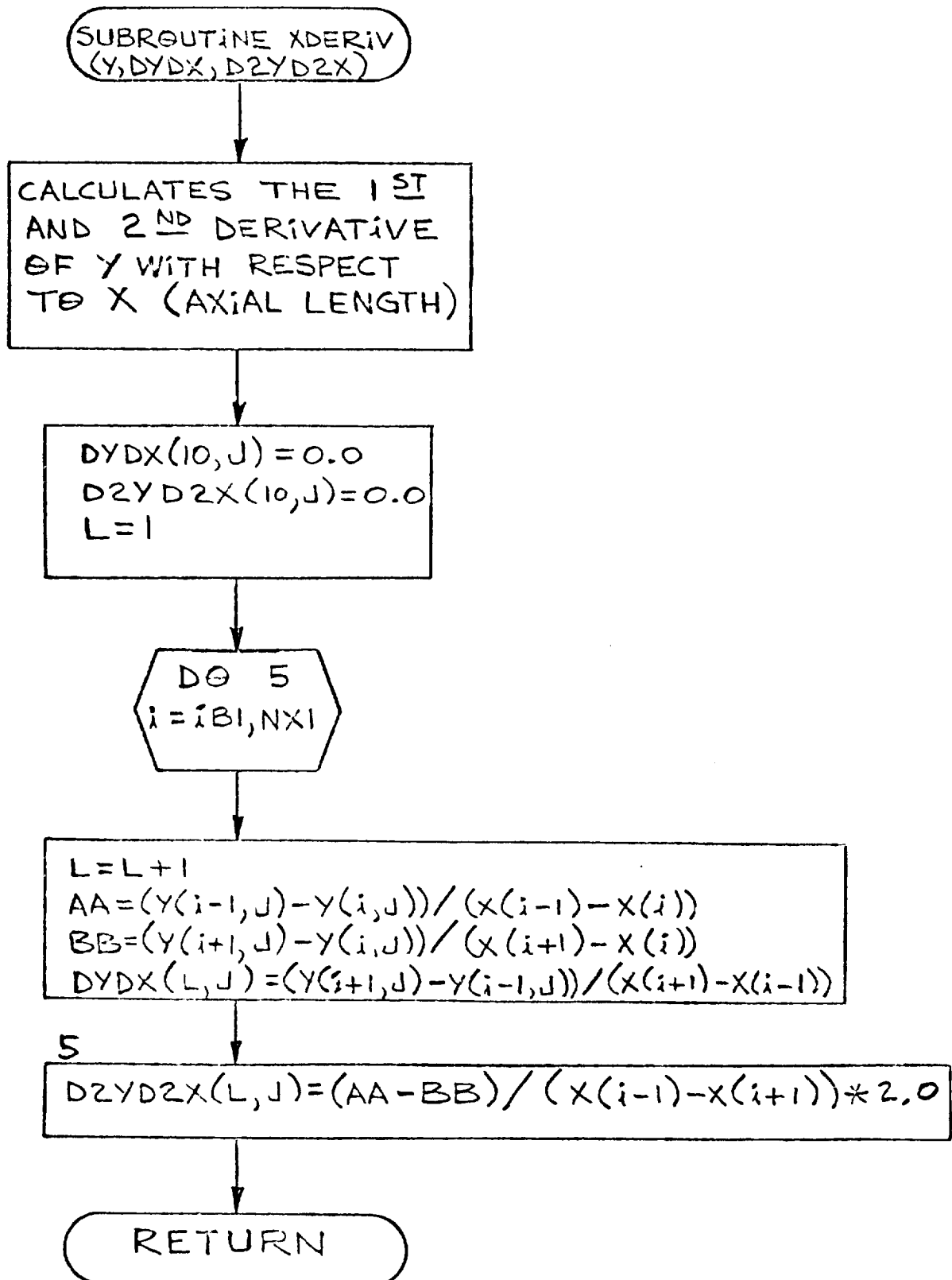
N 35 THERM3 FUNCTION



N 35 THERMP S.R.



N 35 XDERIV S.R.



APPENDIX D

INPUT FORMAT AND SAMPLE DATA SET

APPENDIX D

Part A. Input Format—Data Preparation

N35 DATA PREPARATION

The N35 Program is a compressor design program which iterates on efficiency through blade element loss correlation based on diffusion factor. Energy addition is based on either rotor tip diffusion factor, stator hub Mach number, rotor hub exit relative flow angle, or stator hub diffusion factor. The energy addition can be limited by any one of these variables.

For design, the annulus wall geometry is defined and the aerodynamic properties are computed. The procedure necessary to employ this program is outlined in the following description of input data preparation. Reference is made to the descriptive data sheets.

All data input in each field is specified either as an integer or as a floating point number. The integer must be right adjusted in its field. The noninteger input can be read in as an exponential which will take four columns in each field. This reduces the amount of significant numbers and computing accuracy.

All data cards are displayed by type in the sample data sheet appearing at the end of Part A of this Appendix.

CARD 1—TITLE CARD

Alphanumeric information from Columns 1-72 is printed out at the beginning of the output data.

CARDS 2 AND 3—CONSTANT PRESSURE SPECIFIC HEAT AS FUNCTION OF ABSOLUTE TEMPERATURE

The constant pressure specific heat variable as a function of temperature is determined by:

$$c_p = a_0 + a_1T + a_2T^2 + a_3T^3 + a_4T^4 + a_5T^5$$

where T is in °R. The following sets of constants can be used as derived from Keenan and Kaye gas tables:

<u>Temperature</u>	<u>0 to 1700°R</u>	<u>500 to 3400°R</u>	<u>1500 to 5000°R</u>
a ₀	0.23746571	0.257348261	0.18198209
a ₁	0.21961999 X10 ⁻⁴	-0.82118436 X10 ⁻⁴	0.87076455 X10 ⁻⁴
a ₂	-0.87791471 X10 ⁻⁷	0.11967112 X10 ⁻⁶	-0.28093746 X10 ⁻⁷
a ₃	0.13991136 X10 ⁻⁹	-0.57795091 X10 ⁻¹⁰	0.50606304 X10 ⁻¹¹
a ₄	-0.78056154 X10 ⁻¹³	0.12572563 X10 ⁻¹³	-0.40556182 X10 ⁻¹⁵
a ₅	0.15042604 X10 ⁻¹⁶	-0.10414624 X10 ⁻¹⁷	0.18191946 X10 ⁻¹⁹

CARD 4—LOSS PARAMETER DATA SET BUFFER ZONE

A total of up to ten loss-data sets may be called from the library of permanent data described earlier. A loss-data set consists of the loss parameter $\left(\frac{\bar{\omega}_p \cos \beta'_2}{2\sigma} \right)$ versus diffusion factor at each of the 10, 50, and 90% annulus height stations of the geometric annulus. (For purposes of loss computation, blade height is measured from the hub.) The library may consist of a data deck as this program deck is presently set up or a logical storage unit. The loss-data set is prescribed as an integer and a total of 999 loss-data sets can be defined in the library.

Card 4 is a buffer zone calling up to ten sets of losses. The data sets should be called in the buffer layer in increasing numerical order for read-in time saving. Needed fields in the buffer zone should be filled from left to right with no blank fields to the left of the last used field. However, loss-data sets specified in program data for individual blade rows are identified by an integer describing their location in the buffer zone—(e.g., if loss-data set 015 is retrieved from the master file and stored in the fifth sector of the buffer zone, it is identified as data set 005 when called up in the data for any given blade row).

CARD 5—GENERAL DATA AND OPTIONS

Columns 1 - 5.

The maximum number of compressor stages desired is specified up to a maximum of 12 stages

Columns 6 - 10. Number of streamlines desired for the aerodynamic analysis.

The number that can be specified, which includes the annulus aerodynamic wall boundaries (2), is 5, 7, 9, or 11

Columns 11 - 15. Option on printed output of computed data as a function of streamline position

Options are:

- Integer 1: Print all streamline data computed.
- Integer 2: Print odd number streamline data computed.
- Integer 3: Print hub, mean, and tip streamline data computed.
- Integer 4: Print hub and tip streamline data computed.

Columns 16 - 20. Blank

Columns 21 - 25. Blank

Columns 26 - 30.

Instructions can be given to ensure that each stage has reached a limit on either rotor tip diffusion factor, relative hub exit flow angle, stator hub Mach number, or stator hub diffusion factor. The limit for each value is the value read in. The number "0" is used for this instruction.

Because of the iteration process, the rotor tip diffusion factor may be reduced to a lower value because of rotor hub Mach number limit, for example. If this limit ceases to be a limiting value, the rotor tip diffusion factor can be raised or left to remain at its last reduced value. If this method is desired, then an integer "1" is read in for this instruction.

Summarizing

Number 0: Drive calculation to one of its limits

Integer 1: All parameters will be less than or equal to their input value.

Columns 31 - 40. Desired inlet flow rate in lb_m/sec

Columns 41 - 50. Molecular weight of gas in lb_m/mole

Columns 51 - 60. Inlet total temperature in $^{\circ}\text{R}$

Columns 61 - 70. Inlet total pressure in psia

CARD 6—GENERAL DATA AND CONVERGENCE TOLERANCES

Columns 1 - 10. Desired overall pressure ratio

Calculation will cease when either overall pressure ratio or maximum number of stages from Card 5 is reached.

Columns 11 - 20. Relative error tolerance on iteration for axial velocity

This is used at each streamline and at each axial station. Tolerance indicates accuracy on successive calculations. A recommended value is 0.01. This convergence tolerance is independent of all other tolerances.

Columns 21 - 30. Relative error tolerance on continuity

This is used at each axial station and independent of all other convergence tolerances. A recommended value for this relative error limit is 0.0005.

Columns 31 - 40. Relative error tolerance in iteration for total temperature on each streamline at each axial station

Tolerance indicates accuracy on successive calculations. A recommended value is 0.05 ($^{\circ}\text{R}$). This convergence tolerance is independent of all other tolerances.

Columns 41 - 50. Rotor tip speed (ft/sec) at first rotor inlet defined by geometric axial station and case wall radius

Blade twist and rotor tip clearance are ignored.

Columns 61 - 70. Relative error tolerance in iteration for total enthalpy on each streamline at each axial station

A recommended value for this relative error limit is 0.01.

CARD 7—CONVERGENCE TOLERANCES AND EXIT AREAS

Columns 1 - 10.

Tangential velocity tolerance (B coefficient tolerance) defines the degree of convergence to be obtained during drive option on the B coefficient of whirl velocity.

A recommended tolerance is 0.01.

Columns 11 - 20. Relative error tolerance on rotor and stage adiabatic efficiency for each streamline

A recommended efficiency tolerance is 0.01.

Columns 21 - 30. Relative error tolerance on the stator entrance hub absolute Mach number

A recommended tolerance is 0.01.

Columns 31 - 40. Blank

Columns 41 - 50, 51 - 60, and 61 - 70. Ratio of annulus areas at three axial stations downstream of the last stator exit station to annulus area at the last stator exit station

CARD TYPE 8—FLOW PATH DATA

As many Card Type 8 cards as axial stations are required through the last stage stator exit. There are five inlet stations, the fifth being the first rotor inlet station. For each stage specified in the input data, two additional cards are required. Thus, the maximum number of Card Type 8 cards is 29.

The wall slopes at axial station number one should be zero since the method of analysis assumes them to be zero.

Columns 1 - 10. Axial coordinate station (in.)

Columns 11 - 20. Geometric hub radius (in.)

Columns 21 - 30. Blockage factor at hub expressed as the unblocked fraction of local geometric annulus area

Blockage factor of unity means zero blockage.

Columns 31 - 40. Geometric tip radius (in.)

Columns 41 - 50. Blockage factor at tip

CARD TYPE 9—EXIT STATION DATA

Three exit station cards are required for the exit annulus. The axial station data on these cards will be used if the maximum number of stages entered on Card 5 has been computed. Otherwise, the last three exit station axial locations will be those corresponding to the first three stations of the noncomputed stage data. The exit stations' tip radius is always equal to the last stator out tip radius.

Columns 1 - 10. Axial station location (in.)

Columns 11 - 20. Blank

Columns 21 - 30. Blockage factor at hub

Columns 31 - 40. Blank

Columns 41 - 50. Blockage factor at tip

CARD TYPE 10—STREAMTUBE MASS FLOW

The fractional mass flow to total annulus flow between the hub and each streamline specified on Card 5. Each value is entered in fields of 10 columns. Seven streamline values can be entered on the first Card Type 10. If 9 or 11 streamlines are specified, the additional streamline values are entered on a second Card Type 10. These additional values are entered in Columns 1 - 10 and 11 - 20 for 9 streamlines and Columns 1 - 10, 11 - 20, 21 - 30, and 31 - 40 for 11 streamlines. The first streamline value is obviously equal to zero.

CARD TYPE 11—INLET GUIDE VANE LOSS COEFFICIENTS

The loss coefficient, $\bar{\omega} = (P_{t1} - P_{t2}) / (P_{t1} - P_1)$, for each streamline from hub to tip is specified at axial station 5. Two cards are used, with the data in fields of ten, if more than 7 streamlines are specified as defined for Card Type 10. A value of zero is read in for each streamline if no vanes or zero loss is desired.

CARD TYPE 12—INLET GUIDE VANE WHIRL EXIT DISTRIBUTION

The whirl distribution is given by

$$V_{\theta} = \frac{A}{R^2} + \frac{B}{R} + C + DR + ER^2$$

where V_{θ} is in ft/sec and R is in inches. The tangential velocity is defined as positive in the direction of rotor rotation. A value of zero is read in for each specified constant if no whirl is desired.

CARD TYPE 13—LOADING LIMIT DATA FOR EACH STAGE

Card Types 13 through 20 are placed in sequence as a group of cards for each stage specified on Card 5.

Columns 1 - 10. Rotor tip diffusion factor limit

Columns 11 - 20. Stator hub inlet Mach number limit

Columns 21 - 30. Relative flow angle limit at hub of rotor exit (degrees)

Negative value signifies turning past axial direction.

Columns 31 - 40. Stator hub diffusion factor limit

CARD TYPE 14—BLADE LOSS AND TOTAL MASS FLOW CHANGE

Columns 1 - 5. Rotor loss parameter data set from buffer zone of Card 4 described by an integer identifying the position of the desired loss-data set in the buffer zone

Columns 6 - 10. Stator loss parameter data set from buffer zone of Card 4 described by an integer identifying the position of the desired loss-data set in the buffer zone

Columns 11 - 20. Mass flow added to or subtracted from rotor blade row and/or annulus walls within row (lb_m/sec)

This mass flow change is divided proportionally among stream tubes.

Columns 21 - 30. Mass flow added to or subtracted from stator blade row and/or annulus walls within row (lb_m/sec)

This mass flow change is divided equally among stream tubes.

CARD TYPE 15—ROTOR EXIT TANGENTIAL VELOCITY PROFILE

Tangential velocity (ft/sec) distribution as a function of radius is given by

$$V_{\theta} = \frac{A}{R^2} + \frac{B}{R} + C + DR + ER^2$$

where R is in inches.

Columns 1 - 10. Constant A

Columns 11 - 20. Constant B

Columns 21 - 30. Constant C

Columns 31 - 40. Constant D

Columns 41 - 50. Constant E

CARD TYPE 16—RATIO OF THE SUPERSONIC TURNING TO TOTAL TURNING FOR THE ROTOR

Shock loss calculations require the suction surface Mach number at the incident shock location. Thus, the supersonic turning along the suction surface to shock intersection based on the normal shock model must be specified using

the supersonic turning to total turning ratio, $\frac{\phi_{ss}}{\phi}$. This data is to be es-

tablished along the streamline airfoil section. The method of input is identical

to Card Type 15 where V_{θ} is replaced by $\frac{\phi_{ss}}{\phi}$.

CARD TYPE 17—ROTOR SOLIDITY (Solidity, σ , for the streamline airfoil section as a function of radius)

The method of input is identical to Card Type 15 where V_{θ} is replaced by σ .

CARD TYPE 18—STATOR EXIT TANGENTIAL VELOCITY PROFILE

Is identical procedure to that for the rotor on Card Type 15.

CARD TYPE 19—RATIO OF THE SUPERSONIC TURNING TO TOTAL TURNING
FOR THE STATOR

Is identical procedure to that for the rotor on Card Type 16.

CARD TYPE 20—STATOR SOLIDITY

Is identical procedure to that for the rotor on Card Type 17.

APPENDIX D

Part B. Sample Design Problem Data Set

SECURITY - MARKINGS

☐ UNCLASSIFIED ☐ CONFIDENTIAL ☐ SECRET

☐ RESTRICTED DATA NOTE ☐ ESPIONAGE NOTE ☐ AUTOMATIC DOWNGRADING STAMP

PROBLEM TITLE	EXAMPLE - N35 INPUT DATA SET

JOB NUMBER

RETURN TO

PAGE 1 OF 4

IDENTIFICATION
NUMBER[illegible]

SECURITY - MARKINGS

PROBLEM TITLE	EXAMPLE - N35	INPUT DATA SET																																																				
The following table shows the number of people who visited the museum in each month from January to December. The number of visitors is given in thousands. <table border="1"> <thead> <tr> <th>Month</th> <th>Visitors (thousands)</th> </tr> </thead> <tbody> <tr><td>January</td><td>12</td></tr> <tr><td>February</td><td>15</td></tr> <tr><td>March</td><td>18</td></tr> <tr><td>April</td><td>20</td></tr> <tr><td>May</td><td>22</td></tr> <tr><td>June</td><td>25</td></tr> <tr><td>July</td><td>28</td></tr> <tr><td>August</td><td>30</td></tr> <tr><td>September</td><td>28</td></tr> <tr><td>October</td><td>25</td></tr> <tr><td>November</td><td>22</td></tr> <tr><td>December</td><td>20</td></tr> </tbody> </table> The following table shows the number of people who visited the museum in each month from January to December. The number of visitors is given in thousands. <table border="1"> <thead> <tr> <th>Month</th> <th>Visitors (thousands)</th> </tr> </thead> <tbody> <tr><td>January</td><td>12</td></tr> <tr><td>February</td><td>15</td></tr> <tr><td>March</td><td>18</td></tr> <tr><td>April</td><td>20</td></tr> <tr><td>May</td><td>22</td></tr> <tr><td>June</td><td>25</td></tr> <tr><td>July</td><td>28</td></tr> <tr><td>August</td><td>30</td></tr> <tr><td>September</td><td>28</td></tr> <tr><td>October</td><td>25</td></tr> <tr><td>November</td><td>22</td></tr> <tr><td>December</td><td>20</td></tr> </tbody> </table>			Month	Visitors (thousands)	January	12	February	15	March	18	April	20	May	22	June	25	July	28	August	30	September	28	October	25	November	22	December	20	Month	Visitors (thousands)	January	12	February	15	March	18	April	20	May	22	June	25	July	28	August	30	September	28	October	25	November	22	December	20
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JOB NUMBER

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PAGE 2 OF 4

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IDENTIFICATION
NUMBER[illegible]

ALLISON 7094 COMPUTER DATA SHEET

PROBLEM TITLE	EXAMPLE - N35	INPUT	DATA SET

JOB NUMBER

CHARGE NO

RETURN TO:

PAGE 4 OF 4

IDENTIFICATION
NUMBER

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1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26																																																						

APPENDIX E

OUTPUT FORMAT—SAMPLE DESIGN PROBLEM

12/15/67

***** ADVANCED MULTI-STAGE AXIAL-FLOW COMPRESSOR *****

*** ANALYSIS AT DESIGN CONDITIONS ***

----INPUT DATA----

THE MACHINE IS TO HAVE NO MORE THAN 8 STAGES A TOTAL PRESSURE RATIO OF 9.000 IS DESIRED
 CALCULATIONS ARE TO BE PERFORMED AT 11 STREAMLINES THE INLET TOTAL PRESSURE IS 14.70 LBS/SQ. INCH,
 THE INLET MASS FLOW RATE IS 401.00 LB/SEC THE INLET TOTAL TEMPERATURE IS 518.59 DEG. R
 MOLECULAR WEIGHT OF THE FLUID IS 28.57 THE TIP SPEED IS 1200.0 FT./SEC.
 AXIAL VELOCITY TOLERANCE IS 0.0100 8 COEFFICIENT TOLERANCE IS 0.0010
 THE EFFICIENCY TOLERANCE IS 0.0100 MACH NUMBER TOLERANCE IS 0.0100
 THE CONTINUITY TOLERANCE 0.0005

THE FRACTION OF THE TOTAL MASS FLOW BETWEEN THE HUB AND THE J-TH STREAMLINE IS.

0.000 0.100 0.200 0.300 0.400 0.500 0.600 0.700 0.800 0.900 1.000

THE INLET GUIDE VANE LOSS COEFFICIENTS FOR THE 11 STREAMLINES ARE (FROM HUB TO TIP)

0.0000-0.0000-0.0000-0.0000-0.0000-0.0000-0.0000-0.0000-0.0000-0.0000-0.0000

NOTE ALL POLYNOMIALS (EXCEPT FOR THE SPECIFIC HEAT POLYNOMIAL) ARE OF THE FORM -
 $P(R) = A/R^{**2} + B/R + C + D*R + E*R^{**2}$

A = -0.000000E-38 B = -0.000000E-38 C = 0.000000E-38 D = -0.000000E-38 E = -0.000000E-38

THE SPECIFIC HEAT POLYNOMIAL IS IN THE FOLLOWING FORM

CP = 0.23747E 00 + 0.21962E-04*T + -0.87791E-07*T**2 + 0.13991E-09*T**3 + -0.78036E-13*T**4 + 0.15043E-16*T**5

THE RATIO OF THE AREAS OF THE LAST 3 STATIONS TO THE AREA OF THE LAST STATOR EXIT ARE 0.7400, 0.9300, 0.9200

-----FLOWPATH DESCRIPTION-----

STATION NO.	AXIAL COORDINATE (INCHES)	HUB RADIUS (INCHES)	HUB BLOCKAGE FACTOR	TIP RADIUS (INCHES)	TIP BLOCKAGE FACTOR
1	0.000	7.000	1.000	25.000	1.000
2	3.000	7.415	1.000	25.000	1.000
3	6.000	8.580	1.000	25.000	1.000
4	9.000	10.350	1.000	25.000	1.000
5	12.000	12.500	0.995	25.000	0.995
6	15.125	14.900	0.992	25.000	0.992
7	17.650	16.400	0.990	25.000	0.990
8	20.107	17.750	0.987	25.000	0.987
9	22.178	18.700	0.985	25.000	0.985
10	24.658	19.698	0.982	25.000	0.982
11	26.783	20.522	0.980	25.000	0.980
12	28.575	21.150	0.980	25.000	0.980
13	30.175	21.625	0.980	25.000	0.980
14	31.525	21.991	0.980	25.000	0.980
15	33.100	22.400	0.980	25.000	0.980
16	34.480	22.753	0.980	25.000	0.980
17	35.400	22.948	0.980	25.000	0.980
18	36.800	23.240	0.980	25.000	0.980
19	37.700	23.300	0.980	25.000	0.980
20	39.000	23.300	0.980	25.000	0.980
21	40.000	23.300	0.980	25.000	0.980
22	41.000	-0.000	0.980	-0.000	0.980
23	42.000	-0.000	0.980	-0.000	0.980
24	43.000	-0.000	0.980	-0.000	0.980

.... LOSS DATA SET NUMBER 1

D-FACTOR	AT 10 PERCENT	AT 50 PERCENT	AT 90 PERCENT	(OF BLADE HEIGHT) LOSS (IN GEOMETRIC HUN)
0.000	0.0070	0.0060	0.0030	
0.100	0.0073	0.0060	0.0033	
0.130	0.0076	0.0068	0.0030	
0.200	0.0080	0.0072	0.0036	
0.250	0.0083	0.0077	0.0103	
0.300	0.0090	0.0080	0.0114	
0.350	0.0097	0.0087	0.0127	
0.400	0.0108	0.0097	0.0141	
0.450	0.0121	0.0108	0.0157	
0.500	0.0137	0.0119	0.0180	
0.550	0.0157	0.0134	0.0205	
0.600	0.0182	0.0152	0.0239	
0.650	0.0213	0.0178	0.0265	
0.700	0.0250	0.0204	0.0351	
0.750	0.0290	0.0236	0.0424	
0.800	0.0339	0.0277	0.0515	
0.850	0.0395	0.0330	0.0623	
0.900	0.0464	0.0397	0.0737	
0.950	0.0534	0.0464	0.0924	
1.000	0.0604	0.0531	0.1034	

.... LOSS DATA SET NUMBER 2

D-FACTOR	AT 10 PERCENT	AT 30 PERCENT	AT 90 PERCENT	(OF BLADE HEIGHT FROM THE GEOMETRIC HUB)
0.000	0.0000	0.0000	0.0000	
0.100	0.0000	0.0030	0.0060	
0.150	0.0000	0.0060	0.0060	
0.200	0.0000	0.0072	0.0072	
0.250	0.0000	0.0077	0.0077	
0.300	0.0000	0.0080	0.0080	
0.350	0.0000	0.0089	0.0089	
0.400	0.0000	0.0097	0.0097	
0.450	0.0000	0.0108	0.0108	
0.500	0.0000	0.0119	0.0119	
0.550	0.0000	0.0134	0.0134	
0.600	0.0000	0.0152	0.0152	
0.650	0.0000	0.0176	0.0176	
0.700	0.0000	0.0204	0.0204	
0.750	0.0000	0.0236	0.0236	
0.800	0.0000	0.0277	0.0277	
0.850	0.0000	0.0330	0.0330	
0.900	0.0000	0.0397	0.0397	
0.950	0.0000	0.0464	0.0464	
1.000	0.0000	0.0531	0.0531	

ROTOR TIP D-FACTOR LIMIT VIOLATED AT STATION 5

ROTOR TIP D-FACTOR LIMIT VIOLATED AT STATION 8

ROTOR TIP D-FACTOR LIMIT VIOLATED AT STATION 10

-----STATION NUMBER 1-----

S.L. NO.	STREAMLINE RADIUS (IN.)	ABS. MACH NUMBER	ABS. VEL. (FT/SEC)	AXIAL VEL. (FT/SEC)	RADIAL VEL. (FT/SEC)	STREAMLINE SLOPE (DEGS)	STREAMLINE CURVATURE	FLOW ANGLE (DEGREES)
1	7.0000	0.413	453.78	453.78	0.0000	0.00	0.00	0.0
2	10.3247	0.413	453.78	453.78	0.0000	0.00	0.00	0.0
3	12.6141	0.413	453.78	453.78	0.0000	0.00	0.00	0.0
4	14.8530	0.413	453.78	453.78	0.0000	0.00	0.00	0.0
5	16.7153	0.413	453.78	453.78	0.0000	0.00	0.00	0.0
6	18.3576	0.413	453.78	453.78	0.0000	0.00	0.00	0.0
7	19.8645	0.413	453.78	453.78	0.0000	0.00	0.00	0.0
8	21.2650	0.413	453.78	453.78	0.0000	0.00	0.00	0.0
9	22.5788	0.413	453.78	453.78	0.0000	0.00	0.00	0.0
10	23.8202	0.413	453.78	453.78	0.0000	0.00	0.00	0.0
11	25.0000	0.413	453.78	453.78	0.0000	0.00	0.00	0.0

S.L. NO. STREAMLINE TOTAL PRES. (LB/SC IN.) TOTAL TEMP. (DEGREES)

1	7.0000	14.70	518.65
2	10.3247	14.70	518.65
3	12.8141	14.70	518.65
4	14.8530	14.70	518.65
5	16.7153	14.70	518.65
6	18.3576	14.70	518.65
7	19.8645	14.70	518.65
8	21.2650	14.70	518.65
9	22.5788	14.70	518.65
10	23.8202	14.70	518.65
11	25.0000	14.70	518.65

-----STATION NUMBER 2-----

S.L. NO.	STREAMLINE RADIUS (IN.)	ABS. MACH NUMBER	ABS. VEL. (FT/SEC)	AXIAL VEL. (FT/SEC)	RADIAL VEL. (FT/SEC)	STREAMLINE SLOPE (DEGS)	STREAMLINE CURVATURE	FLOW ANGLE (DEGREES)
1	7.4150	0.268	294.51	264.80	74.7557	14.75	0.08	0.0
2	11.3857	0.350	388.66	374.45	55.2584	14.43	-0.06	0.0
3	13.9234	0.394	453.73	429.21	74.9675	12.55	-0.09	0.0
4	15.9103	0.422	483.55	453.50	75.0217	10.69	-0.10	0.0
5	17.5930	0.442	495.64	478.15	75.3697	9.40	-0.09	0.0
6	19.0768	0.455	497.99	494.27	60.3014	7.01	-0.08	0.0
7	20.4289	0.464	507.65	505.83	47.4387	5.56	-0.05	0.0
8	21.6756	0.471	514.52	513.37	34.4350	3.34	-0.03	0.0
9	22.8430	0.475	518.74	518.27	22.0873	2.44	-0.03	0.0
10	23.9472	0.477	521.02	520.91	10.5772	1.16	-0.01	0.0
11	25.0000	0.478	521.72	521.72	0.0000	0.00	0.00	0.0

S.L. NO. STREAMLINE TOTAL PRES. (LB/SC IN.) TOTAL TEMP. (DEGREES)

1	7.4150	14.70	518.65
2	11.3857	14.70	518.65
3	13.9234	14.70	518.65
4	15.9103	14.70	518.65
5	17.5930	14.70	518.65
6	19.0768	14.70	518.65
7	20.4289	14.70	518.65
8	21.6756	14.70	518.65
9	22.8430	14.70	518.65
10	23.9472	14.70	518.65
11	25.0000	14.70	518.65

----STATION NUMBER 3 ----

S.L. NO.	STREAMLINE RADIUS (IN.)	ABS. MACH NUMBER	ABS. VEL. (FT/SEC)	AXIAL VEL. (FT/SEC)	RADIAL VEL. (FT/SEC)	STREAMLINE SLOPE (DEGS)	STREAMLINE CURVATURE	FLOW ANGLE (DEGREES)
1	8.5800	0.340	374.93	338.79	164.7470	26.07	0.05	0.0
2	11.8684	0.357	456.07	416.87	127.9750	17.20	0.09	0.0
3	14.1605	0.420	407.38	456.00	102.5335	12.87	0.09	0.0
4	16.0261	0.444	400.45	479.40	82.1535	9.75	0.09	0.0
5	17.6438	0.450	458.81	494.55	65.1062	7.74	0.08	0.0
6	19.0557	0.464	507.01	504.49	50.5257	5.94	0.06	0.0
7	20.4276	0.469	512.41	511.01	37.8605	4.43	0.05	0.0
8	21.6675	0.472	515.75	515.10	26.7246	3.12	0.04	0.0
9	22.8345	0.474	517.66	517.39	18.8358	1.96	0.02	0.0
10	23.9420	0.474	518.33	518.20	7.9818	0.93	0.01	0.0
11	25.0000	0.474	517.99	517.99	0.0000	0.00	0.00	0.0

S.L. NO.	STREAMLINE RADIUS (IN.)	TOTAL PRES. (LB/SC IN.)	TOTAL TEMP. (DEGREES)
1	8.5800	14.70	518.65
2	11.8684	14.70	518.65
3	14.1605	14.70	518.65
4	16.0261	14.70	518.65
5	17.6438	14.70	518.65
6	19.0557	14.70	518.65
7	20.4276	14.70	518.65
8	21.6675	14.70	518.65
9	22.8345	14.70	518.65
10	23.9420	14.70	518.65
11	25.0000	14.70	518.65

----STATION NUMBER 4 ----

S.L. NO.	STREAMLINE RADIUS (IN.)	ABS. MACH NUMBER	ABS. VEL. (FT/SEC)	AXIAL VEL. (FT/SEC)	RADIAL VEL. (FT/SEC)	STREAMLINE SLOPE (DEGS)	STREAMLINE CURVATURE	FLOW ANGLE (DEGREES)
1	10.3500	0.358	395.05	328.40	219.5628	33.78	0.03	0.0
2	13.2425	0.423	464.58	421.50	194.5050	24.75	0.00	0.0
3	15.2944	0.464	507.61	479.15	167.5850	19.28	-0.02	0.0
4	16.9633	0.492	536.70	517.33	141.0659	15.34	-0.02	0.0
5	18.4080	0.512	557.13	544.90	115.8144	12.00	-0.03	0.0
6	19.7040	0.525	571.58	564.11	92.0716	9.27	-0.03	0.0
7	20.9323	0.539	581.58	577.37	74.6557	6.90	-0.02	0.0
8	22.0023	0.542	586.14	586.03	49.1607	4.60	-0.02	0.0
9	23.0486	0.546	591.54	591.19	29.8951	2.90	-0.01	0.0
10	24.0448	0.547	593.51	593.39	11.9917	1.16	-0.01	0.0
11	25.0000	0.547	593.24	593.22	-4.6383	-0.45	-0.01	0.0

S.L. NO.	STREAMLINE RADIUS (IN.)	TOTAL PRES. (LB/SC IN.)	TOTAL TEMP. (DEGREES)
1	10.3500	14.70	518.65
2	13.2425	14.70	518.65
3	15.2944	14.70	518.65
4	16.9633	14.70	518.65
5	18.4080	14.70	518.65
6	19.7040	14.70	518.65
7	20.9323	14.70	518.65
8	22.0023	14.70	518.65
9	23.0486	14.70	518.65
10	24.0448	14.70	518.65
11	25.0000	14.70	518.65

-----STATION NUMBER 5 ----- (INLET GUIDE VANE EXIT)

S.L. NC.	STREAMLINE RADIUS (IN.)	ABS. MACH NUMBER	ABS. VEL. (FT/SEC)	AXIAL VEL. (FT/SEC)	RADIAL VEL. (FT/SEC)	STREAMLINE SLOPE (DEG)	STREAMLINE CURVATURE	FLOW ANGLE (DEGREES)
1	12.5934	0.529	574.45	457.29	347.7472	37.25	0.00	-3.0
2	14.6340	0.558	604.53	556.20	279.1901	27.55	0.00	-0.0
3	16.2594	0.576	622.90	580.56	224.7113	21.22	0.03	-0.0
4	17.6611	0.588	635.10	605.03	180.0707	16.57	0.04	-0.0
5	18.7194	0.596	643.60	627.64	142.4275	12.69	0.02	-0.0
6	20.0755	0.603	649.72	640.38	109.7567	9.62	0.03	-0.0
7	21.1539	0.607	654.12	649.10	80.8909	7.19	0.02	-0.0
8	22.1710	0.610	657.21	654.89	55.1872	4.99	0.02	-0.0
9	23.1380	0.612	659.26	658.48	32.1837	2.85	0.01	-0.0
10	24.0633	0.613	660.50	660.40	11.5625	1.03	0.01	-0.0
11	24.9531	0.614	661.02	661.05	-6.9675	-0.60	0.00	-0.0

S.L. NC.	STREAMLINE RADIUS (IN.)	TOTAL PRES. (LB/SQ. IN.)	TOTAL TEMP. (DEGREES)	REL. VEL. (FT/SEC)	WIRL VEL. (FT/SEC)	RELATIVE MACH NO.	REL. FLOW ANG. (DEG)	WHEEL SPEED (FT/SEC)
1	12.5934	14.70	518.69	833.93	-0.00	0.767	46.457	504.483
2	14.6340	14.70	518.69	926.77	-0.00	0.855	49.255	702.461
3	16.2594	14.70	518.69	958.55	-0.00	0.923	51.405	780.450
4	17.6611	14.70	518.69	1059.25	-0.00	0.981	52.161	847.735
5	18.9194	14.70	518.69	1113.07	-0.00	1.032	54.674	908.132
6	20.0755	14.70	518.69	1162.20	-0.00	1.078	56.010	963.623
7	21.1539	14.70	518.69	1207.85	-0.00	1.121	57.210	1015.389
8	22.1710	14.70	518.69	1250.78	-0.00	1.151	58.302	1064.209
9	23.1380	14.70	518.69	1291.56	-0.00	1.199	59.307	1110.626
10	24.0633	14.70	518.69	1330.56	-0.00	1.235	60.237	1155.040
11	24.9531	14.70	518.69	1368.06	-0.00	1.270	61.104	1197.743

***** FINAL FLOW PARAMETERS FOR STAGE NUMBER 1 *****

*** STAGE INPUT PARAMETERS ***

KLICK TIP D-FACTOR LIMIT 0.3500
 HUB RELATIVE FLOW ANGLE LIMIT AT THE ROTOR EXIT 20.0
 STATOR HUB MACH NUMBER LIMIT (IN) 0.7300
 STATOR HUB D-FACTOR LIMIT 0.4700

---ROTOR---

---STATOR---

	WHIRL VELOCITY	RATIO SUPERSONIC TO TOTAL TURNING	SOLIDITY	WHIRL VELOCITY	RATIO SUPERSONIC TO TOTAL TURNING	SOLIDITY
A	0.271602E 06	-0.000000E-38	0.376419E 03	A	0.000000E-38	0.583418E 03
B	-0.741389E 05	-0.857658E 01	0.231419E 02	B	-0.000000E-38	-0.872248E 02
C	0.671981E 04	0.631310E 00	-0.42745E 01	C	-0.000000E-38	0.251534E 00
D	-0.250782E 03	0.347610E-01	0.267885E 00	D	-0.000000E-38	-0.486280E-01
E	0.363706E 01	-0.000000E-38	-0.425900E-02	E	-0.000000E-38	-0.140000E-03

*** STAGE SCALER QUANTITIES ***

	ASPECT RATIO	GEOMETRIC RADIUS (IN.)	HUB RADIUS (IN.)	GEOMETRIC TIP RAD. (IN.)	HUB ANGLE (DEG)	TIP RAMP ANGLE (DEG)	AXIAL LENGTH (IN.)	MASS FLOW (LB/SEC)	MASS AVE. ADIABATIC EFF.
-ROTOR--	4.000	14.9000	25.0000	37.524	0.000	0.000	3.1250	401.0000	0.9006
-STATOR-	4.000	16.4000	25.0000	30.713	0.000	0.000	2.5250	401.0000	0.8879

	VEL. RATIO AT THE MEAN	HUB BLOCKAGE FACTOR	TIP BLOCKAGE FACTOR	MASS AVE. PR. RATIO	MASS AVE. TEMP. RATIO	CUMULATIVE MASS AVE. PR. RATIO	CUMULATIVE MASS AVE. TEMP. RATIO	MASS AVE. ADIABATIC EFF.
-ROTOR--	0.925	0.9920	0.9920	1.4143	1.1157	1.4143	1.1157	0.9006
-STATOR-	1.102	0.9900	0.9900	1.4077	1.1157	1.4077	1.1157	0.8879

LOSS DATA
SET USED

-ROTOR-- 1
 -STATOR- 2

D COEFFICIENT OF WHIRL VELOCITY AT ROTOR EXIT = -0.74447774E 05

***** R E T U R N E X I T *****

S.L. NO.	STREAMLINE	AXIAL VEL. (FT/SEC)	WHIRL VEL. (FT/SEC)	RADIAL VEL. (FT/SEC)	ABS. VEL. (FT/SEC)	ABS. MACH NUMBER	AJS. FLOW ANGLE (DEG)	REL. FLOW ANGLE (DEG)
1	15.0078	500.523	464.55	346.79	765.896	0.6814	37.340	22.769
2	16.4373	536.405	427.68	282.28	741.336	0.6579	35.205	30.799
3	17.6727	558.461	402.54	222.26	726.541	0.6429	33.645	36.390
4	18.7852	572.043	383.75	190.19	714.613	0.6311	32.480	40.668
5	19.8094	583.349	369.27	154.38	707.452	0.6237	31.465	43.944
6	20.7645	592.060	358.13	122.38	702.685	0.6136	30.641	46.556
7	21.6660	597.036	349.79	93.60	698.179	0.6157	30.066	48.798
8	22.5259	599.093	343.54	66.60	693.947	0.6090	29.711	50.735
9	23.3534	598.515	340.39	41.19	689.770	0.6041	29.570	52.455
10	24.1549	596.303	339.05	16.41	686.200	0.5997	29.610	53.975
11	24.5354	592.782	339.88	-2.56	683.513	0.5957	29.828	55.329

S.L. NO.	TOTAL TEMP. RATIO	TOTAL PRES. RATIO	ADIABATIC EFFICIENCY	DIFFUSION FACTOR	WHEEL SPEED (FT/SEC)	SOLIDITY	A*/S	LOSS COEFF.
1	1.1074	1.4123	0.9856	0.2957	720.37	2.279	0.6541	0.0395
2	1.1080	1.4131	0.9625	0.3344	786.59	1.921	0.6421	0.0393
3	1.1091	1.4136	0.9543	0.3446	843.29	1.727	0.6295	0.0437
4	1.1105	1.4128	0.9356	0.3466	901.09	1.606	0.6165	0.0517
5	1.1121	1.4138	0.9275	0.3453	950.65	1.524	0.5998	0.0572
6	1.1140	1.4152	0.9151	0.3388	996.70	1.455	0.5824	0.0631
7	1.1163	1.4155	0.8979	0.3354	1039.97	1.419	0.5659	0.0719
8	1.1190	1.4152	0.8771	0.3332	1081.24	1.382	0.5505	0.0829
9	1.1222	1.4145	0.8528	0.3323	1120.96	1.351	0.5356	0.0961
10	1.1260	1.4142	0.8264	0.3326	1159.44	1.323	0.5214	0.1108
11	1.1306	1.4145	0.7982	0.3345	1196.90	1.298	0.5078	0.1270

S.L. NO.	TOTAL TEMP. (DEGREES)	TOTAL PRES. (LB/SQ IN.)	STATIC TEMP. (DEGREES)	STATIC PRES. (LB/SQ IN.)	SLOPE (DEGREES)	CURVATURE /IN.	REL. VEL. (FT/SEC)	REL. MACH NUMBER
1	574.42	20.75	525.58	15.21	34.72	-0.035	560.4820	0.5876
2	574.70	20.77	528.89	15.53	27.76	-0.023	705.6040	0.6258
3	575.28	20.78	531.34	15.73	22.59	-0.023	751.3444	0.6648
4	576.00	20.76	533.49	15.88	18.39	-0.018	794.7717	0.7018
5	576.85	20.78	535.19	15.98	14.83	-0.014	838.6731	0.7389
6	577.84	20.80	536.75	16.06	11.63	-0.010	879.3642	0.7742
7	579.02	20.80	538.45	16.13	8.85	-0.006	917.3027	0.8053
8	580.42	20.80	540.34	16.19	6.28	-0.003	952.3621	0.8357
9	582.08	20.79	542.48	16.24	3.92	-0.000	984.4825	0.8622
10	584.06	20.78	544.88	16.30	1.77	0.001	1014.2722	0.8864
11	586.42	20.75	547.57	16.35	-0.25	0.001	1042.6557	0.9084

***** S I A T U R E K I T *****

S.L. NO.	STREAMLINE RADIUS (IN.)	AXIAL VEL. (FT/SEC)	TWIRL VEL. (FT/SEC)	RADIAL VEL. (FT/SEC)	ABS. VEL. (FT/SEC)	ABS. MACH NUMBER	ABS. FLOW ANGLE (DEG)	REL. FLOW ANGLE (DEG)
1	16.5062	588.491	0.00	5.7.28	678.293	0.5975	0.000	49.426
2	17.6031	610.448	0.00	280.29	771.723	0.5912	0.000	51.524
3	18.6096	625.807	0.00	233.51	867.934	0.5873	0.000	53.212
4	19.5400	639.631	0.00	192.88	964.244	0.5834	0.000	54.694
5	20.4150	644.681	0.00	157.42	1063.522	0.5824	0.000	55.693
6	21.2435	652.335	0.00	125.49	1164.296	0.5825	0.000	56.917
7	22.0339	657.558	0.00	96.09	1264.542	0.5821	0.000	57.858
8	22.7533	661.158	0.00	68.90	1364.739	0.5815	0.000	58.718
9	23.5266	663.507	0.00	43.63	1464.941	0.5809	0.000	59.510
10	24.2376	665.364	0.00	20.04	1565.866	0.5807	0.000	60.216
11	24.9287	667.605	0.00	-2.17	1667.312	0.5812	0.000	60.834

S.L. NO.	TOTAL TEMP. RATIO	TOTAL PRES. RATIO	ADIABATIC EFFICIENCY	DIFFUSION FACTOR	WHEEL SPEED (FT/SEC)	SOLIDITY	A*/S	LOSS COEFF.
1	1.0000	0.9922	0.9424	0.2791	752.39	1.843	0.7172	0.0290
2	1.0000	0.9936	0.9433	0.2726	845.19	1.621	0.7241	0.0254
3	1.0000	0.9944	0.9375	0.2651	933.26	1.471	0.7287	0.0230
4	1.0000	0.9950	0.9253	0.2678	1019.69	1.362	0.7309	0.0213
5	1.0000	0.9954	0.9149	0.2662	1099.92	1.273	0.7343	0.0199
6	1.0000	0.9957	0.9032	0.2650	1179.69	1.212	0.7372	0.0189
7	1.0000	0.9960	0.8869	0.2647	1257.65	1.156	0.7381	0.0180
8	1.0000	0.9962	0.8669	0.2651	1334.06	1.111	0.7374	0.0173
9	1.0000	0.9965	0.8434	0.2664	1409.28	1.071	0.7350	0.0167
10	1.0000	0.9965	0.8176	0.2681	1483.41	1.039	0.7315	0.0162
11	1.0000	0.9967	0.7901	0.2704	1556.58	1.003	0.7269	0.0157

S.L. NO.	TOTAL TEMP. (DEGREES)	TOTAL PRES. (LB/SQ IN.)	STATIC TEMP. (DEGREES)	STATIC PRES. (LB/SQ IN.)	SLOPE (DEGREES)	CURVATURE /IN.	REL. VFL. (FT/SEC)	REL. MACH NUMBER
1	574.42	20.55	536.12	16.18	29.32	-0.011	1043.0571	0.9189
2	574.70	20.63	537.14	16.29	24.93	-0.002	1079.6102	0.9502
3	575.23	20.66	538.14	16.36	20.50	0.002	1115.3811	0.9607
4	576.00	20.68	539.28	16.40	16.92	0.004	1149.9112	1.0095
5	576.85	20.68	540.20	16.44	13.77	0.004	1183.4844	1.0386
6	577.84	20.71	541.12	16.48	10.93	0.003	1215.9852	1.0671
7	579.02	20.72	542.20	16.47	8.35	0.001	1249.6775	1.0941
8	580.42	20.72	543.64	16.48	5.93	-0.001	1280.1830	1.1200
9	582.08	20.71	545.28	16.48	3.79	-0.002	1310.5014	1.1448
10	584.06	20.71	547.17	16.48	1.74	-0.002	1340.4815	1.1690
11	586.42	20.72	549.31	16.48	-0.19	-0.000	1370.3175	1.1927

-- FINAL FLOW PARAMETERS FOR STAGE NUMBER 2 ***--***

*** STAGE INPUT PARAMETERS ***

ROTOR TIP D-FACTOR LIMIT 0.4000
 HUB RELATIVE FLOW ANGLE LIMIT AT THE ROTOR EXIT 20.0
 STATOR HUB MACH NUMBER LIMIT (IN) 0.7300
 STATOR HUB D-FACTOR LIMIT 0.4700

---ROTOR---

---STATOR---

	WHEEL VELOCITY	RATIO SUPERSONIC TO TOTAL TURNING	SOLIDITY	WHEEL VELOCITY	RATIO SUPERSONIC TO TOTAL TURNING	SOLIDITY
A	0.81324E 06	-0.00000E-38	0.14360E 04	A	0.00000E-38	-0.00000E-38
B	-0.16361E 06	-0.24233E 02	-0.15339E 03	B	-0.00000E-38	0.43102E 02
C	0.13923E 05	0.18160E 01	0.87714E 01	C	-0.00000E-38	-0.41067E 01
D	-0.50786E 03	0.99900E-02	-0.18777E 00	D	-0.00000E-38	0.11553E 00
E	0.70718E 01	-0.00000E-38	0.16960E-02	E	-0.00000E-38	-0.00000E-38

*** STAGE SCALER QUANTITIES ***

	ASPECT RATIO	GEOMETRIC RADIUS (IN.)	HUB RADIUS (IN.)	HUB RAMP ANGLE (DEG)	TIP RAMP ANGLE (DEG)	AXIAL LENGTH (IN.)	MASS FLOW (LB/SEC)	MASS AVE. ADIABATIC EFF.
-ROTOR--	3.500	17.7500	25.0000	23.787	0.000	2.4570	401.0000	0.9036
-STATOR--	3.501	18.7000	25.0000	24.642	0.000	2.0710	401.0000	0.8907

	VEL. RATIO AT THE MEAN	HUB BLOCKAGE FACTOR	TIP BLOCKAGE FACTOR	MASS AVE. PR. RATIO	MASS AVE. TEMP. RATIO	CUMULATIVE MASS AVE. PR. RATIO	CUMULATIVE MASS AVE. TEMP. RATIO	CUMULATIVE MASS AVE. ADIABATIC EFF.
-ROTOR--	0.909	0.5870	0.5870	1.4444	1.1229	2.0360	1.2526	0.8903
-STATOR--	1.088	0.5850	0.5850	1.4350	1.1229	2.0257	1.2525	0.8833

LOSS DATA
SET USED

-ROTOR-- 1
 -STATOR-- 2

B COEFFICIENT OF WHEEL VELOCITY AT ROTOR EXIT = -0.16364160E 00

***** K O T O R L X I T *****

S.L. NO.	STREAMLINE RADIUS (IN.)	AXIAL VEL. (FT/SEC)	WHIRL VEL. (FT/SEC)	RADIAL VEL. (FT/SEC)	ABS. VEL. (FT/SEC)	ABS. MACH NUMBER	ANG. FLOW ANGLE (DEG)	REL. FLOW ANGLE (DEG)
1	17.8631	565.674	479.80	287.58	725.549	0.6632	37.033	30.750
2	15.7276	574.926	459.28	244.25	775.333	0.5496	36.325	35.138
3	19.5355	580.724	442.31	206.24	728.500	0.5340	35.668	38.795
4	20.3008	583.267	428.09	172.60	743.509	0.6200	35.145	41.923
5	21.0300	588.635	416.31	142.05	754.827	0.6114	34.509	44.407
6	21.7266	593.254	406.84	114.34	768.583	0.6046	33.656	46.472
7	22.3971	594.542	399.54	88.05	774.708	0.5979	33.014	48.340
8	23.0478	594.015	394.31	63.41	775.739	0.5912	33.427	50.002
9	23.6830	591.250	391.15	40.28	770.071	0.5849	33.426	51.523
10	24.3062	588.466	390.11	18.72	766.108	0.5796	33.537	53.642
11	24.9193	584.631	391.25	-1.46	763.636	0.5754	33.782	55.657

S.L. NO.	TOTAL TEMP. RATIO	TOTAL PRES. RATIO	ADIABATIC EFFICIENCY	DIFFUSION FACTOR	WHEEL SPEED (FT/SEC)	SOLIDITY	A*/S	LOSS COEFF.
1	1.1190	1.4455	0.9390	0.3923	657.43	1.982	0.6553	0.0569
2	1.1191	1.4488	0.9369	0.3952	638.93	1.827	0.6350	0.0578
3	1.1193	1.4470	0.9318	0.3953	597.70	1.712	0.6176	0.0506
4	1.1198	1.4457	0.9258	0.3937	574.44	1.632	0.6004	0.0635
5	1.1205	1.4460	0.9212	0.3892	1009.44	1.550	0.5842	0.0648
6	1.1215	1.4463	0.9145	0.3848	1042.88	1.491	0.5701	0.0677
7	1.1228	1.4458	0.9050	0.3822	1075.00	1.442	0.5568	0.0733
8	1.1244	1.4457	0.8914	0.3808	1106.29	1.399	0.5437	0.0802
9	1.1266	1.4447	0.8738	0.3806	1136.78	1.363	0.5320	0.0899
10	1.1292	1.4446	0.8555	0.3815	1166.70	1.331	0.5209	0.1009
11	1.1325	1.4444	0.8341	0.3837	1196.13	1.302	0.5112	0.1141

S.L. NO.	TOTAL TEMP. (DEGREES)	TOTAL PRES. (LB/SQ IN.)	STATIC TEMP. (DEGREES)	STATIC PRES. (LB/SQ IN.)	SLOPE (DEGREES)	CURVATURE /IN.	REL. VEL. (FT/SEC)	REL. MACH NUMBER
1	642.77	29.85	590.21	22.13	26.55	-0.029	736.4404	0.6202
2	643.14	29.85	593.22	22.52	23.02	-0.023	753.6619	0.6399
3	643.93	29.90	596.16	22.81	19.50	-0.017	790.6907	0.6608
4	645.00	29.87	599.09	23.05	16.44	-0.012	817.4821	0.6815
5	646.35	29.91	601.53	23.24	13.57	-0.009	847.6274	0.7053
6	648.03	29.95	603.99	23.40	10.71	-0.003	877.2482	0.7284
7	650.10	29.95	606.67	23.53	8.45	0.000	904.1962	0.7493
8	652.64	29.95	610.13	23.64	6.10	0.003	927.4027	0.7679
9	655.76	29.92	613.92	23.74	3.50	0.004	952.4510	0.7845
10	659.54	29.92	618.10	23.83	1.82	0.004	974.4299	0.7969
11	664.11	29.92	622.05	23.91	-0.14	0.001	994.6176	0.8135

***** S T A T I C R E X I T *****

S.L. NO.	STREAMLINE	AXIAL VEL. (FT/SEC)	WHEEL VEL. (FT/SEC)	RADIAL VEL. (FT/SEC)	ABS. VEL. (FT/SEC)	ABS. MACH NUMBER	ABS. FLOW ANGLE (DEG)	REL. FLOW ANGLE (DEG)
1	18.0101	613.341	0.00	260.52	660.378	0.5525	0.000	51.571
2	19.5219	622.289	0.00	226.56	662.250	0.5487	0.000	54.764
3	20.2179	628.362	0.00	194.95	658.119	0.5447	0.000	55.857
4	20.8757	632.311	0.00	165.23	653.942	0.5402	0.000	56.887
5	21.5082	639.146	0.00	138.41	653.962	0.5400	0.000	57.548
6	22.1167	645.742	0.00	113.01	655.557	0.5406	0.000	58.304
7	22.7051	649.866	0.00	88.36	655.845	0.5400	0.000	58.961
8	23.2770	653.272	0.00	64.72	656.470	0.5394	0.000	59.564
9	23.8353	654.983	0.00	41.97	656.327	0.5380	0.000	60.159
10	24.3819	657.736	0.00	20.22	658.047	0.5376	0.000	60.652
11	24.9173	661.075	0.00	-0.71	661.076	0.5385	0.000	61.069

S.L. NO.	TOTAL TEMP. RATIO	TOTAL PRES. RATIO	ADIABATIC EFFICIENCY	DIFFUSION FACTOR	WHEEL SPEED (FT/SEC)	SOLIDITY	A*/S	LOSS COEFF.
1	1.0000	0.9924	0.9167	0.3416	902.88	1.683	0.7125	0.0295
2	1.0000	0.9933	0.9193	0.3356	937.53	1.564	0.7092	0.0270
3	1.0000	0.9940	0.9159	0.3291	970.45	1.485	0.7057	0.0253
4	1.0000	0.9945	0.9114	0.3230	1002.03	1.428	0.7015	0.0240
5	1.0000	0.9949	0.9076	0.3150	1032.39	1.364	0.7012	0.0229
6	1.0000	0.9952	0.9019	0.3078	1061.60	1.345	0.7014	0.0219
7	1.0000	0.9955	0.8922	0.3031	1089.84	1.307	0.6993	0.0211
8	1.0000	0.9957	0.8806	0.3003	1117.30	1.267	0.6961	0.0203
9	1.0000	0.9959	0.8636	0.3013	1144.10	1.224	0.6916	0.0196
10	1.0000	0.9961	0.8451	0.3034	1170.23	1.177	0.6868	0.0190
11	1.0000	0.9963	0.8254	0.3062	1196.03	1.125	0.6817	0.0163

S.L. NO.	TOTAL TEMP. (DEGREES)	TOTAL PRES. (LB/SQ IN.)	STATIC TEMP. (DEGREES)	STATIC PRES. (LB/SQ IN.)	SLOPE (DEGREES)	CURVATURE /IN.	REL. VEL. (FT/SEC)	REL. MACH NUMBER
1	642.77	29.62	605.971	24.08	23.01	-0.020	1122.1673	0.9303
2	643.14	29.65	606.473	24.20	20.01	-0.019	1147.5435	0.9310
3	643.93	29.72	607.98	24.23	17.24	-0.013	1172.5675	0.9705
4	645.00	29.70	609.455	24.30	14.90	-0.012	1196.3227	0.9889
5	646.35	29.75	610.86	24.40	12.24	-0.011	1222.0882	1.0091
6	648.03	29.81	612.36	24.44	9.74	-0.010	1247.3968	1.0250
7	650.10	29.82	614.40	24.46	7.76	-0.010	1271.9627	1.0473
8	652.64	29.82	616.89	24.47	5.57	-0.009	1295.8761	1.0646
9	655.76	29.80	620.602	24.48	3.63	-0.007	1318.9844	1.0811
10	659.54	29.80	623.62	24.48	1.77	-0.005	1342.5451	1.0974
11	664.11	29.81	627.57	24.48	-0.06	-0.003	1366.5673	1.1132

-- FINAL FLOW PARAMETERS FOR STAGE NUMBER 3 ***--***

*** STAGE INPUT PARAMETERS ***

ROTOR TIP D-FACTOR LIMIT 0.4500
 HUB RELATIVE FLOW ANGLE LIMIT AT THE ROTOR EXIT 20.0
 STATOR HUB MACH NUMBER LIMIT (IN) 0.7300
 STATOR HUB D-FACTOR LIMIT 0.4700

---STATOR---

---ROTOR---

	WHIRL VELOCITY	RATIO SUPERSONIC TO TOTAL TURNING	SOLIDITY	WHIRL VELOCITY	RATIO SUPERSONIC TO TOTAL TURNING	SOLIDITY
A	0.119295E 08	-0.000000E-38	0.853552E 04	A	0.000000E-38	-0.000000E-38
B	-0.219518E 07	-0.472508E 02	-0.162785E 04	B	-0.000000E-38	0.232751E 02
C	0.153435E 06	0.383750E 01	0.121925E 03	C	-0.000000E-38	-0.205989E 01
D	-0.476522E 04	-0.366390E-01	-0.398086E 01	D	-0.000000E-38	0.637280E-01
E	0.558120E 02	-0.000000E-38	0.485580E-01	E	-0.000000E-38	-0.000000E-38

*** STAGE SCALER QUANTITIES ***

	ASPECT RATIO	GEOMETRIC HUB RADIUS (IN.)	GEOMETRIC TIP RAD. (IN.)	HUB RAMP ANGLE (DEG)	TIP RAMP ANGLE (DEG)	AXIAL LENGTH (IN.)	MASS FLOW (LB/SEC)	MASS AVE. ADIABATIC EFF.
-ROTOR--	2.540	19.6880	25.0000	21.724	0.000	2.4800	401.0000	0.9050
-STATOR--	2.500	20.5220	25.0000	21.429	0.000	2.1250	401.0000	0.8931

	VEL. RATIO AT THE MEAN	HUB BLOCKAGE FACTOR	TIP BLOCKAGE FACTOR	MASS AVE. PR. RATIO	MASS AVE. TEMP. RATIO	CUMULATIVE MASS AVE. TEMP. RATIO	CUMULATIVE MASS AVE. ADIABATIC EFF.
-ROTOR--	0.928	0.9820	0.9820	1.4780	1.1297	2.9941	1.4152
-STATOR--	1.124	0.9800	0.9800	1.4704	1.1297	2.9787	1.4152

LOSS DATA
SET USED

-ROTOR-- 1
 -STATOR-- 2

COEFFICIENT OF WHIRL VELOCITY AT ROTOR EXIT = -0.219518E 07

***** R O T A T I O N *****

S.L. NO.	STREAMLINE RADIUS (IN.)	AXIAL VEL. (FT/SEC)	WHIRL VEL. (FT/SEC)	RADIAL VEL. (FT/SEC)	ABS. VEL. (FT/SEC)	ABS. MACH NUMBER	ABS. FLUX ANGLE (DEG)	REL. FLUX ANGLE (DEG)
1	19.7922	569.014	518.64	223.77	801.772	0.6319	40.502	35.216
2	20.3854	578.648	503.86	197.50	792.299	0.6236	39.490	37.821
3	20.9481	585.929	491.52	171.53	782.544	0.6151	38.948	40.161
4	21.4915	585.610	481.57	146.08	772.379	0.6059	38.609	42.323
5	22.0171	581.632	473.68	123.08	767.823	0.6012	38.091	43.979
6	22.5245	568.073	466.92	101.10	759.460	0.5942	37.589	45.361
7	23.0173	600.259	461.69	79.28	751.414	0.5937	37.326	46.728
8	23.4998	600.041	458.10	58.15	751.159	0.5945	37.231	48.015
9	23.9754	556.754	456.42	37.79	752.267	0.5825	37.355	49.266
10	24.4466	553.367	456.56	18.48	749.157	0.5775	37.587	50.356
11	24.9144	559.430	460.15	0.14	747.776	0.5740	37.978	51.300

S.L. NO.	TOTAL TEMP. RATIO	TOTAL PRES. RATIO	ADIABATIC EFFICIENCY	DIFFUSION FACTOR	HEEL SPEED (FT/SEC)	SOLIDITY	A*/S	LOSS COEFF.
1	1.1269	1.4812	0.9322	0.4528	950.22	1.759	0.6047	0.0661
2	1.1267	1.4797	0.9309	0.4453	978.50	1.686	0.5929	0.0661
3	1.1269	1.4783	0.9260	0.4409	1005.51	1.623	0.5814	0.0678
4	1.1273	1.4772	0.9210	0.4384	1031.59	1.560	0.5698	0.0705
5	1.1279	1.4770	0.9164	0.4342	1056.82	1.515	0.5610	0.0725
6	1.1286	1.4778	0.9123	0.4302	1081.16	1.468	0.5524	0.0742
7	1.1296	1.4778	0.9057	0.4286	1104.83	1.425	0.5433	0.0779
8	1.1308	1.4775	0.8969	0.4289	1127.99	1.385	0.5244	0.0834
9	1.1323	1.4770	0.8850	0.4310	1150.82	1.355	0.5252	0.0910
10	1.1343	1.4765	0.8716	0.4346	1173.44	1.326	0.5173	0.1009
11	1.1369	1.4757	0.8597	0.4393	1195.89	1.303	0.5113	0.1138

S.L. NO.	TOTAL TEMP. (DEGREES)	TOTAL PRES. (LB/RSQ IN.)	STATIC TEMP. (DEGREES)	STATIC PRES. (LB/RSQ IN.)	SLOPE (DEGREES)	CURVATURE /IN.	REL. VEL. (FT/SEC)	REL. MACH NUMBER
1	724.32	43.88	671.13	33.54	21.47	-0.003	748.4059	0.5999
2	724.03	43.94	672.74	32.82	18.35	-0.002	774.0451	0.6094
3	725.04	43.93	675.02	34.05	16.37	-0.001	798.3511	0.6259
4	727.12	43.88	677.82	34.26	14.01	0.001	816.3127	0.6403
5	729.02	43.55	680.51	34.44	11.75	0.002	833.7788	0.6576
6	731.40	44.05	682.98	34.60	9.59	0.004	852.2625	0.6746
7	734.34	44.07	686.44	34.74	7.52	0.006	871.3074	0.6866
8	737.99	44.06	690.64	34.87	5.54	0.037	901.2089	0.7004
9	742.51	44.02	695.79	35.00	3.52	0.005	916.3999	0.7056
10	748.12	44.00	701.80	35.12	1.78	0.005	930.4650	0.7175
11	755.03	44.00	708.91	35.22	0.01	0.001	942.7279	0.7254

***** S T A T U S E X I T *****

S.L. NO.	STREAMLINE RADIUS (IN.)	AXIAL VEL. (FT/SEC)	WHEEL VEL. (FT/SEC)	RADIAL VEL. (FT/SEC)	ABS. VEL. (FT/SEC)	ABS. MACH NUMBER	ABS. FLOW ANGLE (DEG)	REL. FLOW ANGLE (DEG)
1	20.0211	628.641	0.00	234.46	630.296	0.5305	0.000	55.494
2	21.1041	648.070	0.00	206.75	680.250	0.5303	0.000	53.114
3	21.5706	653.960	0.00	175.57	678.292	0.5283	0.000	52.771
4	22.0244	657.021	0.00	154.08	674.846	0.5249	0.000	57.443
5	22.4691	664.373	0.00	130.56	677.080	0.5260	0.000	57.370
6	22.8950	672.455	0.00	108.23	681.108	0.5265	0.000	56.210
7	23.3133	677.024	0.00	86.14	682.483	0.5285	0.000	58.322
8	23.7255	680.704	0.00	64.00	683.762	0.5282	0.000	59.017
9	24.1269	682.535	0.00	43.45	685.914	0.5266	0.000	59.456
10	24.5252	685.817	0.00	22.84	686.198	0.5264	0.000	59.762
11	24.9183	689.520	0.00	2.54	689.525	0.5266	0.000	60.057

S.L. NO.	TOTAL TEMP. RATIO	TOTAL PRES. RATIO	ADIABATIC EFFICIENCY	DIFFUSION FACTOR	WHEEL SPEED (FT/SEC)	SOLIDITY	A*/A	LOSS COEFF.
1	1.0000	C.5533	0.9145	0.3567	589.61	1.567	0.6612	0.0283
2	1.0000	C.5936	0.9141	0.3520	1013.00	1.515	0.6642	0.0271
3	1.0000	C.5942	0.9115	0.3483	1035.39	1.466	0.6640	0.0260
4	1.0000	C.5945	0.9074	0.3465	1057.17	1.420	0.6613	0.0251
5	1.0000	C.5948	0.9035	0.3426	1078.37	1.378	0.6630	0.0242
6	1.0000	C.5950	0.9001	0.3386	1098.55	1.339	0.6636	0.0235
7	1.0000	C.5952	0.8940	0.3364	1119.04	1.303	0.6649	0.0229
8	1.0000	C.5954	0.8859	0.3353	1138.72	1.271	0.6621	0.0220
9	1.0000	C.5956	0.8751	0.3353	1158.09	1.242	0.6569	0.0215
10	1.0000	C.5958	0.8617	0.3350	1177.21	1.215	0.6514	0.0210
11	1.0000	C.5959	0.8442	0.3341	1196.08	1.198	0.6454	0.0206

S.L. NO.	TOTAL TEMP. (DEGREES)	TOTAL PRES. (LB/SQ IN.)	STATIC TEMP. (DEGREES)	STATIC PRES. (LB/SQ IN.)	SLOPE (DEGREES)	CURVATURE /IN.	REL. VEL. (FT/SEC)	REL. MACH NUMBER
1	724.33	43.58	686.08	36.00	20.15	-0.020	1201.6543	0.8365
2	724.63	43.60	686.40	36.07	17.70	-0.013	1220.2073	0.9512
3	725.64	43.68	687.63	36.13	15.39	-0.013	1237.7827	0.9641
4	727.12	43.62	689.50	36.18	13.21	-0.017	1254.2022	0.9750
5	729.02	43.72	691.15	36.22	11.13	-0.015	1273.5125	0.9893
6	731.40	43.83	693.08	36.25	9.15	-0.014	1292.6125	1.0031
7	734.34	43.86	695.67	36.27	7.26	-0.013	1310.7347	1.0150
8	737.99	43.86	699.39	36.29	5.43	-0.011	1323.2355	1.0260
9	742.51	43.82	703.91	36.30	3.95	-0.008	1344.9598	1.0356
10	748.12	43.82	705.27	36.30	1.91	-0.004	1362.6023	1.0453
11	755.03	43.82	715.82	36.29	0.21	0.002	1380.5990	1.0543

***** FINAL FLOW PARAMETERS FOR STAGE NUMBER 4 *****

*** STAGE INPUT PARAMETERS ***

ROTOR TIP D-FACTOR LIMIT 0.4500
 HUB RELATIVE FLOW ANGLE LIMIT AT THE ROTOR EXIT 20.0
 STATOR HUB MACH NUMBER LIMIT (IN) 0.7300
 STATOR HUB D-FACTOR LIMIT 0.4700

---ROTOR--- ---STATOR---

	WHIRL VELOCITY	RATIO SUPERSONIC TC TOTAL TURNING	SOLIDITY	WHIRL VELOCITY	RATIO SUPERSONIC TC TOTAL TURNING	SOLIDITY
A	0.292022E 08	-0.000000E-38	-0.266592E 05	A	0.000000E-38	-0.352452E 05
B	-0.529140E 07	-0.928448E 02	0.492533E 04	B	-0.000000E-38	0.456298E 02
C	0.362180E 06	0.785280E 01	-0.280532E 03	C	-0.000000E-38	-0.393707E 01
D	-0.110351E 05	-0.126527E 00	0.757386E 01	D	-0.000000E-38	0.104604E 00
E	0.126560E 03	-0.000000E-38	-0.776540E-01	E	-0.000000E-38	-0.102987E 00

*** STAGE SCALAR QUANTITIES ***

	ASPECT RATIO	GEOMETRIC RADIUS (IN.)	HUB RADIUS (IN.)	GEOMETRIC TIP RAD.(IN.)	HUB RAMP ANGLE (DEG)	TIP RAMP ANGLE (DEG)	AXIAL LENGTH (IN.)	MASS FLOW (LB/SEC)	MASS AVE. ADIABATIC EFF.
-ROTOR--	2.495	21.1500	25.0000	19.313	0.000	0.000	1.7520	401.0000	0.9097
-STATOR-	2.406	21.6250	29.0000	16.535	0.000	0.000	1.0000	401.0000	0.8970

	VEL. RATIO AT THE MEAN	HUB BLOCKAGE FACTOR	TIP BLOCKAGE FACTOR	MASS AVE. PR. RATIO	MASS AVE. TEMP. RATIO	CUMULATIVE MASS AVE. PR. RATIO	CUMULATIVE MASS AVE. TEMP. RATIO	MASS AVE. ADIABATIC EFF.
-ROTOR--	0.920	0.9800	0.9800	1.4288	1.1167	4.2558	1.5803	0.8764
-STATOR-	1.084	0.9800	0.9800	1.4213	1.1167	4.2353	1.5803	0.8748

LOSS DATA
SET USED

-ROTOR-- 1
 -STATOR- 2

6 COEFFICIENT OF WHIRL VELOCITY AT Rotor Exit = -0.8291 8.902 07

*** R U T O K E A I T ***

S.L. NO.	STREAMLINE RADIUS (IN.)	AXIAL VEL. (FT/SEC)	WHEEL VEL. (FT/SEC)	RADIAL VEL. (FT/SEC)	ABS. VEL. (FT/SEC)	ABS. MACH NUMBER	ABS. FLOW ANGLE (DEG)	REL. FLOW ANGLE (DEG)
1	21.2338	607.225	476.57	152.71	607.738	0.5014	37.535	39.366
2	21.6353	611.067	479.59	165.97	759.662	0.5950	37.536	40.960
3	22.0267	611.943	479.91	147.91	791.335	0.5678	37.293	41.543
4	22.4107	610.420	472.83	126.58	762.435	0.5802	37.179	44.041
5	22.7875	613.646	467.38	107.32	776.300	0.5765	36.830	45.159
6	23.1557	618.540	463.23	89.19	778.218	0.5746	36.530	45.031
7	23.5165	620.807	460.51	71.12	775.069	0.5717	36.398	45.952
8	23.8722	620.747	459.45	55.04	774.126	0.5685	36.405	47.771
9	24.2252	617.040	450.28	36.04	770.543	0.5637	36.074	48.659
10	24.5772	614.578	463.25	19.39	769.855	0.5605	36.994	49.363
11	24.9288	610.677	458.64	3.36	769.778	0.5575	37.502	50.006

S.L. NO.	TOTAL TEMP. RATIO	TOTAL PRES. RATIO	ADIABATIC EFFICIENCY	DIFFUSION FACTOR	WHEEL SPEED (FT/SEC)	SOLICITY	A*/S	LOSS COEFF.
1	1.1150	1.4259	0.9256	0.4346	1019.22	1.612	0.5795	0.0648
2	1.1149	1.4290	0.9245	0.4321	1038.50	1.567	0.5736	0.0643
3	1.1149	1.4284	0.9253	0.4308	1037.28	1.525	0.5561	0.0640
4	1.1150	1.4281	0.9215	0.4305	1075.72	1.486	0.5377	0.0644
5	1.1153	1.4275	0.9162	0.4286	1053.30	1.450	0.5535	0.0653
6	1.1157	1.4276	0.9147	0.4263	1111.47	1.415	0.5501	0.0674
7	1.1164	1.4281	0.9106	0.4259	1148.79	1.389	0.5443	0.0696
8	1.1173	1.4287	0.9046	0.4270	1143.37	1.365	0.5383	0.0735
9	1.1184	1.4287	0.8955	0.4306	1162.31	1.340	0.5320	0.0801
10	1.1200	1.4290	0.8846	0.4352	1175.70	1.320	0.5267	0.0883
11	1.1218	1.4289	0.8666	0.4419	1176.58	1.305	0.5225	0.0954

S.L. NO.	TOTAL TEMP. (DEGREES)	TOTAL PRES. (LB/SQ IN.)	STATIC TEMP. (DEGREES)	STATIC PRES. (LB/SQ IN.)	SLOPE (DEGREES)	CURVATURE /IN.	REL. VEL. (FT/SEC)	REL. MACH NUMBER
1	867.60	62.22	753.95	48.35	17.61	-0.027	824.0405	0.6135
2	807.89	62.40	755.32	49.15	42.55	-0.020	540.2354	0.6251
3	809.03	62.35	757.56	49.42	13.59	-0.015	554.5257	0.6347
4	810.77	62.31	760.49	49.66	11.72	-0.010	687.2416	0.6450
5	813.09	62.41	765.25	49.37	9.72	-0.005	863.4476	0.6538
6	816.05	62.57	766.33	50.06	8.20	-0.002	900.7015	0.6653
7	819.80	62.65	770.37	50.25	6.94	0.001	914.7760	0.6739
8	824.53	62.67	775.57	50.38	4.72	0.004	927.0100	0.6808
9	830.46	62.61	781.77	50.51	3.74	0.004	935.7124	0.6842
10	837.86	62.61	785.30	50.64	1.61	0.005	944.1355	0.6874
11	847.63	62.61	795.51	50.75	0.22	-0.000	950.1615	0.6879

***** S T A T I C K E X I T *****

S.L. NO.	STREAMLINE RADIUS (IN.)	AXIAL VEL. (FT/SEC)	WHIRL VEL. (FT/SEC)	RADIAL VEL. (FT/SEC)	ABS. VEL. (FT/SEC)	ABS. MACH NUMBER	ABS. FLOW ANGLE (DEG)	REL. FLOW ANGLE (DEG)
1	21.6576	611.994	0.00	131.53	676.794	0.4937	0.000	50.980
2	22.0477	656.075	0.00	162.25	675.853	0.4979	0.000	57.837
3	22.3905	658.007	0.00	143.09	673.584	0.4937	0.000	57.331
4	22.7279	658.041	0.00	124.02	669.826	0.4922	0.000	59.853
5	23.0595	663.591	0.00	106.37	671.364	0.4932	0.000	53.742
6	23.3834	670.975	0.00	89.27	676.891	0.4962	0.000	58.908
7	23.7020	675.695	0.00	71.94	679.514	0.4970	0.000	59.151
8	24.0152	679.740	0.00	54.71	681.937	0.4974	0.000	59.392
9	24.3250	681.180	0.00	37.44	682.208	0.4958	0.000	59.703
10	24.6323	684.983	0.00	20.42	685.287	0.4939	0.000	59.903
11	24.9370	688.805	0.00	3.40	688.613	0.4935	0.000	60.081

S.L. NO.	TOTAL TEMP. RATIO	TOTAL PRES. RATIO	ADIABATIC EFFICIENCY	DIFFUSION FACTOR	WHEEL SPEED (FT/SEC)	SOLIDITY	A*/S	LOSS COEFF.
1	1.0000	C.5941	0.9098	0.3718	1041.49	1.474	0.5645	0.0273
2	1.0000	C.5944	0.9055	0.3675	1058.29	1.441	0.6038	0.0265
3	1.0000	C.5946	0.9059	0.3651	1074.74	1.409	0.6510	0.0258
4	1.0000	C.5949	0.9078	0.3640	1090.94	1.379	0.6567	0.0252
5	1.0000	C.5951	0.9051	0.3600	1106.86	1.351	0.5560	0.0245
6	1.0000	C.5952	0.9021	0.3559	1122.43	1.324	0.6584	0.0238
7	1.0000	C.5954	0.8984	0.3535	1137.69	1.300	0.6574	0.0233
8	1.0000	C.5955	0.8929	0.3521	1152.73	1.277	0.6549	0.0228
9	1.0000	C.5957	0.8842	0.3527	1167.50	1.257	0.7491	0.0225
10	1.0000	C.5958	0.8738	0.3530	1182.55	1.238	0.6440	0.0222
11	1.0000	C.5958	0.8562	0.3561	1196.97	1.220	0.6373	0.0220

S.L. NO.	TOTAL TEMP. (DEGREES)	TOTAL PRES. (LB/SQ IN.)	STATIC TEMP. (DEGREES)	STATIC PRES. (LB/SQ IN.)	SLOPE (DEGREES)	CURVATURE /IN.	REL. VEL. (FT/SEC)	REL. MACH NUMBER
1	807.60	61.95	769.99	52.21	15.50	-0.015	1242.0730	0.9155
2	807.89	62.05	770.38	52.42	13.90	-0.014	1255.6882	0.9251
3	809.03	62.05	771.80	52.50	12.23	-0.013	1258.2740	0.9335
4	810.77	62.00	773.90	52.57	10.69	-0.013	1280.0566	0.9409
5	813.05	62.10	776.04	52.63	9.13	-0.013	1294.8095	0.9505
6	816.05	62.27	778.46	52.67	7.59	-0.013	1310.7352	0.9608
7	819.80	62.34	781.93	52.70	6.09	-0.013	1325.1745	0.9692
8	824.53	62.39	786.40	52.73	4.61	-0.013	1359.3364	0.9769
9	830.46	62.34	792.32	52.74	3.15	-0.011	1352.2954	0.9827
10	837.66	62.55	799.40	52.75	1.71	-0.007	1358.5892	0.9884
11	847.03	62.55	803.20	52.76	0.28	-0.000	1381.0155	0.9940

***** FINAL FLOW PARAMETERS FOR STAGE NUMBER 5 *****

*** STAGE INPUT PARAMETERS ***

ROTOR TIP D-FACTOR LIMIT 0.4500
 HUB RELATIVE FLOW ANGLE LIMIT AT THE ROTOR EXIT 20.0
 STATOR HUE MACH NUMBER LIMIT (IN) 0.7300
 STATOR HUB D-FACTOR LIMIT 0.4700

---ROTOR---

---STATOR---

	WHIRL VELOCITY	RATIO SUPERSONIC TO TOTAL TURNING	SOLIDITY	WHIRL VELOCITY	RATIO SUPERSONIC TO TOTAL TURNING	SOLIDITY
A	0.48535E 08	-0.000000E-38	-0.29759E 05	A	0.000000E-38	-0.82770E 05
B	-0.68579E 07	-0.18514E 03	0.51647E 04	B	-0.000000E-38	0.13223E 03
C	0.60917E 06	0.16100E 02	-0.32911E 03	C	-0.000000E-38	-0.81686E 03
D	-0.18640E 05	-0.30852E 01	0.53085E 01	D	-0.000000E-38	0.26081E 00
E	0.21433E 03	-0.000000E-38	-0.98017E-01	E	-0.000000E-38	-0.21843E 00

*** STAGE SCALAR QUANTITIES ***

	ASPECT RATIO	GEOMETRIC RADIUS (IN.)	HUB RADIUS (IN.)	GEOMETRIC TIP RADIUS (IN.)	HUB RAMP ANGLE (DEG)	TIP RAMP ANGLE (DEG)	AXIAL LENGTH (IN.)	MASS FLOW (LB/SEC)	MASS AVE. ADIABATIC EFF.
-ROTOR-	2.500	21.9910	25.0000	25.0000	15.169	0.000	1.5500	401.0000	0.9211
-STATOR-	1.910	22.4000	25.0000	25.0000	14.557	0.000	1.5750	401.0000	0.9097

	VEL. RATIO AT THE MEAN	HUB BLOCKAGE FACTOR	TIP BLOCKAGE FACTOR	MASS AVE. PR. RATIO	MASS AVE. TEMP. RATIO	CUMULATIVE MASS AVE. TEMP. RATIO	CUMULATIVE MASS AVE. ADIABATIC EFF.
-ROTOR-	0.917	0.9800	0.9800	1.3655	1.0993	5.7535	0.8752
-STATOR-	1.115	0.9800	0.9800	1.3603	1.0993	5.7514	0.8728

LOSS DATA
SET USED

-ROTOR- 1
 -STATOR- 2

Coefficient of whirl velocity at rotor exit = -0.8857977E 07

***-----** R U T O R E A I I **-----**

S.L. NO.	STREAMLINE	AXIAL VEL. (FT/SEC)	WHIRL VEL. (FT/SEC)	RADIAL VEL. (FT/SEC)	ABS. VEL. (FT/SEC)	ABS. MACH NUMBER	ABS. FLOW ANGLE (DEG)	REL. FLOW ANGLE (DEG)
1	22.0552	553.946	459.30	133.77	766.704	0.5418	36.849	44.305
2	22.5654	600.327	452.70	138.40	764.516	0.5402	35.205	43.221
3	22.6088	602.858	440.54	123.54	750.150	0.5350	35.771	42.203
4	22.9675	602.543	441.37	106.01	754.388	0.5317	35.109	41.217
5	23.2615	607.991	437.41	90.56	754.490	0.5310	35.332	41.845
6	23.5490	615.579	434.82	76.40	757.527	0.5322	35.030	41.272
7	23.8313	619.227	433.84	61.46	758.575	0.5316	34.884	40.770
8	24.1102	620.673	434.69	46.53	759.181	0.5304	34.930	40.260
9	24.3878	618.398	437.82	31.61	758.237	0.5274	35.250	40.810
10	24.6653	616.543	442.87	17.06	759.853	0.5257	35.682	40.212
11	24.9434	614.415	450.69	2.87	761.995	0.5241	36.261	40.547

S.L. NO.	TOTAL TEMP. RATIO	TOTAL PRES. RATIO	ADIABATIC EFFICIENCY	DIFFUSION FACTOR	WHEEL SPEED (FT/SEC)	SOLIDITY	A*/3	LOSS COEFF.
1	1.0985	1.3652	0.9285	0.4275	1058.85	1.514	0.3489	0.0565
2	1.0983	1.3652	0.9307	0.4207	1073.54	1.486	0.3441	0.0541
3	1.0981	1.3651	0.9319	0.4161	1088.10	1.460	0.3381	0.0524
4	1.0980	1.3649	0.9322	0.4133	1102.44	1.435	0.3313	0.0516
5	1.0980	1.3649	0.9314	0.4094	1116.55	1.413	0.3255	0.0514
6	1.0983	1.3650	0.9291	0.4059	1130.35	1.393	0.3278	0.0524
7	1.0988	1.3654	0.9252	0.4050	1143.90	1.374	0.3153	0.0547
8	1.0995	1.3654	0.9182	0.4062	1157.24	1.357	0.3228	0.0595
9	1.1000	1.3660	0.9093	0.4103	1170.61	1.341	0.3184	0.0659
10	1.1019	1.3661	0.8977	0.4161	1183.94	1.326	0.3161	0.0747
11	1.1036	1.3666	0.8815	0.4242	1197.23	1.311	0.3138	0.0857

S.L. NO.	TOTAL TEMP. (DEGREES)	TOTAL PRES. (LB/SQ IN.)	STATIC TEMP. (DEGREES)	STATIC PRES. (LB/SQ IN.)	SLOPE (DEGREES)	CURVATURE /IN.	REL. VEL. (FT/SEC)	REL. MACH NUMBER
1	887.12	84.58	859.18	69.35	14.52	-0.007	857.3439	0.6059
2	887.26	84.71	859.59	69.55	12.92	-0.006	874.8391	0.6180
3	888.37	84.71	861.25	69.72	11.47	-0.004	883.8603	0.6274
4	890.21	84.62	863.82	69.89	9.94	-0.002	900.7305	0.6349
5	892.81	84.76	866.41	70.04	8.51	0.000	916.1610	0.6447
6	896.26	85.00	869.50	70.18	7.06	0.002	931.5525	0.6547
7	900.77	85.12	873.90	70.31	5.57	0.004	944.1425	0.6616
8	906.58	85.18	879.66	70.43	4.24	0.005	953.7017	0.6662
9	913.97	85.15	887.20	70.55	2.93	0.006	959.5315	0.6674
10	923.25	85.16	895.36	70.65	1.59	0.004	964.4127	0.6674
11	934.86	85.20	907.57	70.77	0.27	-0.000	969.5035	0.6650

***** S T A T U S E X I T *****

S.L. NO.	STREAMLINE RADIUS (IN.)	AXIAL VEL. (FT/SEC)	TANGENTIAL VEL. (FT/SEC)	RADIAL VEL. (FT/SEC)	ANG. VEL. (FT/SEC)	ANG. MACH NUMBER	ANG. FLUX ANGLE (DEG)	REL. FLUX ANGLE (DEG)
1	22.4550	661.111	0.00	162.47	500.735	0.4753	0.000	57.723
2	22.7221	668.230	0.00	145.55	553.990	0.4800	0.000	55.196
3	22.9840	671.530	0.00	128.59	604.143	0.4904	0.000	53.552
4	23.2425	673.051	0.00	111.63	682.285	0.4786	0.000	51.671
5	23.4972	679.806	0.00	95.53	806.542	0.4810	0.000	50.079
6	23.7470	688.907	0.00	80.74	923.523	0.4852	0.000	50.000
7	23.9923	695.126	0.00	65.31	1036.183	0.4875	0.000	50.000
8	24.2345	700.278	0.00	49.83	1202.048	0.4885	0.000	50.000
9	24.4746	703.266	0.00	34.21	1404.098	0.4850	0.000	50.000
10	24.7132	707.526	0.00	18.69	1667.772	0.4882	0.000	50.000
11	24.9507	713.076	0.00	3.21	1993.023	0.4853	0.000	50.000

S.L. NO.	TOTAL TEMP. RATIO	TOTAL PRES. RATIO	AUXILIARY EFFICIENCY	DIFFUSION FACTOR	WHEEL SPEED (FT/SEC)	SOLIDITY	A*/S	LOSS COEFF.
1	1.0000	0.5956	0.9153	0.3166	1077.84	1.460	0.6309	0.0243
2	1.0000	0.5958	0.9179	0.3166	1090.60	1.430	0.6341	0.0236
3	1.0000	0.5955	0.9195	0.3092	1103.25	1.411	0.6339	0.0230
4	1.0000	0.5961	0.9202	0.3074	1115.94	1.385	0.6314	0.0226
5	1.0000	0.5962	0.9198	0.3034	1127.57	1.360	0.6337	0.0220
6	1.0000	0.5963	0.9178	0.2988	1139.35	1.345	0.6379	0.0215
7	1.0000	0.5963	0.9141	0.2963	1151.03	1.325	0.6385	0.0211
8	1.0000	0.5964	0.9074	0.2950	1163.25	1.307	0.6372	0.0208
9	1.0000	0.5965	0.8994	0.2955	1174.78	1.291	0.6322	0.0206
10	1.0000	0.5965	0.8854	0.2980	1186.24	1.275	0.6276	0.0204
11	1.0000	0.5966	0.8714	0.2956	1197.53	1.259	0.6315	0.0202

S.L. NO.	TOTAL TEMP. (DEGREES)	TOTAL PRES. (LB/SQ IN.)	STATIC TEMP. (DEGREES)	STATIC PRES. (LB/SQ IN.)	SLOPE (DEGREES)	CURVATURE /IN.	REL. VEL. (FT/SEC)	REL. MACH NUMBER
1	887.12	84.21	845.35	74.08	13.79	-0.011	1274.5073	0.957
2	887.26	84.25	845.12	74.10	12.59	-0.012	1287.3959	0.9046
3	888.37	84.37	850.22	72.12	10.63	-0.012	1293.1433	0.9119
4	890.21	84.29	850.43	72.14	9.42	-0.012	1307.7324	0.9175
5	892.81	84.44	854.40	72.15	8.05	-0.012	1320.3372	0.9251
6	895.26	84.58	857.07	72.17	6.59	-0.012	1336.1069	0.9334
7	900.77	84.81	861.08	72.18	5.07	-0.012	1343.7435	0.9400
8	905.56	84.87	865.47	72.18	4.07	-0.011	1351.6873	0.9454
9	913.57	84.85	873.56	72.19	2.79	-0.009	1361.6148	0.9493
10	923.25	84.88	882.50	72.21	1.91	-0.003	1381.5390	0.9527
11	934.80	84.91	893.54	72.21	0.26	-0.003	1393.7408	0.9559

***** FINAL FLOW PARAMETERS FOR STAGE NUMBER 3 *****

*** STAGE INPUT PARAMETERS ***

ROTOR TIP D-FACTOR LIMIT 0.4500
 HUB RELATIVE FLOW ANGLE LIMIT AT THE ROTOR EXIT 20.0
 STATOR HUB MACH NUMBER LIMIT (IN) 0.7300
 STATOR HUB D-FACTOR LIMIT 0.4700

---ROTOR---

---STATOR---

	WHIRL VELOCITY	RATIO SUPERSONIC TO TOTAL TURNING	SOLIDITY	WHIRL VELOCITY	RATIO SUPERSONIC TO TOTAL TURNING	SOLIDITY
A	-0.000000E-38	-0.000000E-38	0.143417E 00	A	0.000000E-38	-0.000000E-38
B	0.251730E 06	-0.247905E 03	-0.232294E 03	B	-0.000000E-38	0.156363E 03
C	-0.203875E 05	0.215175E 02	0.141428E 04	C	-0.000000E-38	-0.134135E 02
D	0.440058E 03	-0.425643E 00	-0.361592E 02	D	0.000000E-38	0.302507E 00
E	-0.000000E-38	-0.000000E-38	0.366687E 00	E	-0.000000E-38	-0.000000E-38

*** STAGE SCALAR QUANTITIES ***

	ASPECT RATIO	GEOMETRIC HUB RADIUS (IN.)	GEOMETRIC TIP RAD. (IN.)	HUB RAMP ANGLE (DEG)	TIP RAMP ANGLE (DEG)	AXIAL LENGTH (IN.)	MASS FLOW (LB/SEC)	MASS AVE. ADIABATIC EFF.
-ROTOR--	1.884	22.7330	25.0000	13.566	0.000	1.3600	401.0000	0.9235
-STATOR--	2.464	22.9480	25.0000	15.154	0.000	0.9200	401.0000	0.9156

	VEL. RATIO AT THE MEAN	HUB PLUGGAGE FACTOR	HUB PLUGGAGE TIP PLUGGAGE FACTOR	MASS AVE. PR. RATIO	MASS AVE. TEMP. RATIO	CUMULATIVE MASS AVE. PR. RATIO	CUMULATIVE MASS AVE. TEMP. RATIO	CUMULATIVE MASS AVE. ADIABATIC EFF.
-ROTOR--	0.946	0.9800	0.9800	1.3615	1.0967	7.6441	1.9052	0.9735
-STATOR--	1.056	0.9800	0.9800	1.3556	1.0967	7.6102	1.9072	0.9709

LOSS DATA
SET USED

-ROTOR-- 1
 -STATOR-- 2

B COEFFICIENT OF WHIRL VELOCITY AT ROTOR EXIT = 0.017300E 00

***** R O T U R E X I I *****

S.L. NO.	STREAMLINE RADIUS (IN.)	AXIAL VEL. (FT/SEC)	WHIRL VEL. (FT/SEC)	RADIAL VEL. (FT/SEC)	WHEEL VEL. (FT/SEC)	ABS. MACH NUMBER	ABS. FLOW ANGLE (DEG)	REL. FLOW ANGLE (DEG)
1	22.7806	832.305	487.54	148.02	614.383	0.5509	36.774	43.885
2	23.0091	839.572	470.41	131.46	809.195	0.5471	36.230	43.203
3	23.2343	839.520	471.47	115.19	803.149	0.5429	35.946	42.715
4	23.4577	838.252	460.59	99.54	790.002	0.5375	35.841	42.559
5	23.6785	843.719	463.67	85.08	797.572	0.5375	35.530	42.022
6	23.8954	851.898	462.59	71.41	802.551	0.5337	35.193	41.622
7	24.1089	856.347	463.25	57.40	805.415	0.5402	35.112	41.457
8	24.3205	858.654	465.57	43.48	807.753	0.5401	35.196	41.755
9	24.5316	856.820	463.40	29.50	807.083	0.5370	35.528	41.121
10	24.7434	854.813	474.84	15.91	809.013	0.5355	35.640	41.421
11	24.9567	850.563	481.62	2.52	809.767	0.5324	35.496	41.730

S.L. NO.	TOTAL TEMP. RATIO	TOTAL PRES. RATIO	ADIABATIC EFFICIENCY	DIFFUSION FACTOR	WHEEL SPEED (FT/SEC)	SOLIDITY	A*/S	LOSS COEFF.
1	1.0575	1.3656	0.9529	0.4291	1093.47	1.449	0.5376	0.0555
2	1.0965	1.3628	0.9548	0.4230	1104.43	1.429	0.5363	0.0528
3	1.0959	1.3605	0.9561	0.4204	1115.25	1.411	0.5329	0.0509
4	1.0956	1.3599	0.9567	0.4191	1125.97	1.395	0.5282	0.0494
5	1.0955	1.3599	0.9565	0.4165	1135.57	1.380	0.5270	0.0494
6	1.0958	1.3603	0.9548	0.4144	1146.98	1.360	0.5294	0.0502
7	1.0963	1.3609	0.9314	0.4149	1157.23	1.352	0.5290	0.0525
8	1.0969	1.3614	0.9460	0.4175	1167.53	1.340	0.5280	0.0564
9	1.0977	1.3615	0.9454	0.4229	1177.52	1.327	0.5257	0.0625
10	1.0982	1.3605	0.9054	0.4295	1187.08	1.315	0.5244	0.0706
11	1.0994	1.3586	0.8525	0.4350	1197.32	1.302	0.5235	0.0707

S.L. NO.	TOTAL TEMP. (DEGREES)	TOTAL PRES. (LB/SQ IN.)	STATIC TEMP. (DEGREES)	STATIC PRES. (LB/SQ IN.)	SLOPE (DEGREES)	CURVATURE /IN.	REL. VEL. (FT/SEC)	REL. MACH NUMBER
1	573.48	114.95	919.86	53.76	15.12	-0.006	830.2247	0.6019
2	572.85	114.55	919.09	53.56	11.02	-0.005	808.4286	0.6115
3	573.52	114.81	921.33	54.15	10.41	-0.003	914.9953	0.6181
4	575.28	114.63	923.50	54.33	8.85	-0.001	925.0702	0.6227
5	578.11	114.83	926.07	54.51	7.25	0.002	935.0958	0.6300
6	582.12	115.20	930.10	54.57	6.25	0.004	947.8754	0.6374
7	587.48	115.42	935.12	54.51	5.00	0.007	958.5202	0.6419
8	594.43	115.55	941.01	54.55	3.76	0.008	963.4597	0.6440
9	1003.25	115.52	950.00	55.06	2.57	0.003	968.2436	0.6430
10	1014.23	115.48	951.50	55.21	1.39	0.005	964.0815	0.6407
11	1027.72	115.38	975.04	55.33	0.15	-0.000	967.8061	0.6363

***** S T A T I C K I T *****

S-L. NO.	STREAMLINE RADIUS (IN.)	AXIAL VEL. (FT/SEC)	WHIRL VEL. (FT/SEC)	RADIAL VEL. (FT/SEC)	ABS. VEL. (FT/SEC)	ABS. MACH NUMBER	ABS. FLUX ANGLE (DEG)	REL. FLUX ANGLE (DEG)
1	22.9508	623.072	0.00	146.60	698.501	0.4655	0.000	27.065
2	23.1951	681.882	0.00	126.77	773.934	0.4615	0.000	33.052
3	23.3581	678.925	0.00	112.52	788.153	0.4570	0.000	38.503
4	23.6034	675.159	0.00	95.66	782.260	0.4533	0.000	43.052
5	23.8013	660.010	0.00	82.74	765.025	0.4422	0.000	47.305
6	23.9990	660.514	0.00	69.55	742.020	0.4343	0.000	51.031
7	24.1937	654.647	0.00	56.29	710.924	0.4267	0.000	54.076
8	24.3863	659.902	0.00	42.97	703.015	0.4200	0.000	56.209
9	24.5779	702.196	0.00	29.50	704.430	0.4153	0.000	57.353
10	24.7691	702.246	0.00	16.09	706.662	0.4619	0.000	57.460
11	24.9605	706.856	0.00	2.84				

S-L. NO.	TOTAL TEMP. RATIO	TOTAL PRES. RATIO	ADIABATIC EFFICIENCY	DIFFUSION FACTOR	HEEL SPEED (FT/SEC)	SOLIDITY	A*/S	LOSS COEFF.
1	1.0000	C.5953	0.9190	0.3596	1103.50	1.392	0.0382	0.0252
2	1.0000	C.9555	0.9211	0.3600	1113.36	1.374	0.0359	0.0249
3	1.0000	C.9550	0.9227	0.3620	1123.11	1.355	0.0387	0.0247
4	1.0000	C.9557	0.9235	0.3649	1134.52	1.339	0.0356	0.0245
5	1.0000	C.9557	0.9235	0.3635	1142.40	1.323	0.0360	0.0241
6	1.0000	C.9556	0.9224	0.3605	1151.95	1.307	0.0424	0.0237
7	1.0000	C.9556	0.9189	0.3593	1161.30	1.293	0.0435	0.0234
8	1.0000	C.9559	0.9138	0.3590	1170.54	1.279	0.0427	0.0231
9	1.0000	C.9559	0.9065	0.3607	1179.74	1.267	0.0381	0.0230
10	1.0000	C.9560	0.8933	0.3660	1188.92	1.255	0.0331	0.0230
11	1.0000	C.9560	0.8805	0.3687	1198.11	1.244	0.0201	0.0229

S-L. NO.	TOTAL TEMP. (DEGREES)	TOTAL PRES. (LB/SQ IN.)	STATIC TEMP. (DEGREES)	STATIC PRES. (LB/SQ IN.)	SLOPE (DEGREES)	CURVATURE /IN.	REL. VEL. (FT/SEC)	REL. MACH NUMBER
1	573.48	114.45	934.06	96.61	12.07	-0.020	1306.0435	0.8765
2	972.85	114.43	933.94	98.77	10.54	-0.013	1311.9152	0.8805
3	573.52	114.30	935.27	98.91	9.39	-0.017	1317.1549	0.8834
4	575.28	114.13	937.69	99.04	8.14	-0.017	1322.4174	0.8859
5	978.11	114.34	940.22	99.15	6.94	-0.015	1332.0939	0.8912
6	982.12	114.71	943.47	99.23	5.77	-0.015	1342.8505	0.8975
7	587.48	114.93	948.30	99.30	4.03	-0.013	1354.5679	0.9024
8	994.45	115.07	954.80	99.34	3.51	-0.014	1364.5072	0.9061
9	1003.25	115.05	963.40	99.38	2.40	-0.012	1373.5212	0.9091
10	1014.23	115.01	974.53	99.45	1.31	-0.007	1381.9368	0.9089
11	1027.72	114.91	987.61	99.45	0.23	-0.000	1391.0859	0.9090

***** FINAL FLOW PARAMETERS FOR STAGE NUMBER 7 *****

*** STAGE INPUT PARAMETERS ***

ROTOR TIP D-FACTOR LIMIT 0.4500
 HUB RELATIVE FLOW ANGLE LIMIT AT THE ROTOR EXIT 20.0
 STATOR HUB MACH NUMBER LIMIT (IN) 0.7300
 STATOR HUB D-FACTOR LIMIT 0.4700

---STATOR---

---ROTOR---

	WHIRL VELOCITY	RATIO SUPERSONIC TO TOTAL TURNING	SOLIDITY	WHIRL VELOCITY	RATIO SUPERSONIC TO TOTAL TURNING	SOLIDITY
A	-0.000000E-38	-0.000000E-38	-0.213807E 06	A	0.000000E-38	-0.000000E-38
B	0.449382E 06	-0.471551E 03	0.361733E 05	B	-0.000000E-38	0.203703E 03
C	-0.368745E 05	0.402056E 02	-0.228614E 04	C	-0.000000E-38	-0.170851E 02
D	0.775907E 03	-0.815283E 00	0.641375E 02	D	-0.000000E-38	0.375986E 00
E	-0.000000E-38	-0.000000E-38	-0.575473E 00	E	-0.000000E-38	-0.133502E 02

*** STAGE SCALER QUANTITIES ***

	ASPECT RATIO	GEOMETRIC RADIUS (IN.)	HUB RAMP ANGLE (DEG)	TIP RAMP ANGLE (DEG)	AXIAL LENGTH (IN.)	MASS FLOW (LB/SEC)	MASS AVE. ADIABATIC EFF.
-ROTOR--	1.466	23.2400	11.781	0.000	1.4000	401.0000	0.9324
-STATOR--	1.956	23.3000	5.814	0.000	0.9000	401.0000	0.9216

	VEL. RATIO AT THE MEAN	HUB BLOCKAGE FACTOR	TIP BLOCKAGE FACTOR	MASS AVE. PR. RATIO	MASS AVE. TEMP. RATIO	CUMULATIVE MASS AVE. TEMP. RATIO	CUMULATIVE MASS AVE. ADIABATIC EFF.
-ROTOR--	0.975	0.9800	0.9800	1.2402	1.0599	10.4675	0.9721
-STATOR--	0.988	0.9800	0.9800	1.5529	1.0595	10.4182	0.9697

	LOSS DATA SET USED
-ROTOR--	1
-STATOR--	2

E COEFFICIENT OF WHIRL VELOCITY AT ROTOR EXIT = 0.449382E 06

***** R C T C R E X I T *****

S.L. NO.	STREAMLINE	AXIAL VEL. (FT/SEC)	WHL VEL. (FT/SEC)	RADIAL VEL. (FT/SEC)	ADS. VEL. (FT/SEC)	ABS. MACH NUMBER	ADS. FLOW ANGLE (DEG)	REL. FLOW ANGLE (DEG)
1	23.2765	686.525	492.20	102.78	850.767	0.5518	35.38	42.001
2	23.4472	578.933	463.54	96.10	838.806	0.5437	35.745	43.128
3	23.6182	670.595	477.34	78.23	847.130	0.5359	35.889	44.169
4	23.7697	662.900	473.90	67.16	817.577	0.5284	35.417	45.078
5	23.9608	664.799	471.74	57.49	817.192	0.5278	35.253	45.473
6	24.1259	671.018	471.58	48.36	822.069	0.5300	35.005	45.560
7	24.2965	675.728	473.24	39.62	825.383	0.5311	34.860	45.676
8	24.4629	677.548	476.63	28.57	828.930	0.5312	35.100	45.808
9	24.6290	674.571	481.71	20.09	829.475	0.5289	35.102	46.050
10	24.7964	671.218	488.38	10.83	830.101	0.5283	36.038	46.274
11	24.9660	663.570	496.60	1.68	828.317	0.5217	36.810	46.603

S.L. NO.	TOTAL TEMP. RATIO	TOTAL PRES. RATIO	ADIABATIC EFFICIENCY	DIFFUSION FACTOR	WHEEL SPEED (FT/SEC)	SOLIDITY	A*/S	LOSS COEFF.
1	1.0506	1.3433	0.9385	0.4139	1117.27	1.414	0.5350	0.0508
2	1.0898	1.3408	0.9403	0.4127	1125.47	1.399	0.5295	0.0484
3	1.0893	1.3382	0.9418	0.4150	1133.87	1.385	0.5230	0.0466
4	1.0890	1.3386	0.9431	0.4141	1141.91	1.373	0.5164	0.0452
5	1.0889	1.3386	0.9434	0.4153	1150.12	1.360	0.5157	0.0447
6	1.0891	1.3393	0.9425	0.4123	1158.24	1.349	0.5177	0.0449
7	1.0895	1.3401	0.9402	0.4155	1166.25	1.339	0.5183	0.0466
8	1.0901	1.3407	0.9354	0.4170	1174.22	1.329	0.5183	0.0503
9	1.0907	1.3409	0.9287	0.4235	1182.19	1.320	0.5164	0.0559
10	1.0915	1.3404	0.9197	0.4314	1190.34	1.310	0.5141	0.0637
11	1.0922	1.3368	0.9042	0.4424	1198.57	1.302	0.5120	0.0741

S.L. NO.	TOTAL TEMP. (DEGREES)	TOTAL PRES. (LB/SQ IN.)	STATIC TEMP. (DEGREES)	STATIC PRES. (LB/SQ IN.)	SLOPE (DEGREES)	CURVATURE /IN.	REL. VEL. (FT/SEC)	REL. MACH NUMBER
1	1061.67	153.75	1003.71	125.24	8.92	-0.117	534.1351	0.6057
2	1060.22	153.42	1005.92	125.79	7.36	-0.103	936.4170	0.6084
3	1060.43	153.07	1005.67	126.21	6.95	-0.088	841.2430	0.6097
4	1062.06	152.77	1008.57	126.57	5.79	-0.074	943.5642	0.6104
5	1065.10	153.05	1011.68	126.90	4.94	-0.060	951.5568	0.6147
6	1069.65	153.62	1015.52	127.19	4.21	-0.047	961.7196	0.6201
7	1075.87	154.02	1021.58	127.43	3.31	-0.035	968.7118	0.6229
8	1083.99	154.27	1029.15	127.64	2.50	-0.024	972.9182	0.6234
9	1084.27	154.27	1039.42	127.84	1.71	-0.015	972.9707	0.6204
10	1107.00	154.16	1052.14	128.00	0.92	-0.007	971.2036	0.6157
11	1122.50	153.83	1057.93	128.14	0.16	-0.002	965.6205	0.6080

***** S T A T I C K I F **-----**

S.L. NO.	STREAMLINE RADIUS (IN.)	AXIAL VEL. (FT/SEC)	WHIRL VEL. (FT/SEC)	RADIAL VEL. (FT/SEC)	ABS. VEL. (FT/SEC)	ABS. MACH NUMBER	ABS. FLOW ANGLE (DEG)	REL. FLUX ANGLE (DEG)
1	23.3352	674.454	0.00	45.54	676.278	0.4341	0.000	50.878
2	23.5003	664.562	0.00	44.35	666.040	0.4276	0.000	50.440
3	23.6664	655.098	0.00	39.27	656.274	0.4211	0.000	50.984
4	23.8335	647.462	0.00	34.40	648.575	0.4155	0.000	60.437
5	24.0002	650.930	0.00	30.11	651.027	0.4171	0.000	60.506
6	24.1646	660.355	0.00	26.01	660.407	0.4225	0.000	60.326
7	24.3265	667.653	0.00	21.67	668.205	0.4259	0.000	50.220
8	24.4867	673.756	0.00	17.07	674.912	0.4282	0.000	50.168
9	24.6464	674.853	0.00	12.03	674.961	0.4255	0.000	50.294
10	24.8063	676.737	0.00	6.75	675.771	0.4255	0.000	60.367
11	24.9671	675.661	0.00	0.95	675.662	0.4219	0.000	60.586

S.L. NO.	TOTAL TEMP. RATIO	TOTAL PRES. RATIO	ADIABATIC EFFICIENCY	DIFFUSION FACTOR	WHEEL SPEED (FT/SEC)	SOLIDITY	A/S	LOSS COEFF.
1	1.0000	6.5946	0.9223	0.4084	1120.03	1.432	0.0107	0.0283
2	1.0000	6.5949	0.9244	0.4099	1126.01	1.422	0.0451	0.0282
3	1.0000	6.5951	0.9263	0.4127	1135.99	1.411	0.0364	0.0282
4	1.0000	6.5952	0.9279	0.4154	1144.01	1.399	0.0318	0.0281
5	1.0000	6.5953	0.9284	0.4114	1152.01	1.389	0.0322	0.0277
6	1.0000	6.5953	0.9279	0.4052	1159.99	1.380	0.0359	0.0271
7	1.0000	6.5954	0.9256	0.4009	1167.97	1.372	0.0371	0.0257
8	1.0000	6.5954	0.9214	0.3984	1175.98	1.365	0.0361	0.0264
9	1.0000	6.5955	0.9118	0.4023	1183.02	1.357	0.0311	0.0266
10	1.0000	6.5955	0.9025	0.4043	1190.70	1.349	0.0247	0.0264
11	1.0000	6.5956	0.8905	0.4105	1198.42	1.335	0.0148	0.0265

S.L. NO.	TOTAL TEMP. (DEGREES)	TOTAL PRES. (LB/SQ IN.)	STATIC TEMP. (DEGREES)	STATIC PRES. (LB/SQ IN.)	SLOPE (DEGREES)	CURVATURE /IN.	REL. VEL. (FT/SEC)	REL. MACH NUMBER
1	1061.67	152.95	1025.11	134.61	4.41	0.015	1300.4159	0.5399
2	1060.22	152.44	1024.75	134.85	3.82	0.012	1305.719	0.5410
3	1060.43	152.31	1026.00	135.05	3.45	0.010	1311.9365	0.5418
4	1062.06	152.03	1028.46	135.22	5.04	0.007	1314.9586	0.5428
5	1065.10	152.33	1031.18	135.37	2.55	0.004	1321.5350	0.5472
6	1069.65	152.91	1034.77	135.49	4.26	0.001	1324.9801	0.5521
7	1075.87	153.31	1040.24	135.58	1.36	-0.001	1343.5474	0.5576
8	1083.99	153.57	1047.77	135.64	1.45	-0.002	1354.9064	0.5607
9	1094.27	153.57	1057.99	135.75	1.03	-0.002	1366.9281	0.5612
10	1107.00	153.47	1070.58	135.77	0.57	-0.002	1382.5926	0.5612
11	1122.50	153.15	1086.45	135.77	0.23	0.000	1377.7572	0.5591

***----- JULET FLOW PARAMETERS ***-----

STA NO.	AXIAL COORDINATE (IN.)	GEOMETRIC HUB RADIUS (IN.)	GEOMETRIC TIP RADIUS (IN.)	HUB BLOCKAGE FACTOR	TIP BLOCKAGE FACTOR	STATION NUMBER	20	21	22	TOTAL TEMP. (DEG. F R)	TOTAL PRES. (LB/SQ IN.)
20	23.405	23.405	23.000	0.980	0.930	STATION NUMBER	20	21	22	1061.67	152.9
21	23.423	23.423	23.000	0.960	0.950	12.55	721.43	732.00	732.64	1060.22	152.6
22	23.441	23.441	23.000	0.980	0.930	11.49	33.76	715.38	727.42	1060.43	152.3
						10.33	713.00	710.50	716.56	1062.06	152.0
						9.10	25.72	714.20	719.20	1065.10	152.3
						7.93	22.04	723.43	730.89	1069.35	152.9
						6.76	18.57	730.89	736.84	1075.37	153.3
						5.55	15.09	736.84	739.44	1083.95	153.5
						4.23	11.61	739.44	741.77	1094.27	153.0
						2.93	8.05	741.77	741.77	1107.30	153.5
						1.63	4.42	741.77	741.46	1122.50	153.1
						0.24	0.75	741.46			
						STATION NUMBER	20	21	22		
1	23.4727	23.4727	23.000	0.980	0.930	12.55	721.43	732.00	732.64	1061.67	152.9
2	23.6258	23.6258	23.000	0.960	0.950	11.49	33.76	715.38	727.42	1060.22	152.6
3	23.7790	23.7790	23.000	0.980	0.930	10.33	713.00	710.50	716.56	1060.43	152.3
4	23.9323	23.9323	23.000	0.960	0.950	9.10	25.72	714.20	719.20	1062.06	152.0
5	24.0849	24.0849	23.000	0.980	0.930	7.93	22.04	723.43	730.89	1065.10	152.3
6	24.2355	24.2355	23.000	0.960	0.950	6.76	18.57	730.89	736.84	1069.35	152.9
7	24.3836	24.3836	23.000	0.980	0.930	5.55	15.09	736.84	739.44	1075.37	153.3
8	24.5305	24.5305	23.000	0.960	0.950	4.23	11.61	739.44	741.77	1083.95	153.5
9	24.6765	24.6765	23.000	0.980	0.930	2.93	8.05	741.77	741.77	1094.27	153.0
10	24.8227	24.8227	23.000	0.960	0.950	1.63	4.42	741.77	741.46	1107.30	153.5
11	24.9696	24.9696	23.000	0.980	0.930	0.24	0.75	741.46		1122.50	153.1

