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Part II — Radial Distribution of Total Pressure and Flow Path or Axial Velocity Ratio Specified (Program III)

Prepared for

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Contract NAS3-7277

Allison Division • General Motors

Indianapolis, Indiana

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AXIAL FLOW COMPRESSOR DESIGN COMPUTER PROGRAMS INCORPORATING FULL RADIAL EQUILIBRIUM PART II—RADIAL DISTRIBUTION OF TOTAL PRESSURE AND FLOW PATH OR AXIAL VELOCITY RATIO SPECIFIED (PROGRAM III)

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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. It was desired that the design system have the capability of producing design information for given annulus geometry or, alternatively, computing annulus geometry along with aerodynamic design information. These capabilities are available as alternative options in the computer program described herein. The option in which design is performed for given annulus geometry is designated as Modification I; the option designated as Modification II requires input of axial velocity ratio at the mid-streamline for each rotor and stator, and establishes annulus geometry subject to certain limitations described later in this report. 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 profile of total pressure at each rotor exit, and through specification of limiting values on five 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

5. Rotor tip exit whirl velocity

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 two sample design problems. Appendix E illustrates the format of program output, through presentation of the computed results for both sample design problems.

INTRODUCTION

As a part of Contract NAS3-7277 for the NASA-Lewis Research Center, four axial flow computer programs were developed. The first (Reference 1) assumed simple radial equilibrium of static pressure and constant efficiency radially—limits are specified 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; the velocity diagram and stage-by-stage performance are calculated.

The second program (Reference 2) 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.

A third program, Axial Flow Design Program III, was developed under this contract and is reported herein. Program III differs from Program II in that the radial distribution of energy is established by specifying the polynomial variation of total pressure at the exit of each rotor blade row, and there is the option of specifying either the flow path or the axial velocity ratios and calculating the resulting flow path. Program III also offers the option of specifying as blade element data either the flow angle at the shock or the ratio of supersonic to total turning, to calculate values of shock loss coefficient.

SYMBOLS

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

a	sonic velocity, ft/sec
A, B, C, D, E	constants in total pressure profile and whirl velocity polynomials
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-43) through (A-45)
g_c	universal gravitational constant, 32.174 ft-lb_m/lb_f-sec^2
H	enthalpy, BTU/lb_m
J	conversion factor, 778 ft-lb_f/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	fraction of blade height, $\frac{R - R_{H_g}}{R_{T_g} - R_{H_g}}$
P	pressure, $lb_f/in.^2$ abs
Q	heat transfer rate, BTU/lb_m-sec
R	radius, in.
R_c	total pressure ratio
R_i	i^{th} rotor

$\mathcal{R}$	gas constant, ft-lb_f/lb_m-R°
S	entropy, BTU/lb_m-R°
S_i	i^{th} stator
t	time, sec
T	temperature, °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.

<u>Greek</u>

α	ramp angle, degrees
β	air angle, measured from engine axis, degrees
γ	ratio of specific heats
δ	blockage; 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; stage
s	shock
ss	supersonic
T	tip section
t	total
θ	whirl component
Z	axial component

Superscript

'	relative value of a variable

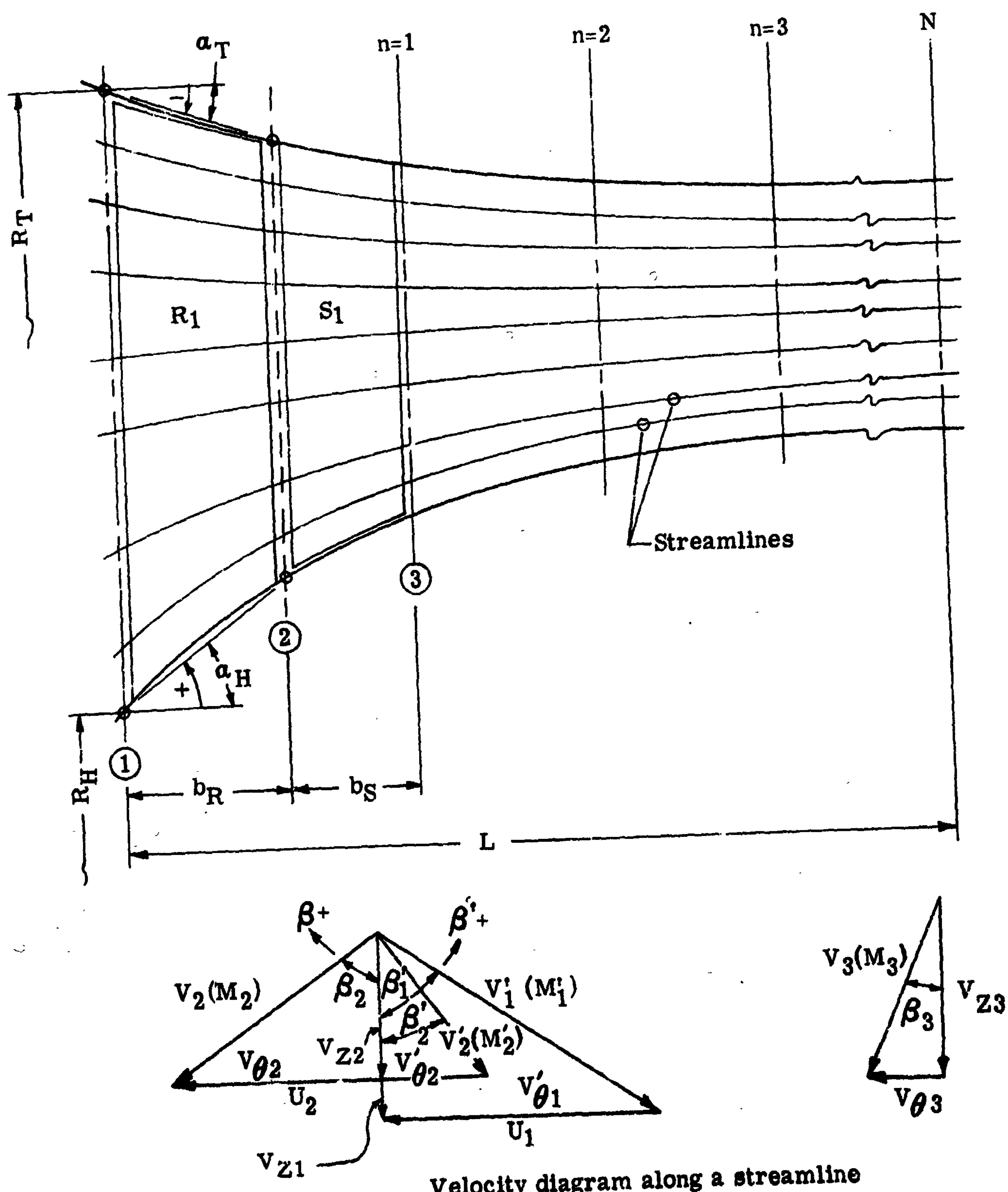

Figure 1. Schematic presentation of symbols.

TECHNICAL DISCUSSION

The Modification I/II program, bearing Allison identification Q-4F, 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.

For use of Mod I, 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 3, using the ratio of supersonic turning to total turning input as a function of blade span for each blade row, or alternatively using input-specified values of flow angle at the shock.

For use of Mod II, where stage flow path geometry is established by computation, the inlet geometry is input as for Mod I. For each blade row, limits on hub and tip ramp angle must be given, along with an initial value of aspect ratio (difference in inlet geometric radii, divided by axial length) and the ratio of exit axial velocity to inlet axial velocity for the row at the mid-streamline. Hub and tip ramp angles (α_H and α_T) are shown in Figure 1. The computation of annulus geometry for any given blade row begins with the specified initial value of aspect ratio and α_T = 0. In any required reduction of annulus area at the exit of a blade row, α_H is first increased to its limit value, if necessary. Next, α_T is increased to its given limit value, and, if necessary, the aspect ratio is finally reduced by an appropriate amount, to achieve the required level of exit axial velocity. Under no circumstances is a positive value of α_T permitted. Inasmuch as Mod II can yield irregular geometry, depending upon input constraints, the curvature of streamlines can produce severe gradients in flow properties and result in failure of the calculation with appropriate error messages printed out. Input of reasonable constraints is discussed further in Appendix D. Adiabatic efficiencies are computed as in Mod I.

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 $(\bar{\omega}_p \cos\beta_2')/2\sigma$ 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 five 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
5. Rotor tip exit whirl velocity

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 4.

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

Continuity Equation

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

Radial Equation of Motion

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

Circumferential Equation of Motion

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

Axial Equation of Motion

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

Energy Equation

$$\frac{DH_t}{Dt} = Q + \frac{\omega}{g_c J} \frac{D(R V_\theta)}{Dt} \tag{5}$$

Gradient of Entropy

$$\frac{DS}{Dt} = \frac{Q}{T} \tag{6}$$

Condition of Integrability

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

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

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

and Equation (2) is then written as:

$$V_Z^2 - V_{Z_j}^2 = 2g_c J \int_{T_{t_j}}^{T_t} c_p\ (T)\ dT - (V_\theta^2 - V_{\theta_j}^2) - 2 \int_{R_j}^{R} \frac{V_\theta^2}{R} dR$$

$$- 2g_c J \int_{R_j}^{R} T \frac{\partial S}{\partial R} dR + 2 \int_{R_j}^{R} V_Z \left(\frac{\partial V_R}{\partial Z}\right)_R dR, \tag{9}$$

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

$$g_c J\ (\Delta H_t) = \omega\ \Delta(RV_\theta) \tag{10}$$

As outlined earlier, the program user may elect to solve this system of equations by specifying flow path geometry or, alternatively, by computing the annulus geometry for each designed stage using specified mid-streamline axial velocity ratio plus specified constraints on flow path. Energy addition for a stage is established using a profile of total pressure at the rotor exit, given in the form

$$\frac{P_t}{P_{t_{r,1}}} = \frac{A}{B + p} + C + Dp + Ep^2\ , \tag{11}$$

and 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 3).

With blade inlet conditions known, exit velocity conditions are then computed iteratively through Equations (8) and (9) for Mod I. For Mod II, where exit axial velocity at the mid-streamline is established through the given ratio for a blade row and the known inlet axial velocity, Equations (8) and (9) are used to establish the exit annulus area required to satisfy continuity and radial equilibrium at the blade row exit. Hub and tip ramp angles and aspect ratio are varied in the sequence outlined earlier.

The primary objective of this computer program is to calculate design parameters 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 five 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.

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

At a point in the stage design computations, limiting values of the aerodynamic parameters may be used to establish stage energy addition, using current axial and radial velocities and current efficiency. Using the given limiting values of D_{S_H}, M_{S_H} and β'_{2_H}, it is possible to compute three values for rotor effective hub exit tangential velocity. On the assumption that all aerodynamic parameters increase monotonically with one another and with local tangential velocity, the lowest of the three values of tangential velocity just computed is used to compute a rotor hub total temperature rise. With rotor entrance conditions and current rotor effective hub efficiency, this is used to compute rotor effective hub exit total pressure. The polynomial describing P_t/P_{t_T} for this rotor is used to establish a value for P_{t_T} directly.

Now, separately, the limiting value for D_{R_T} is used to compute a value for tangential velocity at the rotor effective tip exit. This value is compared with the fifth aerodynamic design parameter, the given maximum value of rotor effective tip exit tangential velocity, and the smaller of the two values used along with the current rotor effective tip efficiency to establish a second value of P_{t_T}. The smaller of the two computed values of P_{t_T} is taken, and the given total pressure profile is used to establish a distribution of P_t at the rotor exit. The current distribution of efficiency yields the distribution of total temperature and the associated rotor exit tangential velocity distribution directly.

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

$$D_{R_T} = 1.0 - \frac{V'_{2_T}}{V'_{1_T}} + \frac{U_{1_T} - V_{\theta\, 1_T} - U_{2_T} + V_{\theta\, 2_T}}{2\sigma\, R_T\, V'_{1_T}}$$

which rearranges to

$$V^2_{\theta\, 2_T} + G\, V_{\theta\, 2_T} + W = 0 \qquad (12)$$

where

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

$$W = \left[\frac{V^2_{Z_{2_T}} + U^2_{2_T} + V^2_{R_{2_T}} - F^2}{1.0 - K^2}\right]$$

$$K = \frac{1}{2\,\sigma\, R_T}$$

$$F = \left[(1.0 - D_{R_T})\, V'_{1_T} + \frac{U_{1_T} - V_{\theta\, 1_T} - U_{2_T}}{2\,\sigma\, R_T}\right]$$

Therefore,

$$V_{\theta\, 2_T} = \frac{-G \pm \sqrt{G^2 - 4W}}{2} \qquad (13)$$

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 (13) 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

$$D_{S_H} = 1.0 - \frac{V_{3_H}}{V_{2_H}} + \frac{V_{\theta 2_H} - V_{\theta 3_H}}{2\sigma_{S_H} V_{2_H}} \tag{14}$$

which rearranges to

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

where

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

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

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

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

Hence,

$$V_{\theta 2_H} = \frac{-G \pm \sqrt{G^2 - 4W}}{2} \tag{15}$$

where the calculation is again restricted to positive, real roots. Using the limiting value of D_{S_H} to evaluate K and F, the resulting solution of Equation (15) represents a critical value of $V_{\theta 2_H}$, based on the specified limit for D_{S_H} in the given stage.

3. The expression for the stator hub Mach number is

$$M_{S_H} = \frac{V_{2_H}}{a_{S_H}}$$

where

$$a_{S_H} = \sqrt{\gamma \quad g_c \quad \mathcal{R} \quad T_{S_H}}$$

This rearranges to

$$V_{\theta_{2_H}} = \left[M^2_{S_H} \quad a^2_{S_H} - (V^2_{Z_{2_H}} + V^2_{R_{2_H}}) \right]^{1/2} \tag{16}$$

If the limiting value of stator hub entrance Mach number is used in Equation (16), there results the corresponding critical value of $V_{\theta_{2_H}}$.

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

$$\beta'_{2_H} = \tan^{-1} \left[\frac{V'_{\theta_{2_H}}}{\left(V^2_{Z_{2_H}} + V^2_{R_{2_H}}\right)^{1/2}} \right]$$

it follows that

$$V'_{\theta_{2_H}} = \left(V^2_{Z_{2_H}} + V^2_{R_{2_H}}\right)^{1/2} \tan (\beta'_{2_H}) \tag{17}$$

and

$$V_{\theta_{2_H}} = U_{2_H} - V'_{\theta_{2_H}} \tag{18}$$

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

The computer program satisfies the stage aerodynamic design parameters in either of two optional ways. The user may elect to: (1) reduce the energy addition for any stage whenever necessary to avoid violation of any of the limiting values specified for the five aerodynamic parameters or (2) use the most critical of the five limiting aerodynamic parameters to establish the energy addition for each calculation pass in each stage of the compressor. The latter or "drive" option ensures that each stage of the final compressor design will satisfy the critical one of the five specified limiting values of design parameters. The "no drive" option ensures only that no designed stage will exceed any of its specified limits.

The radial profile of axial velocity at an axial station is obtained by using the tangential velocity distribution in the radial equilibrium equation (9), and carrying out the integration from a reference streamline j to all other streamlines. For inlet and Mod I stage design computations, the term $V^2_{Z_j}$ serves as the constant of integration and must be adjusted to satisfy continuity; V_{Z_j} is established by trial and error at each axial station, for each pass of the design computation. For use of Mod II, the reference streamline j in any blade row is also taken as the mid-streamline, where axial velocity ratio is given. Thus, the inlet axial velocity and the given ratio fix the exit axial velocity at the mid-streamline, and the blade row exit annulus dimensions are established iteratively according to the previously described sequence of ramp angle and aspect ratio adjustment seeking simultaneous satisfaction of radial equilibrium and continuity.

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 elected 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 total pressure distribution for rotor and exit whirl velocity distribution for stator
- Blade solidity distributions
- Distributions of the ratio of supersonic turning to total turning or of flow angle at the passage shock in rotor and stator
- For Mod II, limiting values for hub and tip ramp angles and initial values for rotor and stator aspect ratio

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 at each blade row for which data is input, total flow rate at each of the maximum number of blade rows 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 inlet only; to initially establish flow conditions in the first rotor, the program either picks up the input geometry or computes a first approximation to rotor annulus geometry, depending upon whether the Mod I or the Mod II option has been selected by the user. (In the case of Mod II design computations, the second stage and subsequent rotors are first taken as a copy of the last upstream rotor.) The initial approximation of rotor one flow conditions is obtained using a loading based on the given limiting value of D_{R_T} and a mid-streamline axial velocity ratio of 0.9, assuming free vortex flow and η_R = 0.90. Next the first stator exit geometry is either picked up from input data or estimated as required, and stator exit flow conditions are initially established using the given stator exit tangential velocity distribution and η_S = 0.89. Next, flow properties in the outlet are established and the limiting values of the aerodynamic parameters are checked; any necessary adjustments in the temperature and pressure profiles are made. Next, the program establishes the current outlet ducting and computes the flow properties there. To this point, only simple radial equilibrium has been employed in flow calculations. Next, 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 D_{R_T}, D_{S_H}, and M_{S_H}, to establish corresponding critical values of tangential velocity, 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 a maximum value of diffusion factor 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

$$D_R = 1 - \frac{V_2'}{V_1'} + \frac{V_{\theta 1}' - V_{\theta 2}'}{2\sigma V_1'} \tag{19}$$

or

$$D_R = 1 - \frac{V_{Z_2}}{|\cos \beta_2'| V_1'} + \frac{(U_1 - V_{\theta 1}) - V_{Z_2} \tan \beta_2'}{2\sigma V_1'} \tag{20}$$

Since with established inlet conditions and V_{Z_2} the rotor diffusion factor is dependent only on $V_{\theta 2}'$ or β_2', Equation (20) can be solved for its maximum value. Differentiating, with β_2' considered to be in the first or fourth quadrant,

$$\frac{d(D_R)}{d\beta_2'} = - \frac{V_{Z_2}}{\cos^2 \beta_2' V_1'} \sin \beta_2' - \frac{V_{Z_2}}{2\sigma V_1'} \frac{1}{\cos^2 \beta_2'} \tag{21}$$

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

$$(\beta_2')_{D_R\ max} = \text{arc sin} \left(- \frac{1}{2\sigma}\right) \tag{22}$$

and that D_R is at its maximum value. Substitution of Equation (22) into Equation (20) yields

$$D_{R\,max} = 1 - \frac{V_{Z_2}}{\left(\frac{\sqrt{4\sigma^2 - 1}}{2\sigma}\right) V_1'} + \frac{(U_1 - V_{\theta_1}) + \frac{V_{Z_2}}{\sqrt{4\sigma^2 - 1}}}{2\sigma V_1'} \tag{23}$$

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

$$D_S = 1.0 - \frac{V_3}{V_2} + \frac{V_{\theta 2} - V_{\theta 3}}{2\sigma V_2} \tag{24}$$

or

$$= 1.0 - \frac{V_3 \left|\cos \beta_2\right|}{V_{Z_2}} + \frac{\left|\cos \beta_2\right| \left\{V_{Z_2} \tan \beta_2 - V_{\theta 3}\right\}}{2\sigma V_{Z_2}} \tag{25}$$

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

$$\frac{dD_S}{d\beta_2} = \sin \beta_2 \left[\frac{V_3}{V_{Z_2}} + \frac{V_{\theta 3}}{2\sigma V_{Z_2}}\right] + \frac{1}{2\sigma}\left[\frac{1 - \sin^2 \beta_2}{\cos \beta_2}\right] \tag{26}$$

It follows that

$$(\beta_2)_{D_S\,max} = \text{arc tan}\left\{\frac{-1}{2\sigma\left[\frac{V_3}{V_{Z_2}} + \frac{V_{\theta 3}}{2\sigma V_{Z_2}}\right]}\right\} \tag{27}$$

Substituting Equation (27) into Equation (25) results in the expression

$$D_{S\,max} = 1.0 - \frac{\cos (\beta_2)_{D_S\,max}}{V_{Z_2}}\left[V_3 + \frac{1}{2\sigma}\left[\frac{V_{Z_2}}{2\sigma\left[\frac{V_3}{V_{Z_2}} + \frac{V_{\theta 3}}{2\sigma V_{Z_2}}\right]} + V_{\theta 3}\right]\right] \tag{28}$$

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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 five aerodynamic parameters in each stage. These parameters are: rotor tip diffusion factor, stator hub diffusion factor, stator hub inlet Mach number, rotor hub exit relative flow angle, and rotor tip exit whirl velocity. 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 five 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:

- Blockages at hub and tip and geometry information for Mod I or Mod II
- Radial distribution of solidity (rotor, stator)
- Radial distribution of rotor exit P_t/P_{t_T}
- 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) or of the relative flow angle at the passage shock
- 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
- Limiting value of rotor tip exit tangential velocity

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

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

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

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

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

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

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

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

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

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

ENERGY EQUATION

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

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

$$H_{t_2} - H_{t_1} = \int_{T_{t_1}}^{T_{t2}} c_p(T)dT \qquad \text{(A-8)}$$

solving for the upper limit of the integral.

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

$$P_{t_2} = P_{t_1} e^{\frac{J}{R}\left[\int_{T_{t1}}^{T_{t_2}} c_p(T) \frac{dT}{T}\right]} \qquad \text{(A-9)}$$

and solving Equation (A-8) for $H_{t_{2,\,i}}$. Efficiency is then found from

$$\eta = \frac{H_{t_{2,\,i}} - H_{t_1}}{H_{t_2} - H_{t_1}} \qquad \text{(A-10)}$$

RADIAL EQUILIBRIUM EQUATION

$$V_Z^{\,2} - V_{Zj}^2 = 2g_cJ \int_{T_{t_j}}^{T_t} c_p\,(T)dT - \left(V_\theta^2 - V_{\theta_j}^{\,2}\right) - 2\int_{R_j}^{R} \frac{V\theta^2}{R}\,dR$$

$$-2g_cJ \int_{R_j}^{R} T\,\frac{\partial S}{\partial R}\,dR + 2\int_{R_j}^{R} V_Z \left(\frac{\partial V_R}{\partial Z}\right)_R dR \qquad \text{(A-11)}$$

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

$$2g_cJ \int_{R_j}^{R} T\frac{\partial S}{\partial R}\,dR = 2g_cJ \int_{R_1}^{R_2} T\,\frac{\partial}{\partial R}\left[\int_{T_{t_1}}^{T_{t_2}} c_p(T)\frac{dT}{T} - \frac{\mathcal{R}}{J}\ln\frac{P_{t_2}}{P_{t_1}}\right] dR \qquad \text{(A-12)}$$

The streamline curvature term is evaluated from

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

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

EQUATION OF STATE

$$\rho = \frac{P}{\mathcal{R}T} \qquad \text{(A-14)}$$

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

From the definition of total enthalpy, the relationship

$$H_t - H = \frac{V^2}{2g_cJ} \qquad \text{(A-15)}$$

is established.

Static temperature is evaluated iteratively from

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

and static pressure is calculated from

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

Relative total enthalpies are determined from

$$H_t' - H_t = \frac{1}{2g_cJ}\left[V'^2 - V^2\right] \tag{A-18}$$

Relative total temperature is found iteratively from

$$H_t' - H = \int_{T}^{T_t'} c_p(T)dT \tag{A-19}$$

and relative total pressure is evaluated using the expression

$$P_t' = P\, e^{\left[\frac{J}{\mathcal{R}} \int_{T}^{T'_t} \frac{c_p(T)}{T}\,dT\right]} \tag{A-20}$$

LOSS CALCULATION

The total pressure loss coefficient is defined for rotors as

$$\bar{\omega}'_t = \frac{P'_{t_{2,i}} - P'_{t_2}}{P'_{t_1} - P_1} \tag{A-21}$$

and for stators as

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

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

$$\bar{\omega}_t = \bar{\omega}_p + \bar{\omega}_s \; . \qquad \text{(A-23)}$$

The shock loss coefficient is calculated on the basis of the normal-shock-in-passage model presented in Reference 3 (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 either: (a) the ratio of supersonic turning to total turning for both rotor and stator or (b) the distribution of flow angle at the shock for rotor and stator. Supersonic turning is computed as

$$\text{(a)} \quad \phi_{ss} = \left(\beta_1' - \beta_2'\right) \frac{\phi_{ss}}{\phi_{total}} \; .$$

or $\qquad \text{(A-24)}$

$$\text{(b)} \quad \phi_{ss} = \left(\beta_1' - \beta_2'\right)$$

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

$$\nu_1 = \sqrt{\frac{\gamma + 1}{\gamma - 1}} \tan^{-1} \sqrt{\frac{\gamma - 1}{\gamma + 1}\left(M_1'^2 - 1\right)} - \tan^{-1} \sqrt{M_1'^2 - 1} \qquad \text{(A-25)}$$

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

$$\nu_{ss} = \nu_1 + \varphi_{ss} \; . \qquad \text{(A-26)}$$

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

$$\nu_{ss} = \sqrt{\frac{\gamma + 1}{\gamma - 1}} \tan^{-1} \sqrt{\frac{\gamma - 1}{\gamma + 1}\left(M_{ss}'^2 - 1\right)} - \tan^{-1} \sqrt{M_{ss}'^2 - 1} \qquad \text{(A-27)}$$

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

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

Using the normal shock relationship, Equation (99), Reference 5 (in report),

$$\left(\frac{P_{t_2}'}{P_{t_1}'}\right)_{\substack{\text{normal}\\ \text{shock}}} = \left[\frac{(\gamma+1)\,M_e'^2}{(\gamma-1)\,M_e'^2+2}\right]^{\gamma/\gamma-1}\left[\frac{\gamma+1}{2\gamma M_e'^2-(\gamma-1)}\right]^{1/\gamma-1} \tag{A-29}$$

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

$$\bar{\omega}_s = \frac{1-\left(\frac{P_{t_2}'}{P_{t_1}'}\right)_{\text{normal shock}}}{1-\left(\frac{P_1}{P_{t_1}'}\right)} \tag{A-30}$$

where

$$\frac{P_1}{P_{t_1}'} = \left[1+\frac{\gamma-1}{2}M_1'^2\right]^{-\gamma/\gamma-1} \tag{A-31}$$

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

$$M_e' = \frac{M_1'}{2}\,(1+M_{ss}') \tag{A-32}$$

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

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

If M_e' is greater than 1.0, $\bar{\omega}_s$ is evaluated using Equations (A-29), (A-31) and (A-30) as before.

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

$$D_R = 1.0 - \frac{V_2'}{V_1'} + \frac{V_{\theta_1}' - V_{\theta_2}'}{2\sigma V_1'} \qquad \text{(For rotors)} \qquad \text{(A-34)}$$

and

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

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 circular interpolation 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 interpolation takes the form

$$\left[\frac{\bar{\omega}_p \cos\beta_2'}{2\sigma}\right]_x = \left[\frac{\bar{\omega}_p \cos\beta_2'}{2\sigma}\right]_{0.5} + r - \frac{r^2}{\sqrt{(x - 0.5)^2 + r^2}} \qquad \text{(A-36)}$$

where $r = \dfrac{(0.16 + d^2)}{2d}$ and $d = \left[\left(\dfrac{\bar{\omega}_p \cos\beta_2'}{2\sigma}\right)_{0.9,\,0.1} - \left(\dfrac{\bar{\omega}_p \cos\beta_2'}{2\sigma}\right)_{0.5}\right]$

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 five 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 five aerodynamic limits in each converged stage design occurs in the so-called "drive" option, where the rotor exit total pressure level 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 adjusts the rotor exit total pressure level 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 rotor exit total pressure in this program option will be reduced to a level such that none of the five design-limiting criteria are equalled in the converged design.

Summarizing, each of the five design criteria may be used to establish a corresponding level of rotor exit total pressure; that is, each aerodynamic limit may be used to determine a level of the rotor exit total pressure at a given point in the design computations. In the "drive" program option, the lowest of these five levels 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 rotor exit total pressure level is changed to correspond to the lowest of the five limiting values only if one or more of the aerodynamic design parameters is found to be greater than its corresponding limit value.

Expressions for the tangential velocity in terms of aerodynamic parameters are developed as follows.

1. <u>Tangential velocity in terms of rotor tip diffusion factor</u>

The diffusion factor at the rotor tip is given by

$$D_{R_T} = 1.0 - \frac{V'_{2_T}}{V'_{1_T}} + \frac{V'_{\theta 1_T} - V'_{\theta 2_T}}{2\sigma_{R_T} V'_{1_T}} \qquad \text{(A-37)}$$

or

$$D_{R_T} = 1.0 - \frac{V'_{2_T}}{V'_{1_T}} + \frac{U_{1_T} - V_{\theta 1_T} - U_{2_T} + V_{\theta 2_T}}{2\sigma_{R_T} V'_{1_T}}$$

This may be rearranged as

$$V'_{2_T} = -\frac{V_{\theta 2_T}}{2\sigma_{R_T}} + \left[\left(1.0 - D_{R_T}\right) V'_{1_T} + \frac{U_{1_T} - V_{\theta 1_T} - U_{2_T}}{2\sigma_{R_T}}\right]$$

or as

$$V'_{2_T} = K\, V_{\theta 2_T} + F \qquad \text{(A-38)}$$

where

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

and

$$F = \left[\left(1.0 - D_{R_T}\right) V'_{1_T} + \frac{U_{1_T} - V_{\theta 1_T} - U_{2_T}}{2\sigma_{R_T}}\right]$$

now

$$V'_{2_T} = \left[\left(U_{2_T} - V_{\theta 2_T}\right)^2 + V^2_{R_{2T}} + V^2_{Z_{2_T}}\right]^{1/2} \qquad \text{(A-39)}$$

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

$$U^2_{2_T} - 2U_{2_T} V_{\theta 2_T} + V^2_{\theta 2_T} + V^2_{R_{2T}}$$

$$+ V_{Z_{2_T}} = K^2\, V^2_{\theta 2_T} + 2KF\, V_{\theta 2_T} + F^2$$

which reduces to

$$V^2_{\theta 2_T} + \left[\frac{-2\left(U_{2_T} + KF\right)}{1.0 - K^2}\right] V_{\theta 2_T} + \left[\frac{V^2_{Z_{2_T}} + U^2_{2_T} + V^2_{R_{2T}} - F^2}{1.0 - K^2}\right] = 0$$

or

$$V^2_{\theta 2_T} + GV_{\theta 2_T} + W = 0 \qquad \text{(A-40)}$$

where

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

and

$$W = \left[\frac{V^2_{Z2_T} + U^2_{2_T} + V^2_{R2_T} - F^2}{1.0 - K^2}\right]$$

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

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

The calculation is restricted to positive real roots.

2. <u>Tangential velocity in terms of stator hub diffusion factor</u>

The stator hub diffusion factor is expressed as

$$D_{S_H} = 1.0 - \frac{V_{3_H}}{V_{2_H}} + \frac{V_{\theta 2_H} - V_{\theta 3_H}}{2\sigma_{S_H} V_{2_H}} \qquad \text{(A-42)}$$

This equation may be arranged as

$$V_{2_H} = -K + FV_{\theta 2_H} \qquad \text{(A-43)}$$

where

$$K = \frac{\left[V^2_{Z_{3_H}} + V^2_{\theta_{3_H}} + V^2_{R_{3_H}}\right]^{1/2} + \frac{V_{\theta_{3_H}}}{2\sigma S_H}}{1.0 - D_{S_H}}$$

and

$$F = \frac{1}{2\sigma_{S_H}\left(D_{S_H} - 1.0\right)}$$

Now, expressing V_{2_H} in terms of its components and squaring Equation (A-43), there results

$$V^2_{\theta_{2_H}} + V_{\theta_{2_H}} G + W = 0 \tag{A-44}$$

where

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

$$W = \frac{K^2 - V^2_{Z_{2_H}} - V^2_{R_{2_H}}}{F^2 - 1.0}$$

Hence,

$$V_{\theta_{2_H}} = \frac{-G \pm \sqrt{G^2 - 4W}}{2} \tag{A-45}$$

where the calculation is again restricted to positive, real roots. Using the limiting value of D_{S_H} to evaluate K and F, the resulting solution of Equation (A-45) represents a critical value of $V_{\theta_{2_H}}$.

3. Tangential velocity in terms of stator hub Mach number

The sonic velocity at a stator hub is

$$a_{S_H} = \sqrt{\gamma g_c \mathcal{R} T_{2_H}} \quad \text{(A-46)}$$

and

$$\frac{V_{2_H}}{a_{S_H}} \equiv M_{S_H} \quad \text{(A-47)}$$

This may be written as

$$M_{S_H} = \frac{\left[V^2_{\theta\,2_H} + V^2_{R_{2_H}} + V^2_{Z_{2_H}}\right]^{1/2}}{a_{S_H}} \quad \text{(A-48)}$$

Squaring and rearranging results in

$$V_{\theta\,2_H} = \left[M^2_{S_H}\, a^2_{S_H} - \left(V^2_{Z_{2_H}} + V^2_{R_{2_H}}\right)\right]^{1/2} \quad \text{(A-49)}$$

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.

4. Tangential velocity in terms of rotor hub exit relative flow angle

The relative exit flow angle at the hub is

$$\beta'_{2_H} = \tan^{-1}\left[\frac{V'_{\theta\,2_H}}{\left(V^2_{Z_{2_H}} + V^2_{R_{2_H}}\right)^{1/2}}\right] \quad \text{(A-50)}$$

Thus,

$$V'_{\theta\,2_H} = \left(V^2_{Z_{2_H}} + V^2_{R_{2_H}}\right)^{1/2} \tan\left(\beta'_{2_H}\right)$$

and

$$V_{\theta 2_H} = U_{2_H} \left(V^2_{Z2_H} + V^2_{R2_H} \right)^{1/2} \tan \left(\beta'_{2H} \right) \qquad \text{(A-51)}$$

The limiting value of β'_{2_H} is employed to evaluate $V_{\theta 2_{H,L}}$.

APPENDIX B

FORTRAN IV SOURCE DECK LISTING

Subroutine Index

```
      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.

      LOGICAL  FPATH
      DOUBLE PRECISION  TITLE
      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),          DELH(11),        DEPV(10,11),
     X DF(20),         DFACT(29,11),    DFL(29),         DFLOW(32),
     X EMACH(29,11),   FOUND(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),        ROSTAG(11),
     X RS(32),         RSLOPE(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 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,   CPO2,   CPO3,   CPO4,
     X CPO5,   DAMP,   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,  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,      K1,      KK,     L,      LIMIT,  LSTAGE,
     X MSTAGE, NLINES, NTUBES, NX,      NX1,    YES
      EQUIVALENCE  (ATAR(1,1),ATAS(1,1)),  (FLOW(1),DFLOW(1))
      COMMON /VGEOM/   ALH(29),         ALT(29),         ALTER,
     X ASPECT(29),     FPATH,           SAVEA(29)

      IF (FPATH)  DT= X(LSTAGE) -X(LSTAGE-1)
      AA= RS(LSTAGE)**2
      BB= RH(LSTAGE)**2
      DO 10 JK=1,3
      JL=LSTAGE+JK
      IF (FPATH)  X(JL)= X(JL-1) +DT
      RS(JL)= RS(LSTAGE)
      RH(JL)= SQRT(AA + (BB-AA)*ATAR(1,JK))
   10 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE  Q45
      COMMON /VANE/ NBLADE
      INTEGER BLADE
      COMMON /VGEOM/   ALH(29),          ALT(29),          ALTER,
     X ASPECT(29),     FPATH,            SAVEA(29)
      INTEGER ALTER,GCOUNT
      LOGICAL  FPATH  ,NO FAIL
      DOUBLE PRECISION  TITLE
      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(32,1[illegible]   CUCO(29,5),
     X CX(32,11),      CXM(10,11),      [illegible]XNEW(1[illegible]1),  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),   FOUND(20,3,10),  FRDEL(10,11),    [illegible]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),      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 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,    CPO2,    CPO3,    CPO4,
     X CPO5,   DAMP,    DCP,     DD,      DIFCM,   DT,      DUMMY,   FRAS1,
     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,   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,       K1,      KK,      L,       LIMIT,   LSTAGE,
     X MSTAGE, NLINES,  NTUBES,  NX,      NX1,     YES
      EQUIVALENCE  (ATAR(1,1),ATAS(1,1)),  (FLOW(1),DFLOW(1))
      LOGICAL  NO FAIL
      COMMON /SPECAL/ NORM(14),NX2,NOFAIL

    1 CONTINUE
C       *** READ THE INPUT
      CALL INPUT

C       *** INITIALIZE THE COUNTERS
C       *** ALTERATIONS TO BLADE ROW GEOMETRY IS MADE SEQUENTIALLY (DOWN
C           STREAM), ONE SMALL CHANGE TO EACH BLADE ROW UNTIL ALL HAVE
C           CONVERGED. THE FIRST BLADE ROW IS AT STATION 5.
C       *** INITIALLY THE NUMBER OF BLADE ROWS CONSIDERED IS 2. AT MOST
C           6 WILL BE CONSIDERED.

      ALTER= 5
```

```
      NBLADE= 2
  115 IPASS= 1
      GCOUNT= 0
  120 CONTINUE
      DAMP= 1.0
      LC6=0
C      *** SET UP THE ROTOR
      CALL ROTOUT
      I= I+1
C      *** SET UP THE STATOR
  130 CALL STAOUT

C         *** CALCULATE CONDITIONS AT THE OUTLET

      CALL OUTLET
C      *** CHECK THE FLOW PARAMETERS AND MAKE ADJUSTMENTS IN THE
C          TEMPERATURE AND PRESSURE PROFILES AS REQUIRED
      CALL DRIVE
C      *** SET THE ITERATION COUNTER TO ZERO
  139 LC6= 0

C         *** PRINT OUTPUT AT THIS POINT, TRANSFER TO A NEW DATA SET

  140 IF (LC6.GT.50)  CALL ERROR(19)

C         *** CALCULATE THE AXIAL VELOCITIES INCLUDING CURVATURE EFFECTS

      LC5= 0
  142 CALL CAXIAL
      LC5= LC5+1
      IF (LC5.GT.50)  CALL ERROR (18)
C      *** TURN THE LOADING ITERATION TRIGGER ON.
      NO FAIL= .TRUE.
      IPASS= 4
C      *** CHECK THE LOADING PARAMETERS AGAINST THEIR DESIRED LIMITS.
C          IF THEY ARE NOT CLOSE MAKE APPROPRIATE CHANGES IN THE ROTOR
C          TEMPERATURE PROFILE.
      CALL DRIVE
C      *** HAVE ALL OF THE FLOW PARAMETER REQUIREMENTS BEEN MET
      IF (.NOT. NO FAIL)  GO TO 142
      IPASS= 2
C      *** CALCULATE THE LOSSES
      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

      GCOUNT= GCOUNT +1
C      *** CHECK THE GEOMETRY ITERATION COUNTER
      IF (GCOUNT.GT.100)  CALL ERROR (35)
      IERROR= .FALSE.
C      *** IS THE GEOMETRY TO BE CALCULATED
```

```
      IF (FPATH)  CALL GEOM
C      *** IS THE GEOMETRY CORRECT
      IF (IERROR)  GO TO 139
C      *** CHECK THE AXIAL VELOCITIES
C          ONE MORE TIME
      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(PO(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),T ERMB(J),TO(1,1))
      TERMB(J)=TERMB(J)/TO(1,1)
  155 DEPV(9,J)= RHO(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)
      V= RINT(NLINES)-RINT(1)
      MAPR=EXP(JOULE*(THERM3((V/SUM+1.0)*TO(1,1))-THERM3(TO(1,1)))/GASK)

C        *** IF THE MASS AVERAGED PRESSURE EXCEEDS THE PRESSURE
C              RATIO DESIRED THE CALCULATION IS COMPLETE

      IF (MAPR.GE.TOTPR) GO TO 175

C        *** SINCE THE MASS AVERAGE PRESSURE RATIO HAS NOT BEEN MET WE
C              CHECK TO SEE IF ANOTHER STAGE MAY BE ADDED. IF NOT THE
C              FLOW PARAMETERS WILL BE PRINTED

      IF ((LSTAGE-5)/2.GE.MSTAGE) GO TO 170

C        *** INITIALIZE THE CALCULATION TO ADD ONE MORE STAGE

      IFIRST=MAX0(IFIRST,LSTAGE-3)
      I= LSTAGE + 1
      IB= IB+2
      IB1= IB1+2
      NX= NX+2
      NX1= NX1+2
      NX2= NX2+2
      NBLADE= MIN0( NBLADE +2, 6)
      LSTAGE=LSTAGE+2

C        *** SINCE THE CALCULATION AND CHECKING IS TO BE CONTINUED
C              UPSTREAM FOR NO MORE THAN 3 WHOLE STAGES,IT IS ASSUMED
C              THAT DR/DX,D2R/DX2 AND D(CX)/DX AT STAGES PREVIOUS TO
C              THESE WILL NOT BE AFFECTED BY THE ADDITION OF ONE MORE
```

```
C            STAGE. THEREFORE THE VALUES CALCULATED FOR THE PREVIOUS
C            CONFIGURATION ARE TO BE SAVED FOR USE IN THE NEW
C            CONFIGURATION
C        *** NOTE  ONE VERSION OF THE ITERATION USES DR/DX AND D(CR)/DX.

      DO 160 J=1,NLINES
      RSLOPE(1,J)=RSLOPE(3,J)
      RCURVE(1,J)=RCURVE(3,J)
  160 CSLOPE(1,J)=CSLOPE(3,J)
      GO TO 115

C          *** PRINT MESSAGE TO INDICATE THAT THE DESIRED PRESSURE RATIO
C              HAS NOT BEEN MET

  170 CALL ERROR(9)
  175 CALL OUTPUT

C          *** RETURN FOR A NEW DATA SET

      IF (I.GE.0) GO TO 1
      RETURN
      END
```

```
      SUBROUTINE CAXIAL
C
C         *** CALCULATES AXIAL VELOCITIES WHICH SATISFY THE
C             AXIAL-VELOCITY EQUATION
C
C
      DOUBLE PRECISION  TITLE
      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),   FOUND(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),       ROSTAG(11),
     X RS(32),         RSLOPE(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 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,    CPO2,    CPO3,    CPO4,
     X CPO5,    DAMP,    DCP,     DD,      DIFCH,   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,   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,       K1,      KK,      L,       LIMITS,  LSTAGE,
     X MSTAGE,  NLINES,  NTUBES,  NX,      NX1,     YES
      EQUIVALENCE  (ATAR(1,1),ATAS(1,1)),  (FLOW(1),DFLOW(1))
      COMMON /ENERGY/ H, T, GAMMER
      REAL  LIMIT
C
C        *** SET LIMITS ON AXIAL VELOCITY TO RESTRAIN THE ITERATION.
C
      TEST= 1.56
      LIMIT= 1.6
      L= 0
      DO 1 I=IB,NX
      L= L+1
C
C        *** SATISFY CONTINUITY.
C
      CALL STREAM
      DO 1 J=1,NLINES
```

```
C        *** SAVE THE AXIAL VELOCITIES.
      BETA(L,J)= CX(I,J)
    1 CONTINUE
      DAMP= 10.0

C           *** INITIALIZE THE ITERATION COUNTER

      LOOPY=0
    5 CONTINUE
C        *** TURN THE CONVERGENCE TRIGGER ON.
      YES= .FALSE.
      LOOPY=LOOPY+1

C           *** ERROR WILL PRINT THE RESULTS OF THE LAST ITERATION
C               AND TRANSFER TO A NEW DATA SET

      IF (LOOPY.GT.250)  CALL ERROR(4)
      DO 125 J=1,NLINES

C           *** GET FIRST AND SECOND DERIVATIVES OF R WITH RESPECT TO X

  125 CALL XDERIV(R,RSLOPE,RCURVE)

      L=0
      DO 130 I=IB,NX
      L=L+1
      CM2=CX(I,JM)**2
      DO 120 J=1,NLINES

C           *** SAVE THE AXIAL VELOCITIES

      CX(I,J)= (4.0*BETA(L,J) +CX(I,J))*0.2
      BETA(L,J)=CX(I,J)
      CU2(J)=CU(I,J)**2
  120 DEPV(L,J)=CU2(J)/R(I,J)
      CALL INTEG (DEPV,2)
      A= THERM1(TO(I,JM))
      DO 130 J=1,NLINES
C        *** CALCULATE THE ENTHALPY AND CENTRIFUGAL FORCE TERMS AS WELL AS
C              THE RADIAL VELOCITY TERM.
  130 TERM1(L,J)= (GJ*(THERM1(TO(I,J))-A)
     X+CR(I,JM)**2 -CR(I,J)* 2
     X   -(CU2(J) -CU2(JM)) -2.0*RINT(J))
     X /CM2

C           *** FIND ENTROPY GRADIENT TERM IN AXIAL-VELOCITY EQUATION
C           *** OBTAIN FIRST DERIVATIVE OF DEPV WITH RESPECT TO RADIUS,
C               RESULT IS IN CO


C           *** NOTE... THE REFERENCE TERMS HAVE BEEN LEFT OUT OF THIS
C               EQUATION SINCE THEIR DERIVATIVES ARE ZERO

      L=0
      DO 235 I=IB,NX
      L=L+1
```

```
      DO 233 J=1,NLINES                                                 CAXI 412
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
                                                                        CAXI 423
  235 ALPHA(L,J)= ALPHA(L,J-1) +0.5*GR*(TSTAT(J) +TSTAT(J-1))           CAXI 424
     X  *(DEPV(L,J) -DEPV(L,J-1))                                       CAXI 425
  210 DO 220 J=1,NLINES                                                 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,CD)                                         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,JM)                                                       CAXI 447
      CM2= HELP*CM**2                                                   CAXI 448
  245 DO 250 J=1,NLINES                                                 CAXI 449
                                                                        CAXI 450
C         *** ... 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) 381,385,383                                            CAXI 462
  385 TERMD=1.0                                                         CAXI 463
      GO TO 400                                                         CAXI 464
                                                                        CAXI 465
          *** CHECK VALUES OF VELOCITY RATIO AGAINST REASONABLE LIMITS  CAXI 466
                                                                        CAXI 467
  381 IF (TERMD.GT.-.99) GO TO 390                                      CAXI 468
                                                                        CAXI 469
C         *** ALTER HELP TO REDUCE CURVATURE EFFECTS (TEMPORARILY)      CAXI 470
```

```
      HELP= HELP*1.1
      IF (ILL.LT.25)  GO TO 365
      TERMD=0.1
      GO TO 400
  383 IF (TERMD.LT.TEST)  GO TC 390
      HELP= HELP*1.1
      IF (ILL.LT.25)  GO TO 365
      TERMD= LIMIT
      GO TO 400
C      *** CALCULATE NEW AXIAL VELOCITY.
  390 TERMD=SQRT(1.0+TERMD)
  400 CXNEW(L,J)=TERMD*CM
  410 CONTINUE

C         *** COMPARE VELOCITIES INTO CURVATURE EQUATION WITH THOSE OUT

      DO 440 J=1,NLINES
      IF (ABS((CXNEW(L,J)-CX(I,J))/CX(I,J)).GT.TOLCX) GO TO 450
  440 CONTINUE
      GO TO 455

C         *** UNSUCCESSFUL CONVERGENCE ON CX

  450 YES= .TRUE.
  455 DO 460 J=1,NLINES
      CX(I,J)= (CX(I,J) +CXNEW(L,J))*0.5
  460 CR(I,J)= CX(I,J)*RSLOPE(L,J)

C         *** SATISFY CONTINUITY

      CALL STREAM

C      *** MAKE AN ADJUSTMENT ON THE STREAMLINE POSITIONS.

      CALL MOVE
  490 CONTINUE
C         *** CHECK CONVERGENCE OF AXIAL VELOCITIES

 1010 L=0
      DO 700 I=IB,NX
      L=L+1
      DO 700 J=1,NLINES
      IF (ABS((BETA(L,J)-CX(I,J))/CX(I,J)).GT.TOLCX) GO TO 1020
  700 CONTINUE
      L= 0


      GO TO 1021
 1020 YES= .TRUE.
 1021 L= 0
      L=L+1
C      *** MOVE THE LIMITS ON AXIAL VELOCITY.
      TEST= 1.02*TEST
      LIMIT= SQRT(1.0 +TEST)
```

```
IF (YES) GO TO 5                                         CAXI 525
IT= 0                                                    CAXI 526
RETURN                                                   CAXI 527
END                                                      CAXI 528
```

```
      SUBROUTINE   COPY                                                 COPY 529
      LOGICAL  FPATH                                                    COPY 530
      COMMON /VGEOM/    ALH(29),          ALT(29),         ALTER,       COPY 531
     X ASPECT(29),      FPATH,            SAVEA(29)                     COPY 532
      DOUBLE PRECISION  TITLE                                           COPY 533
      REAL  MACH,  MAPR,  MOLEWT,  JOULE                                COPY 534
      DIMENSION ATAS(29,11),  FLOW(32)                                  COPY 535
      LOGICAL  IERROR, YES                                              COPY 536
      COMMON /MATRIX/   ALPHA(10,11),    ATAR(29,11),     B2(29),       COPY 537
     X BETA(10,11),     BH(32),          BLADE(29),       BT(32),       COPY 538
     X CO(10,11),       CP(32,11),       CPCO(6),         CR(32,11),    COPY 539
     X CSLOPE(10,11),   CU2(11),         CU(32,11),       CUCO(29,5),   COPY 540
     X CX(32,11),       CXM(10,11),      CXNEW(10,11),    CXRATO(29),   COPY 541
     X CXS(10,11),      DA(10),          DELM(11),        DEPV(10,11),  COPY 542
     X DF(20),          DFACT(29,11),    DFL(29),         DFLOW(32),    COPY 543
     X EMACH(29,11),    FOUND(20,3,10),  FRDEL(10,11),    GAMMA(32,11), COPY 544
     X HMN(29),         HUB(32),         IKK(10),         MACH(29,11),  COPY 545
     X OBAR(29,11),     PO(32,11),       R(32,11),        RCURVF(10,11),COPY 546
     X RH(32),          RHO(32,11),      RINT(11),        ROSTAG(11),   COPY 547
     X RS(32),          RSLOPE(10,1...,  RTRAIL(11),      SOCO(29,5),   COPY 548
     X SOLID(29,11),    SSCU(29,5),      TERM1(10,11),    TERMA(11),    COPY 549
     X TERMB(11),       TERMC(11),       TIP(32),         TITLE(12),    COPY 550
     X TO(32,11),       TSTAT(11),       U(32,11),        W(11),        COPY 551
     X X(32)                                                            COPY 552
      COMMON /SCALER/   A,     AA,    A10A0,  A202A0, A303A0, A404A0,   COPY 553
     X A505A0, B,       BB,    CC,    CM,     CMEAN,  CMEANP, COINTG,   COPY 554
     X CPI2,   CPI3,    CPI4,  CPI5,  CPI6,   CPO2,   CPO3,   CPO4,     COPY 555
     X CPO5,   DAMP,    DCP,   DD,    DIFCM,  DT,     DUMMY,  ERAS1,    COPY 556
     X G,      GASK,    GJ,    GR,    GR2,    JOULE,  MAPR,   MOLEWT,   COPY 557
     X PCCO,   C,       RPM,   TCP,   TERMD,  TESTBH, TESTDS, TESTMS,   COPY 558
     X TOCO,   TOL,     TOLAT, TOLB2, TOLMIN, TOLMS,  TOLTIP, TOLCP,    COPY 559
     X TOLCX,  TOLR,    TOTINT, TOTPR, V,     VMI                       COPY 560
      COMMON /INTEGR/   I,     IB,    IB1,    IDUMP,  IERROR, IFIRST,   COPY 561
     X ˋG,     IOUTTR,  IPASS, IS,    IT,     J,      JIN,    JJ,       COPY 562
     X JM,     JM1,     K,     K1,    KK,     L,      LIMIT,  LSTAGE,   COPY 563
     X MSTAGE, NLINES,  NTUBES, NX,   NX1,    YES                       COPY 564
      EQUIVALENCE  (ATAR(1,1),ATAS(1,1)),  (FLOW(1),DFLOW(1))           COPY 565
                                                                        COPY 566
      L= I-2                                                            COPY 567
C      *** IS THE GEOMETRY BEING CALCULATED.                                 567
      IF (FPATH)  GO TO 20                                              COPY 568
C      *** PICK UP THE HUB AND TIP RADIUS.                                   569
      RH(I)= HUB(I)                                                     COPY 569
      RS(I)= TIP(I)                                                     COPY 570
      GO TO 30                                                          COPY 571
C      *** SET THE TIP, ESTIMATE THE HUB (LOW) AND COMPUTE THE SPACING.      572
   20 RS(I)= RS(I-1)                                                    COPY 572
      DT=  (RS(I-1) -RH(I-1))/ASPECT(I)                                 COPY 573
      RH(I)= AMIN1(RH(I), RH(I-1) +DT*ALH(I))                           COPY 574
      X(I)= X(I-1) +DT                                                  COPY 575
C      *** ESTIMATE THE AXIAL VELOCITIES, SET THE EFFICIENCY (ON THE         576
C          HIGH SIDE) AND ESTIMATE THE TEMPERATURE AND PRESSURE.
   30 CALL RSTART                                                       COPY 576
      DO 50 J=1,NLINES                                                  COPY 577
      CX(I,J)= (CX(L,J) +CX(L,JM))*0.5                                  COPY 578
```

```
      ATAR(I,J)=SQRT(ATAR(L,J))                                  COPY 579
      PO(I,J)= PO(I-1,J)*PO(L,J)/PO(L-1,J)                       COPY 580
      TO(I,J)= TO(I-1,J)*TO(L,J)/TO(L-1,J)                       COPY 581
      CALL THERMP                                                COPY 582
      CU(I,J)= CU(L,J)                                           COPY 583
   50 CR(I,J)= CR(L,J)                                           COPY 584
      L= 2                                                       COPY 585
      CALL STREAM                                                COPY 586
      CALL MOVE                                                  COPY 587
      RETURN                                                     COPY 588
      END                                                        COPY 589
```

```
      BLOCK DATA
      DOUBLE PRECISION  TITLE
      REAL  MACH,  MAPR,  MOLEWT,  JOULE
      DIMENSION ATAS(29,11),  FLOW(32)
      LOGICAL  IERROR, YES
      COMMCN /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),   FOUND(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),        ROSTAG(11),
     X RS(32),         RSLOPE(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 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,    CP02,    CP03,    CP04,
     X CP05,    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,   TOLTIP,  TOLCP,
     X TCLCX,   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,       K1,      KK,      L,       LIMIT,   LSTAGE,
     X MSTAGE,  NLINES,  NTUBES,  NX,      NX1,     YES
       EQUIVALENCE  (ATAR(1,1),ATAS(1,1)),  (FLOW(1),DFLOW(1))
       COMMON /VMIN/ VO(29)

       DIMENSION ZZ(171), ZX(171), ZY(45), Z(387)
       EQUIVALENCE (CO,Z,ZZ), (Z(172),ZX), (Z(343),ZY)
       DATA G, GJ, JOULE/ 1545.44, 50070.47, 778.12 /
       DATA DF /0.0, 0.1, 0.15, 0.2, 0.25, 0.3, 0.35, 0.4, 0.45, 0.5,
     X  0.55,  0.6, 0.65, 0.7, 0.75, 0.8, 0.85, 0.   0.95, 1.0/
       DATA  ZZ /
     X 4H    ,4H THI,4HS PR,4HOGRA,4HM MU,4HST B,4HE US,4HED W,4HITH ,
     X 4HCONS,4HIDER,4HABLE,4H CAR,4HE AN,4HD TH,4HOUGH,4HT.   ,4HSTEE,
     X 4HP    ,4H    ,4HPARA,4HMETE,4HR PR,4HOFIL,4HES,  ,4HROUG,4HH FL,
     X 4HOWPA,4HTHS,,4H AND,4H DAT,4HA IN,4HCONS,4HISTE,4HNT W,4HITH ,
     X 4HTHE ,4HPROG,4HRAM ,4H    ,4HASSU,4HMPTI,4HONS ,4HWILL,4H USU,
     X 4HALLY,4H LEA,4HD TO,4H FAI,4HLURE,4H OF ,4HTHE ,4HITER,4HATIO,
     X 4HN.  ,4H    ,4H    ,4H    ,4H    ,4H    ,4H    ,4H    ,4H    ,
     X 4H    ,4H    ,4H    ,4H    ,4H    ,4H    ,4H    ,4H    ,4H    ,
     X 4H    ,4H    ,4H    ,4H    ,4H    ,4H    ,4H    ,4H    ,4H    ,
     X 4H IF ,4HTHE ,4HPROG,4HRAM ,4HCAN ,4HNOT ,4HFIND,4H A S,4HOLUT,
     X 4HION ,4HIT W,4HILL ,4HPRIN,4HT AN,4H ERR,4HOR M,4HESSA,4HGE  ,
     X 4H    ,4HFOLL,4HOWED,4H BY ,4HTHE ,4HSTAN,4HDARD,4H OUT,4HPUT.,
     X 4H  TH,4HIS I,4HS TO,4H BE ,4HUSED,4H TO ,4HDETF,4HRMIN,4HE   ,
```

```
X 4H    ,4H    ,4H    ,4HTHE ,4HCAUS,4HE OF,4H THE,4H FAI,4HLURE,  DATA 645
X 4H.   ,4H    ,4H    ,4H    ,4H    ,4H    ,4H    ,4H    ,4H    ,  DATA 646
X 4H    ,4H    ,4H    ,4H    ,4H    ,4H    ,4H    ,4H    ,4H    ,  DATA 647
X 4H    ,4H    ,4H    ,4H    ,4H    ,4H    ,4H    ,4H    ,4H    ,  DATA 648
X 4H    ,4H    ,4H    ,4H    ,4H    ,4H    ,4H    ,4H    ,4H AT ,  DATA 649
X 4HTHE ,4HFIRS,4HT AN,4HD  L,4HAST ,4H AXI,4HAL S,4HTA   ,HONS /  DATA 650
 DATA  ZX /                                                         DATA 651
X 4H IT ,4HIS A,4HSSUM,4HED T,4HHAT ,4HTHE ,4HFLOW,4H    ,4H    ,  DATA 652
X 4HIS P,4HARAL,4HLEL ,4HTO T,4HHE A,4HXIS ,4HOF R,4HOTAT,4HION.,  DATA 653
X 4H  IN,4HLET ,4HAND ,4HEXIT,4H GEO,4HMETR,4HY SH,4HOULD,4H BE ,  DATA 654
X 4H    ,4H    ,4HCONS,4HISTE,4HNT W,4HITH ,4HTHIS,4H ASS,4HUMPT,  DATA 655
X 4HION.,4H  TH,4HE SP,4HACIN,4HG OF,4H THE,4H AXI,4HAL S,4HTATI,  DATA 656
X 4HONS ,4HSHOU,4HLD  ,4H    ,4HBE R,4HEGUL,4HAR, ,4HBUT ,4HNEED,  DATA 657
X 4H NOT,4H BE ,4HEQUA,4HL.  ,4H    ,4H    ,4H    ,4H    ,4H    ,  DATA 658
X 4H    ,4H    ,4H    ,4H    ,4H    ,4H    ,4H    ,4H    ,4H    ,  DATA 659
X 4H    ,4H    ,4H    ,4H    ,4H    ,4H    ,4H    ,4H    ,4H    ,  DATA 660
X 4H    ,4H    ,4H    ,4H    ,4H    ,4H    ,4H    ,4H    ,4H    ,  DATA 661
X 4H D-F,4HACTO,4HR LI,4HMITS,4H WHI,4HCH A,4HRE U,4HNREA,4HSONA,  DATA 662
X 4HBLE ,4HAND ,4HMACH,4H NUM,4HBER ,4HLIMI,4HTS W,4HHICH,4H    ,  DATA 663
X 4H    ,4HARE ,4HTOO ,4HLOW ,4HWILL,4H USU,4HALLY,4H CAU,4HSE F,  DATA 664
X 4HAILU,4HRE O,4HF TH,4HE IT,4HERAT,4HION.,4H    ,4H    ,4H    ,  DATA 665
X 4H    ,4H    ,4H    ,4H    ,4H    ,4H    ,4H    ,4H    ,4H    ,  DATA 666
X 4H    ,4H    ,4H    ,4H    ,4H    ,4H    ,4H    ,4H    ,4H    ,  DATA 667
X 4H    ,4H    ,4H    ,4H    ,4H    ,4H    ,4H THE,4H AXI,4HAL V,  DATA 668
X 4HELOC,4HITY ,4HAT E,4HACH ,4HSTRE,4HAMLI,4HNE I,4HS CO,4HNSTR,  DATA 669
X 4HAINE,4HD TO,4H LIE,4H BET,4HWEEN,4H    ,4H    ,4HLIMI,4HTS W/  DATA 670
 DATA  ZY /                                                         DATA 671
X 4HHICH,4H ARE,4H APP,4HROXI,4HMATE,4HLY 1,4HO PE,4HRCEN,4HT AN,  DATA 672
X 4HD 10,4HO PE,4HRCEN,4HT OF,4H MID,4H-STR,4HEAML,4HINE ,4H    ,  DATA 673
X 4HAXIA,4HL VE,4HLOCI,4HTY. ,4H SHO,4HULD ,4HTHE ,4HSOLU,4HTION,  DATA 674
X 4H LIE,4H BEY,4HOND ,4HTHES,4HE FA,4HILUR,4HE OF,4H THE,4H    ,  DATA 675
X 4H    ,4H    ,4HITER,4HATIO,4HN WI,4HLL O,4HCCUR,4H.   ,4H    /  DATA 676
 END                                                                DATA 677
```

```
      SUBROUTINE CATAL

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

      DOUBLE PRECISION  TITLE
      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),   FOUND(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),       ROSTAG(11),
     X RS(32),         RSLOPE(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 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,    CPO2,    CPO3,    CPO4,
     X CPO5,    DAMP     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,   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,       K1,      KK,      L,       LIMIT,   LSTAGE,
     X MSTAGE, NLINES, NTUBES, NX,      NX1,     YES
      EQUIVALENCE  (ATAR(1,1),ATAS(1,1)),  (FLOW(1),DFLOW(1))

      DIMENSION Z(387)
      EQUIVALENCE (CO,Z)
      WRITE (6,333) Z
  333 FORMAT (1H1/////(12X20A4))
      READ (5,910)IG
  910 FORMAT (24I3)
      REWIND 2
      DO 920 I=1,IG
      READ (5,925)  ((CX(K,J),K=1,20),J=1,3)
  920 WRITE (4)  ((CX(K,J),K=1,20),J=1,3)
  960 END FILE 4
      REWIND 4
  925 FORMAT (12F6.0)
      CALL  Q45
      RETURN
```

```
END                                                        DATA  55
```

```
      SUBROUTINE  DERIV(R,RSLOPE,RCURVE,X)
      COMMON /INTEGR/  I,      IB,IB1, IDUMP,  IERROR, IFIRST   ,
     X IG, IOUTTR, IPASS, IS, IT, J, JIN, JJ, JM, JM1, K, K1, KK, L,
     X LIMIT, LSTAGE, MSTAGE, NLINES, NTUBES, NX, NX1, YES
      L= 1
      DO 5 I=IB1,NX1
      L= L+1
      AA= (R(I-1,J) -R(I,J))/(X(I-1)-X(I))
      BB= (R(I+1,J) -R(I,J))/(X(I+1)-X(I))
      RSLOPE(L,J)= (R(I+1,J) -R(I-1,J))/(X(I+1) -X(I-1))
    5 RCURVE(L,J)= (AA -BB)/(X(I-1) -X(I+1))*2.0
      RETURN
      END
```

```
      SUBROUTINE DRIVE
C
C         *** OPTIMIZES TO ONE OF FIVE LIMITS
C
      DOUBLE PRECISION  TITLE
      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),   FOUND(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),        ROSTAG(11),
     X RS(32),         RSLOPE(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 TO(32,11),      TSTAT(11),       U(32,11),        W(11),
     X X(32)
      COMMON /SCALER/  A,      AA,      A1OA0,   A2O2A0,  A3O3A0,  A4O4A0,
     X A5O5A0, 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,     JOULE,   MAPR,    MOLEWT,
     X POCO,   Q,      RPM,    TCP,     TERMD,   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,     IOUTTR, 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
      COMMON /VMIN/ VO(29)

      COMMON /SPECAL/ NORM(14),NX2,NOFAIL
      LOGICAL  NO FAIL
      REAL MSH,      NORM
      IF (LSTAGE.GT.11)   GO TO 8
C
C         *** CALCULATE INLET GUIDE VANE EXIT QUANTITIES
C
      T= TOCO
      B= THERM3(T)
      DO 5 J=1,NLINES
      CU(5,J)= (CUCO(5,1)/R(5,J) +CUCO(5,2))/R(5,J) +CUCO(5,3)
     X        +(CUCO(5,4) +CUCO(5,5)*R(5,J))*R(5,J)
      H= -(CX(5,J)**2 +CR(5,J)**2 +CU(5,J)**2)/GJ
      CA   .  ENTALP
    5 P(  5,J)= POCO -W(J)*(POCO -POCO*EXP((THERM3(TSTAT(J))-B)/DCP))
```

```
    8 CONTINUE
      DO 50 I=IFIRST,LSTAGE,2

C         *** COMPUTE PERTINENT QUANTITIES

      J=1
      K= I/2
      A= (R(I,NLINES) +R(I-1,NLINES) -(RH(I)+RH(I-1)))/ (RS(I)+RS(I-1)
     X  -(RH(I)+RH(I-1)))
      SOLID(I,NLINES)= SOCO(I,1)/(SOCO(I,2)+A)+SOCO(I,3)+(SOCO(I,4)
     X  +SOCO(I,5)*A)*A
      A= (R(I,1) +R(I+1,1)-RH(I)-RH(I+1))/(RS(I)+RS(I+1)-RH(I)-RH(I+1))
      SOLID(I+1,1)= SOCO(I+1,1)/(SOCO(I+1,2)+A) +SOCO(I+1,3)
     X  +(SOCO(I+1,4) +SOCO(I+1,5)*A)*A
      V= SQRT(CX(I-1,NLINES)**2 +CR(I-1,NLINES)**2
     X       +(CU(I-1,NLINES)-U(I-1,NLINES))**2)

C         *** IS THIS AN UPDATE WITH NEW EFFICIENCIES

      IF (IPASS.EQ.3.OR.IPASS.EQ.2)  GO TO 15
      A= SQRT(CX(I,NLINES)**2 +CR(I,NLINES)**2
     X       +(CU(I,NLINES) -U(I,NLINES))**2)
      DRT= 1.0 -A/V +(U(I-1,NLINES)-CU(I-1,NLINES)-U(I,NLINES)+CU(I,
     X      NLINES))/V/SOLID(I,NLINES)/2.0
      A= SQRT(CX(I+1,1)**2+CR(I+1,1)**2+CU(I+1,1)**2)
      B= SQRT(CX(I,1)**2 +CR(I,1)**2 +CU(I,1)**2 )
      DSH= 1.0 -A/B + (CU(I,1)-CU(I+1,1))/B/SOLID(I+1,1)/2.0
      H=-B*B/GJ
      T= TO(I,1)
      CALL  ENTALP
      CALL  GAM
      MSH= B/SQRT(GR2*GAMMER*TSTAT(J))
      REL FLO= ATAN((U(I,1)-CU(I,1))/SQRT(CX(I,1)**2 +CR(I,1)**2))

C         *** CHECK FOR LIMIT VIOLATIONS

      IF ( (DRT -DFL(I))/DFL(I).GT. TOLB2
     X .OR.(DSH -DFL(I+1))/DFL(I+1).GT. TOLB2
     X .OR.(MSH -HMN(I))/HMN(I).GT. TOLB2
     X .OR.(CU(I,NLINES) -VO(I))/VO(I) .GT. TOLB2
     X .OR. HMN(I+1) -REL FLO.GT. TOLB2 )  GO TO 10

C         *** IS ONE OF THE LIMITS TO BE MET

      IF (LIMIT.NE.0)  GO TO 50

C         *** HAS ONE OF THE LIMITS BEEN MET

      IF ((ABS((DRT-DFL(I))/DFL(I)).LT.TOLB2 .OR.
     X      ABS((DSH-DFL(I+1))/DFL(I+1)).LT.TOLB2 .OR.
     X      ABS((MSH-HMN(I))/HMN(I)).LT.TOLB2 .OR.
     X      ABS((CU(I,NLINES) -VO(I))/VO(I)).LT.TOLB2 .OR.
     X      ABS(REL FLO -HMN(I+1)).LT.TOLB2 ) .AND. NO FAIL ) GO TO 50
   10 NO FAIL= .FALSE.

C         *** CALCULATE THE TANGENTIAL VELOCITY FROM
```

```
C          THE ROTOR TIP D-FACTOR

      Q= 0.5/SOLID(I,NLINES)
      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
      B= 0.5*B
      B= AMIN1(VO(I),B)
      H= (U(I,NLINES)*B -U(I-1,NLINES)*CU(I-1,NLINES))*ATAR(I,NLINES)
     X   *2.0/GJ
      T= TO(I-1,NLINES)
      CALL  ENTALP
      PTIP= PO(I-1,NLINES)*EXP((THERM3(TSTAT(J)) -THERM3(T))/DCP)

C       *** CALCULATE THE TANGENTIAL VELOCITY FROM
C            THE HUB ABSOLUTE MACH NUMBER

      SQCO=CX(I,1)**2 +CR(I,1)**2
      V= SQCO +CU(I,1)**2
      H= -V/GJ
      T= TO(I,1)
      CALL  ENTALP
      CALL  GAM
      VMI=  GR2*GAMMER*TSTAT(J)
      A= VMI*HMN(I)**2 -SQCO
      IF (A.LE.0.0) CALL ERPOR(3C)
      CUHMN= SQRT(A)

C       *** CALCULATE THE TANGENTIAL VELOCITY FROM
C            THE HUB RELATIVE FLOW ANGLE

      CUBETA= U(I,1) -SQRT(CX(I,1)**2 +CR(I,1)**2)*TAN(HMN(I+1))

C       *** CALCULATE THE TANGENTIAL VELOCITY FROM
C            THE STATOR HUB D-FACTOR

      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

C         *** ERROR TRANSFER TO A NEW DATA SET

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

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

```
      IF (CU(I,1).LE.0.0) CU(I,1)=AA-CC

C       *** SELECT THE MINIMUM OF THE HUB TANGENTIAL VELOCITIES

      CU(I,1)= AMIN1(CU(I,1), CUHMN, CUBETA)
      H= (CU(I,1)*U(I,1) -CU(I-1,1)*U(I,1))*ATAR(I,1)*2.0/GJ
      T= TO(I-1,1)
      CALL  ENTALP
      A= (R(I,1) -RH(I))/(RS(I) -RH(I))
      A= NORM(K)*(CUCO(I,1)/(CUCO(I,2) +A) +CUCO(I,3)
     X + (CUCO(I,4) +CUCO(I,5)*A)*A)

C       *** CALCULATE THE REQUIRED TIP TOTAL PRESSURE


      PO(I,NLINES)= AMIN1( PTIP, PO(I-1,1)*EXP((THERM3(TSTAT(J))
     X  -THERM3(T))/ DCP) /A )

C         *** DETERMINE FLOW PARAMETERS

   15 DO 20 J=1,NTUBES

C       *** DETERMINE THE TOTAL PRESSURES FROM THE PROFILE

      A= (R(I,J)-RH(I))/(RS(I)-RH(I))
   20 PO(I,J)= PO(I,NLINES)*NORM(K  )*(CUCO(I,1)/(CUCO(I,2)+A)+CUCO(I,3)
     X           +(CUCO(I,4) + CUCO(I,5)*A)*A)
      DO 30 J=1,NLINES
      IF (PO(I,J).LE.PO(I-1,J))  CALL ERROR (22)

C       *** GET THE TOTAL TEMPERATURE PROFILE

      CALL THERM2(PO(I,J)/PO(I-1,J),TO(I,J),TO(I-1,J))
      H= THERM1(TO(I,J)) -THERM1(TO(I-1,J))
      H= H/ATAR(I,J)

C       *** COMPUTE THE CORRESPONDING TANGENTIAL VELOCITY

      CU(I,J)= (0.5*H*GJ +CU(I-1,J)*U(I-1,J))/U(I,J)
      T= TO(I-1,J)
      CALL  ENTALP
      TO(I,J)= TSTAT(J)
      H= ATAS(I+1,J)*H
      CALL  ENTALP
      PO(I+1,J)= PO(I-1,J)*EXP((THERM3(TSTAT(J)) -THERM3(T))/DCP)
      CALL THERMP
      TO(I+1,J)= TO(I,J)
      CP(I+1,J)= CP(I,J)
      GAMMA(I+1,J)= GAMMA(I,J)

C       *** DETERMINE THE TANGENTIAL VELOCITY AT THE STATOR EXIT

   30 CU(I+1,J)= (CUCO(I+1,1)/R(I+1,J) +CUCO(I+1,2))/R(I+1,J)
     X             +CUCO(I+1,3)
     X          +(CUCO(I+1,4) +CUCO(I+1,5)*R(I+1,J))*R(I+1,J)
```

```
 50 CONTINUE
C      *** U.'DATE THE EXIT
    DO 60 I=NX2,NX
    DO 60 J=1,NLINES
    PO(I,J)=     PO(I-1,J)
    CU(I,J)=     CU(I-1,J)*R(I-1,J)/R(I,J)
    CP(I,J)=     CP(I-1,J)
    TO(I,J)=     TO(I-1,J)
 60 GAMMA(I,J)= GAMMA(I-1,J)
    RETURN
    END
```

```
      SUBROUTINE  ENTALP
      DOUBLE PRECISION  TITLE
      COMMON /ENERGY/ H, T, GAMMER

C      *** CALCULATES THE TEMPERATURE RISE CORRESPONDING TO AN
C          ENTHALPY CHANGE
      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),   FOUND(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),       RCSTAG(11),
     X RS(32),         RSLOPE(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 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,   CPO2,   CPO3,   CPO4,
     X CPO5,   CAMP,   DCP,    DD,     DIFCM,  DT,     DUMMY,  ERAS1,
     X G,      GASK,   GJ,     GR,     GR2,    JOULE,  MAPR,   MOLEWT,
     X POCO,   C,      RPM,    TCP,    TERMD,  TESTBH, TESTOS, 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,     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))
      HOT= THERM1(T)
      TSTAT(J)= H/CP(1,1) +T
      DO 10  ITER=1,25
      HIT= THERM1(TSTAT(J))
      E=H-HIT +HOT
      TSTAT(J)= E/CP(1,1) +TSTAT(J)
      IF (ABS(E).LE.0.01)  GO TO 20
   10 CONTINUE
      CALL ERROR(8)
   20 RETURN
      END
```

```
      SUBROUTINE ERROR (IERR)
      DOUBLE PRECISION  TITLE
      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),    FOUND(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),        ROSTAG(11),
     X RS(32),          RSLOPE(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 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,    CPO2,    CPO3,    CPO4,
     X CPO5,    DAMP,    DCP,     DD,      DIFCM,   DT,      DUMMY,   ERAS1,
     X G,       GASK,    GJ,      GR,      GR2,     JOULE,   MAPR,    MOLEWT,
     X POCO,    C,       RPM,     TCP,     TERMD,   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))
      COMMON /ENERGY/ F, T, GAMMER
      COMMON /VMIN/ VO(29)
      INTEGER ALTER
      COMMON /SPECAL/ NORM(14), NX2, NO FAIL
      COMMON /VGEOM/   ALH(29),          ALT(29),          ALTER,
     X ASPECT(29),      FPATH,            SAVEA(29)
      DATA IER /0/
      WRITE (6,5) IERR
    5 FORMAT (/// 13H ERROR NUMBER I3/////)
      IER= IER +1
      IF (IER.GT.25) GO TO 1050
      GO TO (10,  20,  30,  40,  50,  60,  70,  80,  90, 100, 110, 120,
     X 130, 140, 150, 160, 170, 180, 190, 200, 210, 220, 230, 240, 250,
     X 260, 270, 280, 290, 300, 310, 320, 330, 340, 350),IERR
   10 WRITE (6,11)
   11 FORMAT (9X 65HTHE LOSS DATA SET REQUESTED FROM THE MASTER FILE IS
     XNOT AVAILABLE )
      K1 =1
      GO TO 1040
   20 WRITE (6,21)  I
   21 FORMAT (9X 57HTHE AXIAL MACH NUMBER OF THE MIDDLE STREAMLINE AT ST
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  XATION I3 / 9X 11HEXCEEDS 1.0 )                                        ERRO1017
    GO TO 1000                                                           ERRO1018
 30 WRITE (6,31)  I                                                      ERRO1019
 31 FORMAT (9X 44HCONTINUITY COULD NOT BE SATISFIED AT STATION I3 )      ERRO1020
    GO TO 1000                                                           ERRO1021
 40 WRITE (6,41)                                                         ERRO1022
 41 FORMAT (9X 40HTHE AXIAL VELOCITY ITERATION HAS FAILED. )             ERRO1023
    GO TO 1000                                                           ERRO1024
 50 WRITE (6,51)  DELM                                                   ERRO1025
 51 FORMAT (9X 44HTHE FRACTIONAL MASS FLOWS ARE NOT INCREASING / 9X      ERRO1026
   X 11F10.3 / 9X 24HTHEY WILL BE CHANGED TO. )                          ERRO1027
    A= 1.0/FLOAT(NTUBES)                                                 ERRO1028
    DELM(1)= 0.0                                                         ERRO1029
    DO 52 J=2,NLINES                                                     ERRO1030
 52 DELM(J)= DELM(J-1) +A                                                ERRO1031
    WRITE (6,53)  DELM                                                   ERRO1032
 53 FORMAT (9X 11F10.3)                                                  ERRO1033
    GO TO 1040                                                           ERRO1034
 60 WRITE (6,61)                                                         ERRO1035
 61 FORMAT (9X 52HTHE NUMBER OF STREAMLINES MUST BE EITHER 5,7,9 OR 11ERRO1036
   X /9X 21HEXECUTION TERMINATED. )                                      ERRO1037
    GO TO 1030                                                           ERRO1038
 70 WRITE (6,71)                                                         ERRO1039
 71 FORMAT (9X 35HNO MORE THAN 12 STAGES CAN BE INPUT )                  ERRO1040
    MSTAGE= 12                                                           ERRO1041
    GO TO 1040                                                           ERRO1042
 80 WRITE (6,81)H,I,J                                                    ERRO1043
 81 FORMAT (9X 23HA CHANGE IN ENTHALPY OF E14.5, 30H HAS LEAD TO A FAIERRO1044
   XLURE TO FIND /9X 26HA TEMPERATURE NEAR STATION I3, 15H AND STREAMLERRO1045
   XINE I3 )                                                             ERRO1046
    GO TO 1020                                                           ERRO1047
 90 WRITE (6,91)                                                         ERRO1048
 91 FORMAT (9X 58HTHE DESIRED PRESSURE RATIO COULD NOT BE MET (WARNINGERRO1049
   X ONLY))                                                              ERRO1050
    GO TO 1040                                                           ERRO1051
100 WRITE (6,101)                                                        ERRO1052
101 FORMAT (9X 68HEITHER A NON-POSITIVE INLET TEMPERATURE OR PRESSURE ERRO1053
   XHAS BEEN READ IN )                                                   ERRO1054
    TOCO= ABS(TOCO)                                                      ERRO1055
    POCO= ABS(POCO)                                                      ERRO1056
    IF (TOCO*POCO.EQ.0.0)  GO TO 1010                                    ERRO1057
    GO TO 1040                                                           ERRO1058
110 WRITE (6,111)  I                                                     ERRO1059
111 FORMAT (9X 34HTHE STATOR HUB D-FACTOR AT STATION I3, 16H IS UNATTAERRO1060
   XINABLE )                                                             ERRO1061
    GO TO 1000                                                           ERRO1062
120 WRITE (6,121)  I                                                     ERRO1063
121 FORMAT (9X 60HA NEGATIVE STATIC TEMPERATURE HAS BEEN CALCULATED ATERRO1064
   X STATION I3,  5HCHECK /9X 33HTHE INLET CONDITIONS AND THE AREA)     ERRO1065
    GO TO 1020                                                           ERRO1066
130 WRITE (6,131) ALTER                                                  ERRO1067
131 FORMAT (9X 36HA NEGATIVE AREA IS NEEDED AT STATION I3)               ERRO1068
    GO TO 1000                                                           ERRO1069
140 WRITE(6,141)                                                         ERRO1070
141 FORMAT (9X 44HA NON-POSITIVE ASPECT RATIO HAS BEEN READ IN)          ERRO1071
    ASPECT(I)= 2.5                                                       ERRO1072
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      GO TO 1040                                                        ERRO1073
  150 WRITE (6,151)  I                                                  ERRO1074
  151 FORMAT (9X 58HA NON-POSITIVE TOTAL TEMPERATURE HAS BEEN FOUND AT SERRO1075
     XTATION I3 )                                                       ERRO1076
      IER= IER +5                                                       ERRO1077
      GO TO 1020                                                        ERRO1078
  160 WRITE (6,161)  J,I                                                ERRO1079
  161 FORMAT (9X 13HON STREAMLINE I3, 13H NEAR STATION I3, 52H A NON-POSERRO1080
     XITIVE STATIC TEMPERATURE HAS BEEN DETECTED      )                 ERRO1081
      GO TO 1020                                                        ERRO1082
  170 WRITE (6,171) BLADE(I)                                            ERRO1083
  171 FORMAT (9X I5, 44H IS AN ILLEGAL SELECTION OF A LOSS DATA SET. /  ERRO1084
     X 9X 24HIT WILL BE CHANGED TO 1. )                                 ERRO1085
      IER= IER +5                                                       ERRO1086
      BLADE(I)= 1                                                       ERRO1087
      GO TO 1040                                                        ERRO1088
  180 WRITE (6,181)                                                     ERRO1089
  181 FORMAT (9X 64HNONE OF THE AERODYNAMIC LIMITS COULD BE MET AT ONE OERRO1090
     XF THE STAGES)                                                     ERRO1091
      GO TO 1000                                                        ERRO1092
  190 WRITE (6,191)                                                     ERRO1093
  191 FORMAT (9X 38HTHE ITERATION ON EFFICIENCY HAS FAILED )            ERRO1094
      GO TO 1000                                                        ERRO1095
  200 WRITE (6,201)  ICUTTR                                             ERRO1096
  201 FORMAT (I12, 29H IS AN ILLEGAL OUTPUT TRIGGER )                   ERRO1097
      IOUTTR= 1                                                         ERRO1098
      GO TO 1040                                                        ERRO1099
  210 WRITE (6,211)                                                     ERRO1100
  211 FORMAT (9X 45HAN UNREASONABLE HUB BLOCKAGE HAS BEEN READ IN )     ERRO1101
      BH(I)= 1.0                                                        ERRO1102
      GO TO 1040                                                        ERRO1103
  220 WRITE (6,221)  I                                                  ERRO1104
  221 FORMAT (9X 58HTHE TOTAL PRESSURE HAS DROPPED ACROSS THE ROTOR AT SERRO1105
     XTATION I3 )                                                       ERRO1106
      GO TO 1000                                                        ERRO1107
  230 WRITE (6,231)  I                                                  ERRO1108
  231 FORMAT (9X 44HTHE HUB AND TIP RAMP ANGLE LIMITS AT STATION I3 /9X ERRO1109
     X 25HHAVE BEEN READ IN AS ZERO )                                   ERRO1110
      RH(I)= 20.0                                                       ERRO1111
      GO TO 1040                                                        ERRO1112
  240 GO TO 1010                                                        ERRO1113
  250 WRITE (6,251)                                                     ERRO1114
  251 FORMAT (9X 45HAN UNREASONABLE TIP BLOCKAGE HAS BEEN READ IN )     ERRO1115
      BT(I)= 1.0                                                        ERRO1116
      GO TO 1040                                                        ERRO1117
  260 WRITE (6,261)                                                     ERRO1118
  261 FORMAT (9X 44HTHE ITERATION ON TEMPERATURE RISE HAS FAILED )      ERRO1119
      GO TO 1000                                                        ERRO1120
  270 WRITE (6,271)                                                     ERRO1121
  271 FORMAT (9X 13HON STREAMLINE I3, 11H AT STATION I3, 54H A NON-POSITERRO1122
     XIVE STATIC TEMPERATURE HAS BEEN CALCULATED )                      ERRO1123
      IER= IER +9                                                       ERRO1124
      GO TO 1000                                                        ERRO1125
  280 WRITE (6,281) I                                                   ERRO1126
  281 FORMAT (9X 58HAN UNREASONABLE D-FACTOR LIMIT HAS BEEN READ IN AT SERRO1127
     XTATION I3 )                                                       ERRO1128
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      DFL(I)= 0.3
      GO TO 1040
  290 WRITE (6,291)  I, J
  291 FORMAT (9X 57HTHE PRANDLE-MEYER ANGLE ITERATION HAS FAILED NEAR ST
     XATION I3, 14H ON STREAMLINE I3 )
      GO TO 1000
  300 WRITE (6,301)  I
  301 FORMAT (9X 33HTHE HUB MACH NO. LIMIT AT STATION I3, 48H IS TOO LOW
     X.  THE MERIDICNAL MACH NO. IS GREATER 19X 15HTHAN THE LIMIT. )
      GO TO 1)00
  310 GO TO 1010
  320 WRITE (6,321)  I
  321 FORMAT (9X 83HEITHER A PRESSURE DROP OR A NON-POSITIVE TEMPERATURE
     X HAS BEEN CALCULATED AT STATION I3)
      IER= IER +9
      GO TO 1000
  330 WRITE (6,331)  I
  331 FORMAT (9X 33HTHE ROTOR TIP D-FACTOR AT STATION I3, 15H CAN NOT BE
     X MET )
      GO TO 1000
  340 WRITE (6,341)  ALTER
  341 FORMAT (9X 55HTHE EXIT AREA REQUIRED BY THE VELOCITY RATIO AT STAT
     XION I3,19X 21HCAN NOT BE DETERMINED )
      GO TO 1000
  350 WRITE (6,351)
  351 FORMAT (9X 36HTHE ITERATION ON GEOMETRY HAS FAILED )
 1000 CALL  OUTPUT
 1010 CALL  Q45
 1020 CALL  PDU:P(ALPHA,X(32),1,A,VMI,1,I,YES,2,NORM,NOFAIL,1,VO,VO(29)
     X ,1,ALH,SAVEA(29),1)
      GO TO 1010
 1030 CALL  EXIT
 1040 RETURN
 1050 WRITE (6,1051)
 1051 FORMAT (9X 56HTOO MANY ERROR HAVE BEEN DETECTED.  EXECUTION TERMIN
     XATED )
      GO TO 1030
      END
```

```
      SUBROUTINE  GAM
C
C     *** THIS SUBROUTINE CALCULATES THE RATIO OF SPECIFIC HEATS
C
      DOUBLE PRECISION  TITLE
      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),   FOUND(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),        ROSTAG(11),
     X RS(32),         RSLOPE(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 TO(32,11),      TSTAT(11),       U(32,11),        W(11),
     X X(32)
      COMMON /SCALER/  A,      AA,     A1OAO,  A2O2AO, A3O3AO, A4O4AO,
     X A5O5AO, B,      BB,     CC,     CM,     CMEAN,  CMEANP, COINTG,
     X CPI2,   CPI3,   CPI4,   CPI5,   CPI6,   CPO2,   CPO3,   CPO4,
     X CPO5,   DAMP,   DCP,    DD,     DIFCM,  DT,     DUMMY,  ERAS1,
     X G,      GASK,   GJ,     GR,     GR2,    JOULE,  MAPR,   MOLEWT,
     X PUCO,   C,      RPM,    TCP,    TERMD,  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,     IOUTTR, IPASS,  IS,     IT,     J,      JIN,    JJ,
     X JM,     JM1,    K,      K1,     KK,     L,      LIMIT,  LSTAGF,
     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
```

```
      SUBROUTINE GEOM
      COMMON /VANE/ NBLADE
      DOUBLE PRECISION  TITLE
      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),     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),   FOUND(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),         RCUPVF(10,11),
     X RH(32),         RHO(32,11),        RINT(11),         RCSTAG(11),
     X RS(32),         RSLOPE(10,11),     RTRAIL(11),       SOCO(29,5),
     X SCLID(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,  COINTG,
     X CPI2,    CPI3,    CPI4,    CPI5,    CPI6,    CPO2,    CPO3,    CPO4,
     X CPO5,    DAMP,    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,   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))
      INTEGER ALTER
      COMMON /SPECAL/ NORM(14), NX2, NO FAIL
      COMMON /VGEOM/   ALH(29),          ALT(29),          ALTER,
     X ASPECT(29),     FPATH,            SAVEA(29)
      REAL  NORM

C         *** ITERATION DAMPING FACTOR
      DATA RETARD  / 0.4 /


C         *** SET THE BLADE ROW COUNTER TO ZERO
      NTRY= 0

C         *** AFTER ONE BLADE ROW HAS BEEN ALTERED THE PROGRAM WILL
C             LOOK AT ALL OF THE OTHER BLADE ROWS BEFORE CHECKING
C             OR ALTERING THIS ONE AGAIN

   10 ALTER= ALTER +1

C         *** IF THE BLADE ROW JUST CHECKED OR ALTERED WAS PHYSICALLY
```

```
      THE LAST BLADE ROW IN THE COMPRESSOR RETURN TO THE
      FIRST ONE BEING CONSIDERED
   IF (ALTER.GT.LSTAGE)  ALTER= IFIRST

     *** CALCULATE THE VELOCITY RATIO
   V TO V= CX(ALTER,JM)/CX(ALTER-1,JM)

     *** CHECK THE ACTUAL VELOCITY RATIO AGAINST THE DESIRED RATIO
   IF (ABS(V TO V -CXRATO(ALTER)).GT.TOLTIP)  GO TO 30

     *** INCREMENT THE BLADE ROW COUNTER
   NTRY= NTRY+1

     *** HAVE ALL BLADE ROWS BEEN CHECKED
   IF (NTRY.LE.NBLADE) GO TO 10
20 RETURN

     *** INDICATE THAN AN UNDESIRABLE RATIO HAS BEEN FOUND
30 IERROR= .TRUE.

     *** SAVE THE HUB,TIP AND AXIAL COORDINATES
   OLD HUB= RH(ALTER)
   OLD TIP= RS(ALTER)
   OLD X=   X(ALTER)

     *** CALCULATE THE TIP AND HUB LIMITS
   TIP LIM= RS(ALTER-1) +(X(ALTER) -X(ALTER-1))*ALT(ALTER)
   HUB LIM= RH(ALTER-1) +(X(ALTER) -X(ALTER-1))*ALH(ALTER)

     *** DETERMINE THE EXIT AREA
   AREA= (RS(ALTER) -RH(ALTER))*(RS(ALTER) +RH(ALTER))

     *** CALCULATE AN AREA CHANGE
   D AREA= AREA*(( V TO V/CXRATO(ALTER))** RETARD -1.0)

     *** TEST FEASIBILITY OF THE AREA CHANGE
   IF (-D AREA.GE.AREA.OR. D AREA.GE.OLD HUB**2)  CALL ERROR (34)

     *** IS THE AREA TO BE INCREASED
   IF (D AREA.GT.0.0)  GO TO 70

     *** DETERMINE THE NEW HUB
   RH(ALTER)= SQRT(RH(ALTER)**2 -D AREA)

     *** IS THE HUB LESS THAN THE LIMIT
   IF (RH(ALTER).LE.HUB LIM)  GO TO 90

     *** CALCULATE THE AREA TO BE OBTAINED FROM THE TIP
   D AREA= (HUB LIM -RH(ALTER))*(HUB LIM +RH(ALTER))

     *** SET THE HUB ON ITS LIMIT
   RH(ALTER)= HUB LIM

     *** DETERMINE THE TIP RADIUS
   RS(ALTER)= SQRT(RS(ALTER)**2 +D AREA)
```

```
C          *** IS THE TIP ABOVE ITS LIMIT
      IF (RS(ALTER).GE.TIP LIM)  GO TO 90

C          *** CALCULATE THE ANNULUS AREA
      AREA= (RS(ALTER) -RH(ALTER))*(RS(ALTER) +RH(ALTER))

C          *** DETERMINE THE ASPECT RATIO FROM THE REQUIRED AREA

   40 AA= (ALT(ALTER) -ALH(ALTER))*(ALT(ALTER) +ALH(ALTER))

C          *** CHECK FOR TWO POSITIVE ROOTS
      IF (AA.EQ.0.0) GO TO 50
      BB=(RS(ALTER-1)*ALT(ALTER) -RH(ALTER-1)*ALH(ALTER))/AA
      CC= ((RS(ALTER-1) -RH(ALTER-1))*(RS(ALTER-1) +RH(ALTER-1))-AREA)
     X    /AA
      AA= -BB +SQRT(BB**2 -CC)
      GO TO 60
   50 AA= ((RS(ALTER-1) -RH(ALTER-1))*(RS(ALTER-1) +RH(ALTER-1)) -AREA)
     X    /(2.0*ALH(ALTER)*(RS(ALTER-1) +RH(ALTER-1)))
   60 ASPCT= (RS(ALTER-1) -RH(ALTER-1))/AA
C          *** RETARD THE ASPECT RATIO CHANGE

      IF (ABS((ASPECT(ALTER)-ASPCT)/ASPECT(ALTER)).GT.0.1)
     X ASPCT= ASPECT(ALTER)*(1.0 +SIGN(0.1,ASPCT -ASPECT(ALTER)))

C          *** CHECK THE LIMIT
      ASPECT(ALTER)= AMIN1(ASPCT, SAVEA(ALTER))

C          *** CALCULATE THE AXIAL LENGTH
      DT=                  (RS(ALTER-1) -RH(ALTER-1))/ASPECT(ALTER)
      X(ALTER)= X(ALTER-1) +DT

C          *** SET THE HUB AND TIP ON THEIR LIMITS
      RH(ALTER)= RH(ALTER-1) +DT*ALH(ALTER)
      RS(ALTER)= RS(ALTER-1) +DT*ALT(ALTER)
      GO TO 90

C          *** IS THE ASPECT RATIO ON ITS LIMIT
   70 IF (ASPECT(ALTER).EQ.SAVEA(ALTER)) GO TO 80
      AREA= AREA +D AREA
      GO TO 40

C          *** DETERMINE THE TIP RADIUS
   80 RS(ALTER) = SQRT(RS(ALTER)**2 +D AREA)

C          *** IS THE TIP ABOVE ITS LIMIT
      IF (RS(ALTER).LE.RS(ALTER-1))  GO TO 90
      D AREA= (RS(ALTER)-RS(ALTER-1))*(RS(ALTER) +RS(ALTER-1))

C          *** SET THE TIP HORIZONTAL
      RS(ALTER)= RS(ALTER-1)

C          *** DETERMINE THE NEW HUB
      RH(ALTER)= SQRT(RH(ALTER)**2 -D AREA)
   90 I= ALTER
```

```
C          *** MOVE THE STREAMLINES
      CALL RADIUS

C          *** EVALUATE THE PRESSURE NORMALIZING FACTOR IF THIS
C                 IS A ROTOR EXIT

      K= I/2
      IF (K+K.NE.I)  GO TO 95
      A= (R(I,NLINES) -RH(I))/(RS(I) -RH(I))
      NORM(K)= 1.0/(CUCO(I,1)/(CUCO(I,2) +A) +CUCO(I,3)
     X         +(CUCO(I,4) +CUCO(I,5)*A)*A)

C          *** IS THIS THE LAST BLADE ROW
   95 IF (ALTER.EQ.LSTAGE)  GO TO 130
      K= ALTER +1

C          *** UP-DATE THE DOWN STREAM BLADE ROWS

      DO 120 I=K,LSTAGE
      DT= (RS(I-1) -RH(I-1))/ASPECT(I)
      HUB LIM= RH(I-1) +DT*ALH(I)
      TIP LIM= RS(I-1) +DT*ALT(I)
      A= RH(I-1) +(RH(I) -OLD HUB)*DT/(X(I) -OLD X)
      B= RS(I-1) +(RS(I) -OLD TIP)*DT/(X(I) -OLD X)
      OLD HUB= RH(I)
      OLD TIP= RS(I)
      OLD X= X(I)
      X(I)= X(I-1) +DT
      RH(I)= A
      RS(I)= B

C          *** CHECK THE LIMITS

      IF (RS(I).LT.TIP LIM)  GO TO 100
      IF (RH(I).GT.HUB LIM)  GO TO 110
      GO TO 120
  100 RS(I)= TIP LIM
  110 RH(I)= HUB LIM
  120 CALL RADIUS
  130 CALL AN EXIT

C          *** UP-DATE THE COMPRESSOR EXIT

      DO 140 I=NX2,NX
  140 CALL RADIUS
      GO TO 20
      END
```

```
      SUBROUTINE INEST
C        *** MAKES INITIAL ESTIMATES OF AXIAL VELOCITIES FOR
C            STATIONS BETWEEN BLADE ROWS

      DOUBLE PRECISION  TITLE
      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),       B1(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),    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),   FOUND(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),        ROSTAG(11),
     X RS(32),         RSLOPE(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 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,    CPO2,    CPO3,    CPO4,
     X CPO5,    DAMP,     DCP,     DD,      DIFCM,   DT,      DUMMY,   ERAS1,
     X G,       GASK,     GJ,      GR,      GR2,     JOULE,   MAPR,    MOLEWT,
     X POCO,    C,        RPM,     TCP,     TERMD,   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))

      HELP=1.0

C        *** ESTIMATE MID-STREAM VELOCITIES

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

C        *** ERROR TRANSFER TO A NEW DATA SET

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

```
C
C     *** CALCULATE VALUES OF CU**2 AND ESTIMATE STATIC TEMPERATURES
C
      DO 100 J=1,NLINES
      CU2(J)=CU(I,J)**2
      V=(CM2+CU2(J))/GJ/CP(I,J)
  100 TSTAT(J)=TO(I,J)-V
C
C     *** CALCULATE VALUES OF TERMA AND RADIAL DERIVATIVE TERM
C
      DO 110 J=1,NLINES
      TERMA(J)=GJ*(CP(I,J)*TO(I,J)-CP(I,JM)*TO(I,JM))-(CU2(J)-CU2(JM))
      IF (TO(I,J).LT.TOCO)  CALL ERROR (15)

  110 CONTINUE
C
C     *** CALCULATE DERIVATIVE OF DEPV WITH RESPECT TO RADIUS,
C         RESULT IS IN CO
C
C
C
C     *** CALCULATE VALUES OF TERMB
      DO 120 J=1,NLINES

  120 DEPV(L J)=CU2(J)/R(I,J)
      DO 200 J=1,NLINES
      TERMB(J)=2.0*RINT(J)
C
C     *** CALCULATE CX/CM AND CX DISTRIBUTIONS
C
      DUMMY=((TERMA(J)-TERMB(J))/CM2)+1.0
      IF (DUMMY)130,140,140
  130 CONTINUE
      HELP=HELP*1.25
      GO TO 70
  140 IF (DUMMY-1.0)155,150,155
  150 CXM(L,J)=1.0
      GO TO 160
  155 CXM(L,J)=SQRT(DUMMY)
  160 CX(I,J)=CXM(L,J)*CX(I,JM)
  200 CONTINUE
      AA= CX(I,JM)*1.6
      BB= CX(I,JM)*0.4
      DO 400 J=1,NLINES
      IF (CX(I,J).GT.AA) CX(I,J)=AA
      IF (CX(I,J).LT.BB) CX(I,J)=BB
  400 CONTINUE
  210 RETURN
      END
```

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

```
      SUBROUTINE INLET

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

      DOUBLE PRECISION  TITLE
      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),   FOUND(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),        ROSTAG(11),
     X RS(32),         RSLOPE(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 TO(32,11),      TSTAT(11),      U(32,11),        W(11),
     X X(32)
      COMMON /SCALER/  A,      AA,     A1OA0,   A2O2A0, A3O3A0, A4O4A0,
     X A5O5A0, B,      BB,     CC,     CM,      CMEAN,  CMEANP, COINTG,
     X CPI2,   CPI3,   CPI4,   CPI5,   CPI6,    CPO2,   CPO3,   CPO4,
     X CPO5,   DAMP,   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,  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,      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        *** GET INITIAL ESTIMATE OF FLUID FLOW

      IF (I.NE.5)  GO TO 5
      DO 4 J=1,NLINES
    4 CU(5,J)= (CUCO(5,1)/R(5,J) +CUCO(5,2))/R(5,J) +CUCO(5,3)
     X       +  (CUCO(5,4) +CUCO(5,5)*R(5,J))*R(5,J)
    5 CALL INEST

C        *** SOLVE CONTINUITY EQUATION

   10 CALL STREAM
      RETURN
      END
```

```
      SUBROUTINE INPUT
      INTEGER BLADE
      LOGICAL FPATH
      COMMON /VGEOM/   ALH(29),          ALT(29),          ALTER,
     X ASPECT(29),     FPATH,            SAVEA(29)
      COMMON /SPECAL/ NORM(14), NX2, NO FAIL
      DOUBLE PRECISION  TITLE
      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),   FOUND(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),         ROSTAG(11),
     X RS(32),         RSLOPE(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 TO(32,11),      TSTAT(11),       U(32,11),         W(11),
     X X(32)
      COMMON /SCALER/  A,       AA,      A1OAC,   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,     JOULE,  MAPR,   MOLEWT,
     X POCO,   Q,       RPM,     TCP,     TERMD,   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,     IOUTTR,  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 /VMIN/ VO(29)
      DIMENSION  TIL(6)
      DATA  TIL / 4H--IN, 4HLET , 4H    , 4H--FL, 4HOW P, 4HATH /

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

      WRITE (6,12)
   12 FORMAT (1H0)
      CPO2=CPCO(3)/2.
      CPO3=CPCO(4)/3.
```

```
      CP04=CPCO(5)/4.                                                    INPU1703
      CP05=CPCO(6)/5.                                                    INPU1704
      A10A0=CPCO(2)/CPCO(1)                                              INPU1705
      A202A0=CP02/CPCO(1)                                                INPU1706
      A303A0=CP03/CPCO(1)                                                INPU1707
      A404A0=CP04/CPCO(1)                                                INPU1708
      A505A0=CP05/CPCO(1)                                                INPU1709
      COINTG= THERM3(518.688)                                            INPU1710
      CPI2=CPCO(2)/2.                                                    INPU1711
      CPI3=CPCO(3)/3.                                                    INPU1712
      CPI4=CPCO(4)/4.                                                    INPU1713
      CPI5=CPCO(5)/5.                                                    INPU1714
      CPI6=CPCO(6)/6.                                                    INPU1715
   11 FORMAT (12A6)                                                      INPU1716
      KK=1                                                               INPU1717
                                                                         INPU1718
C         *** INPUT INDEX TO INDICATE WHICH LOSS DATA SETS TO USE        INPU1719
                                                                         INPU1720
      READ (5,910) (IKK(J),J=1,10)                                       INPU1721
      K1= IKK(1)                                                         INPU1722
                                                                         INPU1723
C         *** REWIND MASTER TAPE OF LOSS DATA                            INPU1724
                                                                         INPU1725
  935 REWIND 4
      DO 950 L=1,IG                                                      INPU1727
                                                                         INPU1728
C         *** READ LOSS DATA FROM MASTER TAPE                            INPU1729
                                                                         INPU1730
      READ (4) ((FOUND(K,J,KK),K=1,20),J=1,3)
                                                                         INPU1732
C         *** IS THIS SET DESIRED                                        INPU1733
                                                                         INPU1734
      IF (K1.LT.1.OR.K1.GT.IG) CALL ERROR(1)                             INPU1735
  937 IF (K1.NE.L) GO TO 950                                             INPU1736
                                                                         INPU1739
C         *** STORE LOSS DATA FROM MASTER TAPE INTO PROPER ALLOCATION    INPU1740
C             TO BE USED IN LOSS SUBROUTINE                              INPU1741
                                                                         INPU1742
      IF (KK.EQ.10)  GO TO 960                                           INPU1744
      KK=KK+1                                                            INPU1745
      K1=IKK(KK)                                                         INPU1746
      IF (K1.EQ.0) GO TO960                                              INPU1747
  950 CONTINUE                                                           INPU1748
      GO TO 935                                                          INPU1749
  960 REWIND 4
      KK= KK-1                                                           INPU1751
  910 FORMAT (24I3)                                                      INPU1752
                                                                         INPU1753
C         *** READ THE SCALER QUANTITIES                                 INPU1754
                                                                         INPU1755
      READ (5,15) MSTAGE, NLINES, IOUTTR, FPATH, IDUMP, LIMIT,           INPU1756
     X FLOW(1),MOLEWT,TOCO,POCO,TOTPR,TOLCX,TOLR,TOLCP,RPM,DAMP          INPU1757
     X ,TOLMIN,TOLB2,TOLAT,TOLMS,TOLTIP,ATAR(1,1),ATAR(1,2),ATAR(1,3)    INPU1758
                                                                         INPU1759
C         *** ERROR WILL SET THE TEMPERATURE OR PRESSURE TO THE ABSOLUTE INPU1760
C             VALUE OF SAME AND WILL GO TO A NEW DATA SET IF ONE OF THE  INPU1761
```

```
      IF (POCO.LE.0.0.OR.TOCO.LE.0.0) CALL ERROR(10)

C        *** THE NUMBER OF STREAMLINES MUST BE 5,7,9 OR 11, ERROR
C            WILL TERMINATE EXECUTION

      IF (NLINES.LT.5.OR.NLINES.GT.11.OR.MOD(NLINES,2).EQ.0)
     X CALL ERRCR(6)

C        *** ERROR RESETS THE NUMBER OF STAGES TO BE CONSIDERED TO 12.
C            NOTE...NEXT DATA SET MAY NOT EXECUTE PROPERLY

      IF (MSTAGE.GT.12) CALL ERROR(7)
   15 FORMAT (3I5,L5,2I5,4F10.5/7F10.5/7F10.5)
      NX=2*MSTAGE + 8

C        *** READ THE INLET GEOMETRY AND BOUNDARY LAYER BLOCKAGE FACTORS

      READ (5,35) (X(I), RH(I), BH(I), RS(I), BT(I), ASPECT(I),I=1,NX)
      IF (FPATH)  GO TO 1002
      DO 1001 I=6,NX
      HUB(I)= RH(I)
      TIP(I)= RS(I)
 1001 CONTINUE
      GO TO 1004
 1002 NX= NX-3
      DO 1003 I=6,NX
      CXRATO(I)= X(I)
      IF (ASPECT(I).LE.0.0)  CALL ERROR (14)
      SAVEA(I)= ASPECT(I)
      IF (RH(I).EQ.0.0.AND.RS(I).EQ.0.0)  CALL  ERROR (23)
      ALT(I)= -ABS(TAN(RS(I)/57.29578))
 1003 ALH(I)= ABS(TAN(RH(I)/57.29578))
      NX= NX+3

C        *** READ THE FRACTION MASS FLOW BETWEEN THE HUB AND THE J-TH
C            STREAMLINE. THESE NUMBERS MUST INCREASE MONOTONICALLY

 1004 READ (5,20) (DELM(J),J=1,NLINES)
      NTUBES= NLINES-1
      DO 3 I=1,NTUBES
      IF (DELM(I).GE.DELM(I+1))  CALL ERROR (5)
    3 CONTINUE

C        *** READ THE 'OSS FACTORS ACROSS THE INLET GUIDE VANE
C            FOR THE J-TH STREAMLINE

    8 READ (5,20) (W(I),I=1,NLINES)
      READ (5,35) (CUCO(5,J),J=1,5)
      READ (5,20)  (ATAR(6,J),J=1,NLINES)
      READ (5,20)  (ATAR(7,J),J=1,NLINES)


    5 FORMAT (3E20.8)
   20 FORMAT (7F10.5)
```

```
   35 FORMAT (6F10.5)                                                   INPU1818
                                                                        INPU1821
      CALL DATE(DA)                                                     INPU1822
      WRITE (6,39) (TITLE(I),I=1,12),(DA(I),I=1,2)                      INPU1823
      WRITE (6,40) MSTAGE,TOTPR,NLINES,POCO,FLOW(1),TOCO,MOLEWT,RPM,    INPU1824
     X TOLCX, TOLB2, TOLAT, TOLR                                        INPU1825
      IF (FPATH)  WRITE(6,21)  TOLTIP                                   INPU1826
                                                                        INPU1827
   21 FORMAT (/9X 37HTHE AXIAL VELOCITY RATIO TOLERANCE IS F7.4 /)      INPU1828
                                                                        INPU1829
      WRITE (6,38) (DELM(J),J=1,NLINES)                                 INPU1830
   38 FORMAT (/9X 79HTHE FRACTION OF THE TOTAL MASS FLOW BETWEEN THE HUBINPU1831
     X AND THE J-TH STREAMLINE IS. // 9X 11F7.3 )                       INPU1832
      WRITE (6,41) NLINES, (W(I),I=1,NLINES)                            INPU1833
                                                                        INPU1834
C         *** WRITE OUT INLET GEOMETRY                                  INPU1835
                                                                        INPU1836
   39 FORMAT (1H124X14A6)                                               INPU1837
                                                                        INPU1838
   40 FORMAT(////29X63H****---*** ADVANCED MULTISTAGE AXIAL-FLOW COMPRESINPU1839
     XSOR ***---**** //38X43H**--** ANALYSIS AT DESIGN CONDITIONS **--**INPU1840
     X ///47X26H----I N P U T   D A T A---- /// 9X35HTHE MACHINE IS TO HAINPU1841
     XVE NO MORE THAN I3,7H STAGES15X25HA TOTAL PRESSURE RATIO OF F7.3, INPU1842
     X11H IS DESIRED //9X35HCALCULATIONS ARE TO BE PERFORMED AT I3,     INPU1843
     X 12H STREAMLINES 10X 27HTHE INLET TOTAL PRESSURE IS F9.2, 11H LBS/INPU1844
     XSQ IN.//9X  27HTHE INLET MASS FLOW RATE ISF7.2,7H LB/SEC19X30HTHE INPU1845
     XINLET TOTAL TEMPERATURE IS F7.2, 7H DEG. R // 9X 32HMOLECULAR WEIGINPU1846
     XHT OF THE FLUID IS F7.2, 21X 16HTHE TIP SPEED IS F7.1, 9H FT./SEC.INPU1847
     X // 9X 27HAXIAL VELOCITY TOLERANCE IS F7.4, 26X 30HTHE LOADING LIMINPU1848
     XIT TOLERANCE IS F7.4, // 9X 27HTHE EFFICIENCY TOLERANCE IS F7.4,  INPU1849
     X 26X 27HTHE CONTINUITY TOLERANCE IS F7.4 )                        INPU1850
                                                                        INPU1851
   41 FORMAT (//9X46HTHE INLET GUIDE VANE LOSS COEFFICIENTS FOR THE I3, INPU1852
     X 34H STREAMLINES ARE (FROM HUB TO TIP) // 10X 11F7.4 //)          INPU1853
                                                                        INPU1854
   42 FORMAT ( 9X 85HTHE RATIO OF THE AREAS OF THE LAST 3 STATIONS TO THINPU1855
     XE AREA OF THE LAST STATOR EXIT ARE F7.4, 2(1H,F7.4), 2H .)        INPU1856
                                                                        INPU1857
   45 FORMAT (1H1 //// 45X 2H-- 3A4, 15HDESCRIPTION----///23X7HSTATION5XINPU1858
     X5HAXIAL11X3HHUB6X12HHUB BLOCKAGE7X3HTIP7X12HTIP BLOCKAGE / 25X    INPU1859
     X 3HNO.5X10HCOORDINATE 6X6HRADIUS8X6HFACTOR 8X6HRADIUS 8X6HFACTOR/ INPU1860
     X 35X5H(IN.) 10X 5H(IN.) 23X5H(IN.) //)                            INPU1861
                                                                        INPU1862
   46 FORMAT (20XI7,  5F14.3)                                           INPU1863
                                                                        INPU1864
                                                                        INPU1865
      WRITE (6,57) (CUCO(5,J),J=1,5)                                    INPU1866
   57 FORMAT ( 9X 61HTHE INLET GUIDE VANE EXIT TANGENTIAL VELOCITY IS SPINPU1867
     XECIFIED BY / 9X 3HA = E15.6,3X 3HB = E15.6, 3HC = E15.6, 3X 3HD = INPU1868
     X E15.6, 3X 3HE = E15.6 //)                                        INPU1869
                                                                        INPU1870
      WRITE (6,58) CPCO                                                 INPU1871
                                                                        INPU1872
   58 FORMAT (1H033X53HTHE SPECIFIC HEAT POLYNOMIAL IS IN THE FOLLOWING INPU1873
```

```
   XFORM // 3X 4HCP = E12.5,3H + E12.5,5H*T + E12.5,8H*T**2 + E12.5,
   X 8H*T**3 + E12.5,8H*T**4 + E12.5,5H*T**5 // )

    WRITE (6,42)  ATAR(1,1), ATAR(1,2), ATAR(1,3)
    DA(1)= TIL(1)
    DA(2)= TIL(2)
    DA(3)= TIL(3)
    NN= 5
    IF (FPATH)  GO TO 36
    DA(1)= TIL(4)
    DA(2)= TIL(5)
    DA(3)= TIL(6)
    NN= NX
 36 WRITE (6,45) DA(1),DA(2),DA(3)
    DO 37 J=1, NN
    WRITE (6,46) J, X(J), RH(J), BH(J), RS(J), BT(J)
 37 CONTINUE
    NN= NX -3
    IF (FPATH)  WRITE (6,22)  (I,X(I),ASPECT(I),RH(I),BH(I),RS(I),BT(I
   X ),I=6,NN)
 22 FORMAT (1H6 44X 30H*--* GEOMETRIC PARAMETERS *--* /// 10X  9HBLADE
   X ROW 5X10HAXIAL VEL. 5X 12HASPECT RATIO 6X 8HHUB RAMP 6X 12HHUB BL
   XOCKAGE 4X 8HTIP RAMP 6X 12HTIP BLOCKAGE / 10X 9HEXIT STA. 5X 11HRA
   XTIO (O/I) 21X 11HANGLE LIMIT 7X 6HFACTOR 6X 11HANGLE LIMIT 7X
   X 6HFACTOR //(I16,4F16.3,2F15.3))
    N=2*MSTAGE + 4

C        *** READ THE STAGE DATA

    DO 60 I=5,N,2
    READ (5,25)  DFL(I+1), HMN(I+1), HMN(I+2), DFL(I+2), VO(I+1),
   X BLADE(I+1), BLADE(I+2),DFLOW(I+1),DFLOW(I+2),
   X (CUCO(I+1,J),J=1,5),
   X (SSCO(I+1,J),J=1,5),
   X (SOCO(I+1,J),J=1,5),
   X (CUCO(I+2,J),J=1,5),
   X (SSCO(I+2,J),J=1,5),
   X (SOCO(I+2,J),J=1,5)
 60 CONTINUE

 25 FORMAT (5F10.4/2I5,2F10.4/(5E10.4))

C        *** CHECK THE BLOCKAGE FACTORS

    NN=N+1
    DO 61 I=1,NN

C        *** ERROR SETS THE BLOCKAGE FACTOR TO 1.0

    IF (BT(I).GT.1.0.OR.BT(I).LE.0.5)  CALL  ERROR (25)
    IF (BH(I).GT.1.0.OR.BH(I).LE.0.5)  CALL  ERROR (21)
 61 CONTINUE
    DO 70 I=5,N
    B2(I+1)=CUCO(I+1,2)
 70 CONTINUE
    NX=N+4
```

```
 90 FORMAT (1H1,//////43X 25H.... LOSS DATA SET NUMBERI3,5H ....////
   X  9X  8HD-FACTOR 10X 13HAT 10 PERCENT 10X 13HAT 50 PERCENT 10X
   X 13HAT 90 PERCENT 5X 21H(OF BLADE HEIGHT FROM / 91X 21HTHE GEOMETR
   XIC HUB.  ) / 20(F17.3,F18.4,2F23.4/))

C        *** CALCULATE THE GAS CONSTANT

      GASK= G/MCLEWT
      DCP= GASK / JOULE
      GR= 64.348*GASK
      GR2= GR*.5

C        *** CALCULATE THE TOTAL TEMPERATURE, TOTAL PRESSURE, AND
C            SPECIFIC HEAT IN THE INLET

      I=1
      J=1
      TO(1,1)= TOCO
      CALL THERMP
      DO 101 J=1,NLINES
      DO 99 I=1,5
      TO(I,J)= TOCO
      PO(I,J)= POCO
      CP(I,J)= CP(1,1)
 99   GAMMA(I,J)= GAMMA(1,1)

C        *** SET THE RADIAL AND WHIRL VELOCITIES TO ZERO

      DO 100 I=1,NX
      CU(I,J)= 0.
 100  CR(I,J)= 0.

C        *** DR/DX AND D2R/DX2 AND D(CX)/DX ARE ASSUMED ZERO AT
C            THE INLET TO THE MACHINE

      RSLOPE(1,J)= 0.
      RCURVE(1,J)= 0.
 101  CSLOPE(1,J)= 0.
      NX=NX-3
      DO 105 I=6,NX
      IF (DFL(I).LE.0.0.OR.DFL(I).GE.0.9) CALL ERROR(28)
 105  IF (BLADE(I).LT.1.OR.BLADE(I).GT.KK) CALL ERROR(17)

C        *** CONVERT THE RELATIVE FLOW ANGLES TO RADIANS

      DO 106 I=7,NX,2
 106  HMN(I)= HMN(I)/57.2957795

C        *** SET THE MASS FLOW RATE THROUGH THE INLET TO THE VALUE
C            AT THE FIRST STATION

      FLOW(2)= FLOW(1)
      FLOW(3)= FLOW(1)
      FLOW(4)= FLOW(1)
```

```
      FLOW(5)=FLOW(1)

C        *** CALCULATE THE TOTAL FLOW RATE AT EACH STATION

      DO 110 I=5,N
  110 FLOW(I+1)= FLOW(I)+DFLOW(I+1)

C        *** SET THE FLOW RATE AT THE LAST 3 STATIONS EQUAL TO THE
C            FLOW RATE AT THE LAST STATOR EXIT

      FLOW(N+2)= FLOW(N+1)
      FLOW(N+3)= FLOW(N+1)
      FLOW(N+4)= FLOW(N+1)

C        *** CALCULATE THE NUMBER OF STREAMTUBES

      NTUBES= NLINES-1
      JM1= NLINES/2

C        *** CHECK AND CALCULATE THE OUTPUT TRIGGER..
C            1 = ALL STREAMLINES
C            2 = EVERY OTHER ONE
C            3 = MEAN, HUB, AND TIP
C            4 = HUB AND TIP

      IF (IOUTTR.LT.1.OR.IOUTTR.GT.4) CALL ERROR(20)
      IF (IOUTTR.LT.3) GO TO 113
      IF (IOUTTR.EQ.4) GO TO 112
      IOUTTR=JM1
      GO TO 113
  112 IOUTTR=NTUBES
  113 IFIRST=6

C        *** CALCULATE THE MID-STREAMLINE INDEX

      JM= JM1+1

C        *** INITIALIZE THE INDICES (THE FIRST ROTOR INLET
C            IS AT STATION NUMBER 5)

      LSTAGE=7
      NX=10
      L= 1
      NX1=9

C        *** CALCULATE THE SIMPLE RADIAL EQUILIBRIUM SOLUTION
      IB= 1
      IB1= 2
      NX2=8
C            OF THE FLOW EQUATIONS IN THE INLET

      IPASS=1
      RPM= RPM/RS(5)
      CALL INLET
      I= 6
      RETURN
```

```
      SUBROUTINE INTEG (VDEP,IFCON)

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

      DIMENSION VDEP(10,11)

      DOUBLE PRECISION  TITLE
      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),   FOUND(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),        ROSTAG(11),
     X RS(32),         RSLOPE(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 TO(32,11),      TSTAT(11),        U(32,11),        W(11),
     X X(32)
      COMMON /SCALER/  A,       AA,      A1OAO,   A2O2AO,  A3O3AO,  A4O4AO,
     X A5O5AO, B,      BB,      CC,      CM,      CMEAN,   CMEANP,  COINTG,
     X CPI2,   CPI3,   CPI4,    CPI5,    CPI6,    CPO2,    CPO3,    CPO4,
     X CPO5,   DAMP,   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,   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))

      RINT(1)=0.0
      GO TO (50,90),IFCON

C         *** 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))*.5
   15 RINT(J+1)=RINT(J) +DA(J)
      GO TO 150

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

   90 DO 115 J=1,NTUBES
```

```
100 DA(J)=(VDEP(L,J)+VDEP(L,J+1))*(R(I,J+1)-R(I,J))*.5     INTE1641
115 RINT(J+1)= RINT(J) +DA(J)                               INTE1642
150 B= RINT(JM)                                             INTE1643
    DO 200 J=1,NLINES                                       INTE1644
200 RINT(J)= RINT(J)-B                                      INTE1645
    RETURN                                                  INTE1645
    END                                                     INTE1647
```

```
      SUBROUTINE LOSS

C        *** MATCHES LOSS WITH ADIABATIC EFFICIENCY

      LOGICAL  NO FAIL
      COMMON /SPECAL/ NORM(14),NX2,NOFAIL
      INTEGER BLADE
      REAL  LOSE
      DOUBLE PRECISION  TITLE
      DOUBLE PRECISION  TITLE
      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),    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),   FOUND(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),        POSTAG(11),
     X RS(32),         RSLOPE(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 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,    CPO2,    CPO3,    CPO4,
     X CPO5,   CAMP,   DCP,     DD,      DIFCM,   DT,      DUMMY,   ERASI,
     X G,      GASK,   GJ,      GR,      GR2,     JOULE,   MAPR,    MOLEWT,
     X POCO,   C,      RPM,     TCP,     TERMD,   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,     IOUTTR, 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
      DATA RADIAN /57.29578/

C        *** OBAR CONTAINS THE LOSS FUNCTION

      L=-1
      DO 10 I=IFIRST,LSTAGE,2
      L=L+2
      DO 10 J=1,NLINES

C        *** CALCULATE ABSOLUTE PELATIVE VELOCITY

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

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 ABSOLLTE 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
       H= -CXS(L,J)/GJ
       T= TO(I-1,J)
       CALL  ENTALP
       CALL  GAM

C          *** CALCULATE RELATIVE MACH NUMBER

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

C          *** CALCULATE ABSOLLTE 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
       K= L+1
       DO 30  J=1,NLINES

C          *** COMPUTE SUPERSONIC TURNING ANGLE
```

```
      A= (R(I,J)+R(I-1,J)-RH(I)-RH(I-1))/(RS(I)+RS(I-1)-RH(I)-RH(I-1))
      B= (R(I,J)+R(I+1,J)-RH(I)-RH(I+1))/(RS(I)+RS(I+1)-RH(I)-RH(I+1))
      AA= (SSCO(I,1)/(SSCO(I,2) +A) +SSCO(I,3)
     X    +(SSCO(I,4) +SSCO(I,5)*A)*A)
      BB= SSCO(I+1,1)/(SSCO(I+1,2) +B) +SSCO(I+1,3)
     X    +(SSCO(I+1,4) +SSCO(I+1,5)*B)*B

      IF (AND(IDUMP,4).NE.0.0)  GO TO 25

      FRDEL(L,J)= AA*(BETA(L,J) -BETA(L+1,J)  )
      FRDEL(L+1,J)= BB*(ALPHA(L+1,J) -ALPHA(L+2,J))
      GO TO 26
C      *** CALCULATE THE SUPERSONIC TURNING ANGLE FROM THE SHOCK ANGLE.
   25 FRDEL(L,J)= BETA(L,J) -AA/RADIAN
      FRDEL(L+1,J)= ALPHA(L+1,J) -BB/RADIAN
   26 CONTINUE

C        *** TEST FOR SUPERSONIC VELOCITY

      IF(MACH(I,J).LT.1.0) GO TO 28
      A=(MACH(I,J)-1.)*(MACH(I,J)+1.0)

C        *** IF FLOW IS SUPERSONIC ADD PRANDTL-MEYER ANGLE TO
C            SUPERSONIC TURNING ANGLE

      FRDEL(L,J)= FRDEL(L,J) + TERM1(L,J)*ATAN(SQRT(A)/TERM1(L,J)) -
     X ATAN(SQRT(A))
   28 IF (MACH(I+1,J).LT.1.) GO TO 30
      A= (MACH(I+1,J)-1.)*(MACH(I+1,J)+1.0)

C        *** IF FLOW IS SUPERSONIC ADD PRANDTL-MEYER ANGLE TO
C            SUPERSONIC TURNING ANGLE

      FRDEL(L+1,J)= FRDEL(L+1,J) + TERM1(L+1,J)*ATAN(SQRT(A)/TERM1(L+1,
     X J))- ATAN(SQRT(A))
   30 CONTINUE
      L=0
      DO 60 I=IFIRST,LSTAGE
      L=L+1
      DO 60 J=1,NLINES

C        *** INITIALIZE PROFILE SHOCK AND LOSS FUNCTION

      OBAR(I,J)=0.0

C        *** CALCULATE PROFILE SHOCK

      Q=0.1
      CXS(L,J)=1.
      IF (FRDEL(L,J).LT.0.0) GO TO 44
      DO 43 IS=1,100

C        *** CALCULATES DIFFERENCE BETWEEN PRANDTL-MEYER ANGLE FOR MACH
C            NUMBER CXS(L,J) AND SUPERSONIC EXPANSION ANGLE

      VMI= SHOCK(CXS(L,J),FRDEL(L,J))
```

```
      IF (ABS(VMI).LE.0.001) GO TO 44
      IF (VMI.GT.0.0) GO TO 43
      CXS(L,J)=CXS(L,J)-Q
      Q= Q/3.0
   43 CXS(L,J)= CXS(L,J) + Q
      CALL ERROR(29)
   44 IF (MACH(I,J).GE.1.0) GO TO 45

C         *** CALCULATE SUBSONIC SHOCK

      EMACH(I,J)=MACH(I,J)*(1.0+CXS(L,J))*0.5
      IF (EMACH(I,J)-1.0) 60,60,50

C         *** CALCULATE SUPERSONIC SHOCK

   45 EMACH(I,J)=(MACH(I,J)+CXS(L,J))*0.5

C         *** COMPUTE SHOCK LOSS

   50 OBAR(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)-RH(I)-RH(I-1))/(RS(I)+RS(I-1)-RH(I)-RH(I-1))

C         *** CALCULATE ROTOR MEAN SOLIDITY

      SOLID(I,J)=  SOCO(I,1)/(SOCO(I,2)+A)  +SOCO(I,3)
     X             +(SOCO(I,4) +SOCO(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) - RH(I)

C         *** COMPUTE ROTOR PROFILE LOSSES
C         *** LOSE READS THE PROFILE LOSS FROM THE INPUT MAPS

      OBAR(I,J)=OBAR(I,J)+LOSE(DFACT(I,J),(R(I,J)-RH(I))/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))*.5
      B= (R(I,J)+R(I+1,J)-RH(I)-RH(I+1))/(RS(I)+RS(I+1)-RH(I)-RH(I+1))

C         *** CALCULATE STATOR MEAN SOLIDITY

      SOLID(I+1,J)=  SOCO(I+1,1)/(SOCO(I+1,2)+B)  +SOCO(I+1,3)
```

```
     X              +(SOCO(I+1,4) +SOCO(I+1,5)*B)*B

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+1)-RH(I+1)

C          *** LOSE READS THE PROFILE LOSS FROM THE INPUT MAPS

      OBAR(I+1,J)=OBAR(I+1,J)+LOSE(DFACT(I+1,J),(R(I+1,J)-RH(I+1))/A,
     X BLADE(I+1))*2.0*SOLID(I+1,J)/ COS(AMIN1(ALPHA(L+2,J),1.2217))
   80 CONTINUE
      L=-1
      DO 100 I=IFIRST,LSTAGE,2
      L=L+2
      DO 100 J=1,NLINES

C          *** CALCULATE THE STATIC ENTHALPY MINUS THE TOTAL
C              ENTHALPY

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

C          *** GET THE STATIC TEMPERATURE

      CALL  ENTALP
      B= THERM3(T)

C          *** CALCULATE THE STATIC PRESSURE AT THE ROTOR INLET

      PSTAT= PO(I-1,J)*EXP((THERM3(TSTAT(J)) -B)/DCP)
      H= U(I-1,J)*(U(I-1,J) -2.0*CU(I-1,J))/GJ
      CALL  ENTALP

C          *** COMPUTE THE TOTAL RELATIVE PRESSURE

      P REL= PO(I-1,J)*EXP((THERM3(TSTAT(J)) -B)/DCP)
      H= (U(I,J) -U(I-1,J))*(U(I-1,J) +U(I,J))/GJ
      T= TSTAT(J)
      CALL  ENTALP
      B= THERM3(T)

C          *** COMPUTE THE TOTAL IDEAL PRESSURE

      P IDEAL= P REL    *EXP((THERM3(TSTAT(J)) -B)/DCP)

C          *** CALCULATE THE EXIT RELATIVE TOTAL PRESSURE FROM THE
C              LOSS COEFFICIENT

      P= P IDEAL -OBAR(I,J)*(P REL -P STAT)
      H=-U(I,J)*(2.0*CU(I,J) -U(I,J))/GJ
```

```
      T= TO(I,J)
      CALL  ENTALP

C         *** CALCULATE THE EXIT TOTAL PRESSURE

      P= P*EXP((THERM3(T) -THERM3(TSTAT(J)))/DCP)

C         *** GET THE IDEAL EXIT TOTAL TEMPERATURE

      CALL  THERM2(P/PO(I-1,J),T,TO(I-1,J))

C         *** COMPUTE THE CORRESPONDING EFFICIENCY

      EFF= (THERM1(T)        -THERM1(TO(I-1,J)))
     X    /(THERM1(TO(I,J))-THERM1(TO(I-1,J)))
      PO(I,J)= P

C         *** CHECK THE CONVERGENCE

      IF (ABS((ATAR(I,J) -EFF)/ATAR(I,J)).GT.TOLAT)  IPASS= 3
      ATAR(I,J)= EFF
      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= PO(I,J)*EXP((THERM3(TSTAT(J)) -THERM3(T))/DCP)

C         *** CALCULATE THE STATOR EXIT PRESSURE (TOTAL) FROM
C             THE LOSS COEFFICIENT

      P= PO(I,J) -OBAR(I+1,J)*(PO(I,J) -P STAT)

C         *** GET THE IDEAL TOTAL TEMPERATURE

      CALL  THERM2(P/PO(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 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
      NO FAIL= .FALSE.
      CALL DRIVE
      RETURN
      END
```

```
      REAL FUNCTION LOSE(ARG,PERHT,TYPE)

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

      INTEGER TYPE, FIRST
      DOUBLE PRECISION  TITLE
      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),    FOUND(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),        P(32,11),        RCURVE(10,11),
     X RH(32),          RHO(32,11),       RINT(11),        ROSTAG(11),
     X RS(32),          RSLOPE(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 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,   CMEA ,   COINTG,
     X CPI2,   CPI3,    CPI4,    CPI5,    CPI6,    CPO2,    CPO3,    CPO4,
     X CPO5,   DAMP,    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,   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))

      FIRST=1
   10 FIRST=FIRST+1
      IF (DF(FIRST).LT.ARG.AND.FIRST.LT.20) GO TO 10
      JJ=1
      IF (PERHT.GT.0.5) JJ=3
      DEL=(ARG-DF(FIRST-1))/(DF(FIRST)-DF(FIRST-1))
      FCT1=((FOUND(FIRST,2,TYPE)-FOUND(FIRST-1,2,TYPE))*DEL)
     X +FOUND(FIRST-1,2 ,TYPE)
      FCT2=((FOUND(FIRST,JJ,TYPE)-FOUND(FIRST-1,JJ,TYPE))*DEL)
     X +FOUND(FIRST-1,JJ,TYPE)
      DEL= FCT2-FCT1
      IF (ABS(DEL).GT.0.001)  GO TO 20
      LOSE= FCT1
      RETURN
```

```
      LOSE.       - EFN   SOURCE STATEMENT  -  IFN(S)  -                        11/02/67

20 RAD= 0.5*SQRT(DEL**2 +0.16)/SIN(ATAN(2.5*DEL))                              LOSE2096
   LOSE= FCT1 +RAD*(1.0 -COS(ATAN(ABS(PERHT -0.5)/RAD)))                       LOSE2097
   RETURN                                                                      LOSE2098
   END                                                                         LOSE2099
```

```
      SUBROUTINE MOVE

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

      DOUBLE PRECISION  TITLE
      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),       CPCO(6),        CF(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),   FOUND(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),       ROSTAG(11),
     X RS(32),         RSLOPE(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 TO(32,11),      TSTAT(11),       U(32,11),       W(11),
     X X(32)
      COMMON /SCALER/  A,       AA,      A1OAO,   A2O2AO,  A3O3AO,  A4O4AO,
     X A5O5AO, B,      BB,      CC,      CM,      CMEAN,   CMEANP,  COINTG,
     X CPI2,   CPI3,   CPI4,    CPI5,    CPI6,    CPO2,    CPO3,    CPO4,
     X CPO5,   DAMP,   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,   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)
      DO 350  J=2,NTUBES
      TERMA(J)= R(I,J)
      TERMB(J)=CXM(L,J)
      TERMC(J)= TERMC(J-1) +DA(J-1)/TOTINT
C      *** CHECK THE MASS FLOW BETWEEN EACH STREAMLINE
      IF (ABS(TERMC(J) -DELM(J)).GT. 0.005)  YES= .TRUE.
  350 CONTINUE

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

```
      DO 505 J=2,NTUBES
      CALL SLINE(DELM(J),TERMC,TERMA,NLINES,RTRAIL(J))
  504 RTRAIL(J)= R(I,J) +(RTRAIL(J) -R(I,J))/DAMP

C        *** CALCULATE VALUES OF CX AT NEW STREAMLINE RADII

      CALL SLINE(RTRAIL(J),TERMA,TERMB,NLINES,DEPV(L,J))
  505 CONTINUE
      CX(I,1)=CXM(L,1)*CMEANP
      CX(I,NLINES)=CXM(L,NLINES)*CMEANP
      DO 510 J=2,NTUBES
      CX(I,J)=DEPV(L,J)*CMEANP
      R(I,J)=RTRAIL(J)
  510 U(I,J)= R(I,J)*RPM
      RETURN
      END
```

```
      SUBROUTINE 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 CD(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),    FOUND(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),         RCSTAG(11),
     X RS(32),          RSLOPE(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 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,     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,    TESTEH,   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,     IOUTTR,  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))
C        *** YIELDS INITIAL FLOW ESTIMATE FOR THE OUTLET

      DOUBLE PRECISION  TITLE

C        *** INITIALIZE OUTLET LOOP

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

```
    5 PO(I,J)=PC(LSTAGE,J)
C
C         *** GET INITIAL ESTIMATE OF AXIAL VELOCITY
C
      IF (LSTAGE.NE.7) GO TO 6
      CALL INFST
      GO TO 8
    6 DO 7 J=1,NLINES
    7 CX(I,J)= CX(I-1,J)
C
C         *** CALCULATE SIMPLE RADIAL EQUILIBRIUM SOLUTION OF FLOW
C             CONDITIONS
C
    8 CALL STREAM
   10 CALL MOVE
      RETURN
      END
```

```
      SUBROUTINE OUTPUT

      DIMENSION  PMA(29),  PMAB(29),  TMA(29),  TMAB(29),  TMAEP(29)
      DOUBLE PRECISION  TITLE
      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),        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),   FOUND(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),         ROSTAG(11),
     X RS(32),         RSLOPE(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 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,    CPO2,    CPO3,    CPO4,
     X CPO5,   DAMP,   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,    TOLA1,   TOLB2,   TOLMIN,  TOLMS,   TOLTIP,  TOLCP,
     X TOLCX,  TOLR,   TUTINT,  TOTPR,   V,       VMI
      COMMON /INTEGR/  I,       IB,      IB1,     IDUMP,   IERROR,  IFIRST,
     X IG,     IOUTTR, 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 /VMIN/ VO(29)
      COMMON  /ENERGY/  H, T, GAMMER

      TMAEP(5)= THERM1(TO(1,1))
      B= TMAEP(5)
      T= TOCO
      IB=1
      IB1= 2
      NX1= 5
      DO610  J=1,NLINES,IOUTTR
      RSLOPE(1,J)=0.
      RCURVE(1,J)=0.
  610 CALL  DERIV(R,RSLOPE,RCURVE,X)
      WRITE (6,201)
  201 FORMAT (1H1)
      N=0
      DO 58  I=1,5
      DO 58  J=1,NLINES,IOUTTR
```

```
C          *** CALCULATE ABSOLUTE VELOCITY    (INLET)                    OUT.2630
                                                                         OUT.2633
C          *** CALCULATE STATIC TEMPERATURE   (INLET)                    OUT.2634
                                                                         OUT.2635
      H= -CXM(I,J)**2/GJ                                                 OUT.2636
      CALL  ENTALP                                                       OUT.2637
      CALL  GAM                                                          OUT.2638
      CXNEW(I,J)= TSTAT(J)                                               OUT.2639
                                                                         OUT.2640
C          *** CALCULATE ABSOLUTE MACH NUMBER (INLET)                    OUT.2641
                                                                         OUT.2642
      CXS(I,J)= CXM(I,J)/SQRT(GR2*GAMMER*TSTAT(J))                       OUT.2643
                                                                         OUT.2644
C          *** CALCULATE ABSOLUTE FLOW ANGLE (INLET)                     OUT.2645
                                                                         OUT.2646
      A= SQRT(CX(I,J)**2 + CR(I,J)**2)                                   OUT.2647
      ALPHA(I,J)= ATAN(CU(I,J)/A)*57.2957795                             OUT.2648
      RCURVE(I,J)=RCURVE(I,J)/(SQRT(1.+RSLOPE(I,J)**2)**3)               OUT.2649
      RSLOPE(I,J)=ATAN(RSLOPE(I,J))*57.2957795                           OUT.2650
   58 CONTINUE                                                           OUT.2651
      DO 71 I=1,5                                                        OUT.2652
      IF (I.GE.5) GO TO 64                                               OUT.2653
                                                                         OUT.2654
C          *** PRINT INLET DATA                                          OUT.2655
                                                                         OUT.2656
      WRITE (6,61) I                                                     OUT.2657
                                                                         OUT.2658
   61 FORMAT(1H0/10X18H----STATION NUMBER I3,5H ---- //5X70HS.L. STREAMLOUT.2659
     XINE    ABS. MACH     ABS. VEL.     AXIAL VEL.    RADIAL VEL. 4X    OUT.2660
     X39HSTREAMLINE     STREAMLINE    FLOW ANGLE/5X27HNO.  RADIUS (IN.) OUT.2661
     X  NUMBER 6X8H(FT/SEC) 6X8H(FT/SEC) 5X8H(FT/SEC) 5X12HSLOPE (DEGS) OUT.2662
     X 4X9HCURVATURE 5X 9H(DEGREES) / 96X 5H1/IN. /)                    OUT.2663
                                                                         OUT.2664
      GO TO 265                                                          OUT.2665
                                                                         OUT.2666
C          *** PRINT INLET GUIDE VANE EXIT DATA                          OUT.2667
                                                                         OUT.2668
   64 WRITE (6,264) I                                                    OUT.2669
                                                                         OUT.2670
  264 FORMAT (1H0/10X18H----STATION NUMBER I3,31H ----   (INLET GUIDE VAOUT.2671
     XNE EXIT) //5X70HS.L. STREAMLINE   ABS. MACH     ABS. VEL.     AXIAOUT.2672
     XL VEL.   RADIAL VEL. 4X38HSTREAMLINE    STREAMLINE    FLOW ANGLE /OUT.2673
     X 5X27HNO.  RADIUS (IN.)   NUMBER 6X8H(FT/SEC) 6X8H(FT/SEC) 5X8H(FTOUT.2674
     X/SEC)5X12HSLOPE (DEG) 4X9HCURVATURE 5X9H(DEGREES) / 96X 5H1/IN./) OUT.2675
                                                                         OUT.2676
      DO 67 J=1,NLINES,ICUTTR                                            OUT.2677
      CALL  GAM                                                          OUT.2678
      ERAS1= GR2*GAMMER*TSTAT(J)                                         OUT.2679
                                                                         OUT.2680
C          *** COMPUTE RELATIVE VELOCITY (FIRST ROTOR ENTRANCE)          OUT.2681
                                                                         OUT.2682
      CO(5,J)= CX(5,J)**2 + (CU(5,J)-U(5,J))**2 + CR(5,J)**2             OUT.2683
      CO(5,J)=SQRT(CO(5,J))                                              OUT.2684
                                                                         OUT.2685
```

```
C         *** COMPUTE RELATIVE MACH NUMBER (FIRST ROTOR ENTRANCE)

      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)
   67 CXS(5,J)= CO(5,J)/SQRT(ERAS1)
      WRITE (6,272)

  272 FORMAT (1H0 4X15HS.L. STREAMLINE3X11HTOTAL PRES. 3X11HTOTAL TEMP.
     X 3X 9HREL. VEL.3X10HWHIRL VEL. 6X8HRELATIVE 7X 9HREL. FLOW 4X
     X 11HWHEEL 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,IOUTTR

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(I,J),PO(5,J),TO(5,J),CO(5,J)   ,    CU(5,J),
     X CXS(5,J),BETA(2,J),U(5,J)

  274 FORMAT (I7,F11.4,F14.2,3F13.2,F15.3,2F15.3)

   68 FORMAT (I7,F11.4,F13.3,2F14.2,F14.4,F14.2,F14.5,F15.1)

      GO TO 71
  265 DO  69 J=1,NLINES,IOUTTR
   69 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)
      WRITE (6,271)
      DO 269 J=1,NLINES,IOUTTR
  269 WRITE (6,270) J,R(I,J),PO(I,J),TO(I,J)

  270 FORMAT (I7,F11.4,F14.2,F13.2)

  271 FORMAT (1H0 4X43HS.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 (///// 41X 37HITERATION ON LOADING WAS TAKING PLACE )

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
```

```
      DEPV(5,1)= X(IS)-X(IS-1)
      DEPV(5,2)= X(IS+1)-X(IS)

C         *** CALCULATE ROTOR HUB AND STATOR HUB RAMP ANGLE

      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

C         *** CALCULATE ROTOR TIP AND STATOR TIP RAMP ANGLE

      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
      IX=IS+1
      DO 35 JJ=IS,IX
      DO 10 J=1,NLINES
      TERMB(J)=TO(JJ,J)

C         *** CALCULATE THEORETICAL TEMPERATURE RISE

      CALL  THERM2(PO(JJ,J)/POCO    ,TERMB(J),518.688)
      TERMB(J)= TERMB(J)/518.688

C         *** COMPUTE MASS FLOW RATE PER STREAMLINE

   10 DEPV(9,J)= RHO(JJ,J)*CX(JJ,J)*R(JJ,J)
      L=9
      I=JJ

C         *** INTEGRATE MASS FLOW RATE, RESULT IN RINT

      CALL INTEG(DEPV,2)
      SUM= RINT(NLINES)-RINT(1)
      DO 20 J=1,NLINES
   20 DEPV(8,J)= (TERMB(J)-1.)*DEPV(9,J)
      L=8
      CALL INTEG(DEPV,2)
      V=RINT(NLINES)-RINT(1)

C         *** CALCULATE MASS AVERAGED TEMPERATURE AND PRESSURE

      TMA(JJ)= (V/SUM+1.)*518.688
      PMA(JJ)=EXP((THERM3(TMA(JJ)) -COINTG)/DCP)
      DO 30 J=1,NLINES
   30 DEPV(8,J)= (TO(JJ,J)/518.688-1.)*DEPV(9,J)
      CALL INTEG(DEPV,2)
      V=RINT(NLINES)-RINT(1)
      TMA(JJ)= (V/SUM+1.)*518.688/TO(1,1)

C         *** COMPUTE MASS AVERAGED EFFICIENCY

      TMAEP(JJ)= THERM1(TMA(JJ)*TOCO)
   35 CONTINUE

C         *** DETERMINE MASS AVERAGE TEMPERATURES AND PRESSURES
```

```
      TMAB(IS)=TMA(IS)/TMA(IS-1)
      TMAB(IS+1)=TMA(IS+1)/TMA(IS-1)
      PMAB(IS)=PMA(IS)/PMA(IS-1)
      AA= TMA(IS)*TO(1,1)
      BB= AA
      CC= TMA(IS+1)*TO(1,1)
      DD= CC

C        *** YIELDS THEORETICAL TEMPERATURE RISE

      CALL THERM2(PMA(IS),AA,TO(1,1))
      CALL THERM2(PMA(IS)/PMA(IS-1),BB,TMA(IS-1)*TO(1,1))
      CALL THERM2(PMA(IS+1),CC,TO(1,1))
      CALL THERM2(PMA(IS+1)/PMA(IS-1),DD,TMA(IS-1)*TOCO)

C        *** OVERALL MASS AVERAGE ROTOR EFFICIENCY

      CXS(6,1)= (THERM1(AA)-TMAEP(5))/(TMAEP(IS)-TMAEP(5))
      PMAB(IS+1)=PMA(IS+1)/PMA(IS-1)

C        *** MASS AVERAGE ROTOR EFFICIENCY

      CXS(6,2)=(THERM1(BB)-TMAEP(IS-1))/(TMAEP(IS)-TMAEP(IS-1))

C        *** OVERALL MASS AVERAGE STAGE EFFICIENCY

      CXS(7,1)=(THERM1(CC)-TMAEP(5))/(TMAEP(IS+1)-TMAEP(5))

C        *** MASS AVERAGE STAGE EFFICIENCY

      CXS(7,2)=(THERM1(DD)-TMAEP(IS-1))/(TMAEP(IS+1)-TMAEP(IS-1))
      DO 40 J=1,NLINES
      FRDEL(1,J)= THERM1(TO(IS-1,J))
      FRDEL(2,J)= THERM1(TO(IS,J))
      FRDEL(3,J)= THERM1(TO(IS+1,J))
      TERMD=TO(IS,J)
      TERMA(1)=TO(IS,J)
      CALL THERM2(PO(IS,J)/PO(IS-1,J),TERMD,TO(IS-1,J))

C        *** YIELDS THEORETICAL TEMPERATURE RISE

      CALL THERM2(PO(IS+1,J)/PO(IS-1,J),TERMA(1),TO(IS-1,J))

C        *** DETERMINE ROTOR AND STAGE EFFICIENCY

      ATAR(IS,J)= (THERM1(TERMD)-FRDEL(1,J))/(FRDEL(2,J)-FRDEL(1,J))
      ATAS(IS+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(IS,J)**2+CU(IS,J)**2+CR(IS,J)**2)

C        *** CALCULATE ROTOR STATIC TEMPERATURE

      H= -CXM(1,J)**2/GJ
```

```
      CALL  ENTALP
      CXNEW(1,J)= TSTAT(J)
      CALL  GAM
      ERAS1= GR2*GAMMER*TSTAT(J)
      CO(8,J)= PO(IS,J)*EXP((THERM3(TSTAT(J))-THERM3(T))/DCP)

C        *** CALCULATE ROTOR RELATIVE VELOCITY

      CO(5,J)= CX(IS,J)**2 + (CU(IS,J)-U(IS,J))**2 + CR(IS,J)**2
      CO(5,J)=SQRT(CO(5,J))

C        *** CALCULATE STATOR RELATIVE VELOCITY

      CO(6,J)= CX(IS+1,J)**2+(CU(IS+1,J)-U(IS+1,J))**2+CR(IS+1,J)**2
      CO(6,J)=SQRT(CO(6,J))

C        *** CALCULATE ROTOR RELATIVE MACH NUMBER

      CXS(1,J)=  CO(5,J)/SQRT(ERAS1)

C        *** GET A*/S (ROTOR)

      IF (EMACH(IS,J).LT.1.0) EMACH(IS,J)=1.0
      A= GAMMA(IS-1,J)
      BETA(2,J)= BETA(2,J)/57.29578
      EMACH(IS,J)= COS(BETA(2,J))/((0.5*(A+1.0))**(-0.5*(A+1.0)/(A-1.0))
     X /MACH(IS,J)*(1.0 +0.5*(A-1.0)*MACH(IS,J)**2)**(0.5*(A+1.0)/(A-1.0
     X )) * ((A+1.0)*EMACH(IS,J)**2/((A-1.0)*EMACH(IS,J)**2 +2.0))
     X **(A/(A-1.0))
     X *((A+1.0)/(2.0*A*EMACH(IS,J)**2 +1.0 -A))**(1.0/(A-1.0)))
      BETA(2,J)= BETA(2,J)*57.29578
      A=SQRT(CX(IS,J)**2+CR(IS,J)**2)

C        *** CALCULATE ABSOLUTE FLOW ANGLE

      ALPHA(1,J)= ATAN(CU(IS,J)/A)*57.29578

C        *** CALCULATE RELATIVE FLOW ANGLE

      BETA(1,J)= ATAN((U(IS,J) -CU(IS,J))/A)*57.29578

C        *** CALCULATE TOTAL TEMPERATURE RATIO (ROTOR)

      CO(1,J)= TO(IS,J)/TO(IS-1,J)

C        *** CALCULATE TOTAL PRESSURE RATIO    (ROTOR)

      CO(3,J)= PO(IS,J)/PO(IS-1,J)

C        *** CALCULATE TOTAL TEMPERATURE RATIO (STATOR)

      CO(2,J)= TO(IS+1,J)/TO(IS,J)

C        *** CALCULATE TOTAL PRESSURE RATIO    (STATOR)

```

```
      CO(4,J)= PO(IS+1,J)/PO(IS,J)
C            TO AXIAL LENGTH. RESULTS ARE IN RSLOPE AND RCURVE

      CALL  DERIV(R,RSLOPE,RCURVE,X)

C        *** CALCULATE ROTOR CURVATURE

      RCURVE(2,J)= RCURVE(2,J)/(SQRT(1.+RSLOPE(2,J)**2)**3)

C        *** CALCULATE STATOR CURVATURE

      RCURVE(3,J)= RCURVE(3,J)/(SQRT(1.+RSLOPE(3,J)**2)**3)

C        *** CALCULATE ROTOR SLOPE

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

C        *** CALCULATE STATOR SLOPE

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

C        *** GET A*/S (STATOR)

      IF (EMACH(IS+1,J).LT.1.0) EMACH(IS+1,J) = 1.0
      A= GAMMA(IS,J)
      ALPHA(1,J)= ALPHA(1,J)/57.29578
      EMACH(IS+1,J)= COS(ALPHA(1,J))/((0.5*(A+1.0))**(-0.5*(A+1.0)/(A-
     X 1.0))/MACH(IS+1,J)*(1.0+0.5*(A-1.0)*MACH(IS+1,J)**2)**(0.5*(A+1.0
     X )/(A-1.0))*((A+1.0)*EMACH(IS+1,J)**2/((A-1.0)*EMACH(IS+1,J)**2
     X +2.0)) ** (A/(A-1.0))
     X *((A+1.0)/(2.0*A*EMACH(IS+1,J)**2 +1.0 -A))**(1.0/(A-1.0)))
      ALPHA(1,J)= ALPHA(1,J)*57.29578

C        *** CALCULATE ABSOLUTE VELOCITY        (STATOR)

      CXM(2,J)= SQRT(CX(IS+1,J)**2+CU(IS+1,J)**2+CR(IS+1,J)**2)

C        *** CALCULATE STATIC TEMPERATURE       (STATOR)

      H= -CXM(2,J)**2/GJ
      T= TO(IS+1,J)
      CALL  ENTALP
      CALL  GAM
      CXNEW(2,J)= TSTAT(J)
      ERAS1= GR2*GAMMER*TSTAT(J)
      CO(9,J)= PO(IS+1,J)*EXP((THERM3(TSTAT(J))-THERM3(T))/DCP)

C        *** CALCULATE ABSOLUTE MACH NUMBER     (STATOR)

      CXS(2,J)= CXM(2,J)/SQRT(ERAS1)

C        *** CALCULATE STATOR RELATIVE MACH NUMBER

      CO(7,J)= CO(6,J)/SQRT(ERAS1)
```

```
C        *** CALCULATE STATIC PRESSURES


C        *** CALCULATE RELATIVE FLOW ANGLE     (STATOR)

     BETA(2,J)=-ATAN((CU(IS+1,J)-U(IS+1,J))/SQRT(CX(IS+1,J)**2+CR(IS+1,
    X J)**2))*57.2957795

C        *** CALCULATE ABSOLUTE FLOW ANGLE     (STATOR)

     ALPHA(2,J)= ATAN(CU(IS+1,J)/SQRT(CX(IS+1,J)**2+CR(IS+1,J)**2))
    X *57.2957795
 40 CONTINUE

C        *** CONVERT INPUT DATA BACK TO DEGREES

     HMN(IS+1)=HMN(IS+1)*57.2957795

C        *** WRITE STAGE PARAMETERS

     WRITE (6,50) N, DFL(IS), HMN(IS+1), HMN(IS), DFL(IS+1), VO(IS)

 50 FORMAT(1H1///30X47H***--*** FINAL FLOW PARAMETERS FOR STAGE NUMBER
    X I4, 9H ***--*** ////45X30H*** STAGE INPUT PARAMETERS *** /// 24X
    X 24HROTOR TIP D-FACTOR LIMIT F33.4/ 24X48HHUB RELATIVE FLOW ANGLE
    XLIMIT AT THE ROTOR EXIT F9.1 / 24X 33HSTATOR HUB MACH NUMBER LIMIT
    X (IN) F24.4/ 24X 25HSTATOR HUB D-FACTOR LIMIT F32.4/ 24X 31HMAXIMU
    XM TIP TANGENTIAL VELOCITY F26.1 )
     IF (AND(IDUMP,4).EQ.0.0)  GO TO 53
     WRITE (6,51)
     GO TO 54
 53 WRITE (6,52)
 54 CONTINUE
 51 FORMAT (//24X 11H---ROTOR--- 48X 12H---STATOR--- /// 11X
    X 8HPRESSURE 3X 16H   FLOW ANGLE    3X 8HSOLIDITY 23X 5HWHIRL 5X
    X 16H   FLOW ANGLE    3X 8HSOLIDITY / 11X 7HPROFILE 4X
    X 16H  AT THE SHOCK    33X 8HVELOCITY 3X 16H  AT THE SHOCK    //)
 52 FORMAT(//24X                                                11H-
    X--ROTOR--- 48X 12H---STATOR---///11X8HPRESSURE3X 16HRATIO SUPERSON
    XIC  3X 8HSOLIDITY 23X 5HWHIRL 5X 16HRATIO SUPERSONIC 3X 8HSOLIDITY
    X / 11X 7HPROFILE  4X 16HTO TOTAL TURNING 33X 8HVELOCITY 3X 16HTO T
    XOTAL TURNING //)

     WRITE (6,55) CUCO(IS,1), SSCO(IS,1), SOCO(IS,1),
    X             CUCO(IS+1,1),SSCO(IS+1,1),SOCO(IS+1,1),
    X             B2(IS),       SSCO(IS,2),  SOCO(IS,2),
    X             CUCO(IS+1,2),SSCO(IS+1,2),SOCO(IS+1,2),
    X            (CUCO(IS,J),  SSCO(IS,J),  SOCO(IS,J),
    X             CUCO(IS+1,J),SSCO(IS+1,J),SOCO(IS+1,J),J=3,5)

 55 FORMAT (5X1HA3E15.6,14X1HA3E15.6/
    X         5X1HB3E15.6,14X1HB3E15.6/
    X         5X1HC3E15.6,14X1HC3E15.6/
    X         5X1HD3E15.6,14X1HD3E15.6/
    X         5X1HE3E15.6,14X1HE3E15.6,///
```

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

```
      SQCO= CX(IS,JM)/CX(IS-1,JM)
      A=    CX(IS+1,JM)/CX(IS,JM)
      Q=    (RS(IS) -RH(IS))/DEPV(5,2)
      AA=   (RS(IS-1)-RH(IS-1))/DEPV(5,1)
      WRITE (6,56) AA,          RH(IS),       RS(IS),       ALPHA(3,1),
     X ALPHA(3,2), DEPV(5,1),  FLOW(IS),     CXS(6,2),     Q,
     X RH(IS+1),   RS(IS+1),   ALPHA(4,1),   ALPHA(4,2),   DEPV(5,2),
     X FLOW(IS+1), CXS(7,2),   SQCO,         BH(IS),       BT(IS),
     X PMAB(IS),   TMAB(IS),   PMA(IS),      TMA(IS),      CXS(6,1),
     X A,          BH(IS+1),   BT(IS+1),     PMAB(IS+1),   TMAB(IS+1),
     X PMA(IS+1),  TMA(IS+1),  CXS(7,1)

   56 FORMAT (12X33HASPECT  GEOMETRIC HUB  GEOMETRIC 5X 8HHUB RAMP 5X
     X  8HTIP RAMP 4X39HAXIAL LENGTH   MASS FLOW     MASS AVE. / 12X
     X 61HRATIO    RADIUS (IN.)  TIP RAD.(IN.) ANGLE (DEG)  ANGLE (DEG)
     X 6X 5H(IN.)6X26H(LB/SEC)    ADIABATIC EFF. // 9H -ROTOR-- F8.3,
     X F13.4,F14.4,F13.3,F14.3,F13.4,F14.4,F15.4 // 9H -STATOR- F8.3,
     X F13.4,F14.4,F13.3,F14.3,F13.4,F14.4,F15.4 ///
     X 75X 2(10HCUMULATIVE 4X), 11H CUMULATIVE / 9X 10HVEL. RATIO  2X
     X 37HHUB BLOCKAGE  TIP BLOCKAGE  MASS AVE. 5X 9HMASS AVE. 3X
     X 3(9HMASS AVE. 6X), / 9X 11HAT THE MEAN  4X
     X 6HFACTOR 8X6HFACTOR 5X 9HPR. RATIO 4X22HTEMP. RATIO  PR. RATIO
     X 5X27HTEMP. RATIO  ADIABATIC EFF. // 9H -ROTOR-- F8.3,F13.4,F14.4,
     X F13.4,F14.4,F13.4,F14.4,F15.4 // 9H -STATOR- F8.3,F13.4,F14.4,
     X F13.4,F14.4,F13.4,F14.4,F15.4 ///)

      WRITE (6,275) BLADE(IS), BLADE(IS+1)

  275 FORMAT (11X 9HLOSS DATA / 11X 8HSET USED // 9H -ROTOR-- I7  //
     X 9H -STATOR- I7  )



C         *** PRINT ROTOR EXIT QUANTITIES

      WRITE (6,57)

   57 FORMAT(1H1///41X36H**----** R O T O R  E X I T **----**///2X4HS.L.
     X 57H  STREAMLINE   AXIAL VEL.    WHIRL VEL.     RADIAL VEL.
     X 52HABS. VEL.      ABS. MACH     ABS. FLOW      REL. FLOW /3X3HNO.
     X 58H  RADIUS (IN.)  (FT/SEC)       (FT/SEC)       (FT/SEC)
     X 52H(FT/SEC)         NUMBER      ANGLE (DEG)    ANGLE (DEG) /  )

      DO 60 J=1,NLINES,IOUTTR
      WRITE (6,59) J,R(IS,J),CX(IS,J),CU(IS,J),CR(IS,J),CXM(1,J),
     X MACH(IS+1,J),ALPHA(1,J),BETA(1,J)

   59 FORMAT(I5,F11.4,F13.3,2F14.2,F14.3,F15.4,2F14.3 )

   60 CONTINUE
      WRITE (6,65)

   65 FORMAT(1H0/2X4HS.L.43H  TOTAL TEMP.  TOTAL PRES.   ADIABATIC
     X 38HDIFFUSION    WHEEL SPEED      SOLIDITY  8X  4HA*/S 6X
```

```
     X11HLOSS COEFF.
     X                                                /3X3HNO.4X 5HRATIO 9X
     X 5HRATIO6X10HEFFICIENCY5X6HFACTOR 7X 8H(FT/SEC) / )

      DO 70 J=1,NLINES,IOUTTR
      WRITE (6,66) J,CO(1,J),CO(3,J),ATAR(IS,J),DFACT(IS,J),U(IS,J),
     X SOLID(IS,J),EMACH(IS,J),OBAR(IS,J)

   66 FORMAT (I5,F11.4,F13.4,2F14.4,F13.2,F15.3,F15.4,F14.4)

   70 CONTINUE
      WRITE (6,281)

  281 FORMAT (1H0//2X4HS.L.110H  TOTAL TEMP.  TOTAL PRES.   STATIC TEMP.
     X  STATIC PRES.    SLOPE          CURVATURE        REL. VEL.      REL. M
     XACH /3X3HNO.3X 9H(DEGREES)3X11H(LB/SQ IN.) 4X9H(DEGREES) 5X
     X 11H(LB/SQ IN.) 2X9H(DEGREES)9X5H1/IN.8X8H(FT/SEC) 7X6HNUMBER /)

      DO 282 J=1,NLINES,IOUTTR
  282 WRITE (6,283)J,TO(IS,J),PO(IS,J),CXNEW(1,J),CO(8,J),RSLOPE(2,J),
     X RCURVE(2,J),CO(5,J),CXS(1,J)
C
  283 FORMAT (I5,F11.2,2F14.2,F15.2,F11.2,F15.5,F16.4,F13.4)

C         *** PRINT STATOR EXIT QUANTITIES

      WRITE (6,75)

   75 FORMAT (1H1///40X38H**-----** S T A T O R  E X I T **-----** /// 2X
     X4HS.L.57H  STREAMLINE    AXIAL VEL.     WHIRL VEL.     RADIAL VEL.
     X 52HABS. VEL.        ABS. MACH     ABS. FLOW      REL. FLOW /3X3HNO.
     X 58H  RADIUS (IN.)  (FT/SEC)       (FT/SEC)       (FT/SEC)
     X 52H(FT/SEC)          NUMBER      ANGLE (DEG)   ANGLE (DEG) / )

      DO 80 J=1,NLINES,IOUTTR
      WRITE (6,59) J,R(IS+1,J),CX(IS+1,J),CU(IS+1,J),CR(IS+1,J),
     X CXM(2,J),CXS(2,J),ALPHA(2,J),BETA(2,J)
   80 CONTINUE
      WRITE (6,65)
      DO 85 J=1,NLINES,IOUTTR
      WRITE (6,66) J,CO(2,J),CO(4,J),ATAS(IS+1,J),DFACT(IS+1,J),
     X U(IS+1,J),SOLID(IS+1,J),EMACH(IS+1,J),OBAR(IS+1,J)
   85 CONTINUE
      WRITE (6,281)
      DO 284 J=1,NLINES,IOUTTR
  284 WRITE (6,283) J,TO(IS+1,J),PO(IS+1,J),CXNEW(2,J),CO(9,J),RSLOPE(3,
     XJ),RCURVE(3,J),CO(6,J),CO(7,J)
  100 CONTINUE

C         *** PRINT OUTLET QUANTITIES

      WRITE (6,110)

  110 FORMAT (1H140X40H***--*** OUTLET FLOW PARAMETERS ***--*** ///
     X 13X3HSTA7X5HAXIAL7X9HGEOMETRIC5X9HGEOMETRIC4X12HHUB BLOCKAGE 3X
     X 12HTIP BLOCKAGE / 13X3HNO.5X10HCOORDINATE4X10HHUB RADIUS 4X
```

```
     X /)

      JJ=LSTAGE + 1
      DO 120 J=JJ,NX
  120 WRITE (6,115) J,X(J),RH(J),RS(J),BH(J),BT(J)

  115 FORMAT (10XI5,F15.3,F14.3,F13.3,F15.3,F14.3)

      WRITE (6,130) JJ

  130 FORMAT (1H0//50X14HSTATION NUMBER I4 // 5H S.L.3X10HSTREAMLINE 4X
     X 10HAXIAL VEL. 3X10HWHIRL VEL. 4X11HRADIAL VEL. 4X 9HABS. VEL. 5X
     X 9HABS. MACH 4X11HTOTAL TEMP. 3X11HTOTAL PRES. / 4H NO.4X11HRADIUS
     X IN.  3X 8H(FT/SEC) 6X8H(FT/SEC) 6X8H(FT/SEC) 6X8H(FT/SEC) 7X
     X  6HNUMBER 7X 9H(DEG.S R) 4X11H(LB/SQ IN.) /)

      KJ=0
      DO 140IJ=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
      CXNEW(KJ,J)= TSTAT(J)
      CALL  GAM
      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),PO(IJ,J)

  160 FORMAT (1H050X14HSTATION NUMBER I4//)

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

      IF (AND( IDUMP,2).NE.0.0)  WRITE (7,18) (X(I),RH(I),BH(I),RS(I),
     X BT(I),I=1,NX)
   18 FORMAT (5F10.5)
      RETURN

        *** FINISHED AT LAST.......
```

```
      SUBROUTINE  RADIUS
      DOUBLE PRECISION  TITLE
      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),    FOUND(20,3,10), FRUEL(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),          RSLOPE(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 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,   CPO2,   CPO3,   CPO4,
     X CPO5,   DAMP,    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,  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))
      A= (RS(I) -RH(I))*(RS(I) +RH(I))
      CC= RH(I)**2 +A*BT(I)
      AA= RS(I)**2 -A*BH(I)
      BB= R(I,1)**2
      DD= (CC-AA)/(R(I,NLINES)**2-BB)
      AX= RPM
      DO 100 J=1,NLINES
      R(I,J)= SQRT(AA +DD*(R(I,J)**2 -BB))
  100 U(I,J)= R(I,J)*AX
      RETURN
      END
```

```
      SUBROUTINE ROTOUT
      REAL   NORM
      COMMON /SPECAL/ NORM(14),NX2,NOFAIL
      COMMON /VGEOM/   ALH(29),           ALT(29),           ALTFR,
     X ASPECT(29),     FPATH,             SAVEA(29)
      LOGICAL  FPATH
      LOGICAL  NO FAIL
C
C        *** COMPUTES ROTOR EXIT GEOMETRY
C
      DOUBLE PRECISION  TITLE
      REAL  MACF,  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),   FOUND(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),         RSLOPE(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 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,    CPO2,    CPO3,    CPO4,
     X CPO5,   DAMP,   DCP,     DD,      DIFCM,   DT,      DUMMY,   ERAS1,
     X G,      GASK,   GJ,      GR,      GR2,     JOULE,   MAPR,    MOLEWT,
     X POCO,   C,      RPM,     TCP,     TERMD,   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))

      L= 1
      DAMP= 100.0
      IF (LSTAGE.NE.7)  GO TO 45
      IF (.NOT.FPATH)  GO TO 20
C      *** PICK UP ROTOR GEOMETRY
      RS(6)= RS(5)
      DT=     (RS(5) -RH(5))/ASPECT(6)
      X(6)=   X(5) +DT
      RH(6)= RH(5) +DT*AMIN1(0.6, 0.8*ALH(6))
      GO TO 25
   20 RH(I)= HUB(I)
```

```
      RS(I)= TIP(I)
   25 CALL RSTART
C      *** INITIALIZE THE FIRST ROTOR CALCULATION BY COMPUTING THE
C          LOADING FROM THE TIP D-FACTOR AND AN AXIAL VELOCITY RATIO
C          OF 0.9.  USE FREE VORTEX AND AN EFFICIENCY OF 90 PERCENT
C          TO START
      V= 0.9*CX(5,NLINES)
      S= SOCO(6,1)/(SOCO(6,2) +1.0) +SOCO(6,3) +SOCO(6,4) +SOCO(6,5)
      VMI= SQRT(CX(5,NLINES)**2 +(CU(5,NLINES) -U(5,NLINES))**2)
      Q= 0.5/S
      A= VMI*(1.0 -DFL(5)) +(U(5,NLINES)-CU(4,NLINES) -U(4,NLINES))*Q
      B=  2.0*(U(6,NLINES) +A*Q)/(Q*Q-1.0)
      C=  (V*V +U(6,NLINES)**2 -A*A)/(1.0 -Q*Q)
      ERAS1= B*B -4.0*C
      IF (ERAS1.GE.0.0)  GO TO 30
      CU(6,NLINES)= 300.0
      GO TO 35
   30 ERAS1= SQRT(ERAS1)
      CU(6,NLINES)= -B -ERAS1
      IF (CU(6,NLINES).LE.0.0)  CU(6,NLINES)= ERAS1 -B
      CU(6,NLINES)= CU(6,NLINES)*0.5
   35 DT= ((U(6,NLINES)*CU(6,NLINES)-U(5,NLINES)*CU(5,NLINES))/GJ/CP(1,1
     X     ))*2.0
      J= NLINES
      TO(6,J)= TOCO +DT
      CALL THERMP
      DT= 0.9*DT
      CU(6,J)= CU(6,J)*R(6,J)
      DO 40 L=1,NLINES
      TO(6,L)= TO(6,J)
      CP(6,L)= CP(6,J)
      GAMMA(6,L)= GAMMA(6,J)
      PO(6,L)= POCO*(DT/TOCO +1.0)**(GAMMA(6,1)/(GAMMA(6,1)-1.0))
   40 CU(6,L)= CU(6,J)/R(6,L)
      L= 1
      CALL INEST
      CALL STREAM
      CALL MOVE
      GO TO 50
C      *** INITIALIZE SUCCEEDING ROTOR AS A COPY OF THE LAST
   45 CALL COPY
   50 A= (R(I,NLINES)-RH(I))/(RS(I)-RH(I))
      K= I/2
C      *** COMPUTE THE TOTAL PRESSURE PROFILE NORMALIZING FACTOR
C          NOTE. THE EQUATION MUST HAVE THE VALUE OF 1.0 AT THE
C          TIP STREAMLINE
      NORM(K  )= 1.0/(CUCO(I,1)/(CUCO(I,2)+A) +CUCO(I,3)
     X          +(CUCO(I,4) +CUCO(I,5)*A)*A)
      RETURN
      END
```

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

      DOUBLE PRECISION  TITLE
      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),    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),   FOUND(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),        ROSTAG(11),
     X RS(32),         RSLOPE(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 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,    CPO2,    CPO3,    CPO4,
     X CPO5,    DAMP,    DCP,     DD,      DIFCM,   DT,      DUMMY,   ERAS1,
     X G,       GASK,    GJ,      GR,      GR2,     JOULE,   MAPR,    MOLEWT,
     X PCCO,    C,       RPM,     TCP,     TERMD,   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,      IOUTTR,  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))

      A= (RS(I) -RH(I))*(RS(I) +RH(I))
      AA= RS(I)**2 -A*BH(I)
      BB= RH(I)**2 +A*BT(I)
      CC=BB-AA
      DD= RPM
      DO 10 J=1,NLINES
      ERAS1= AA +DELM(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)*DD
      RETURN
      END
```

```
      FUNCTION SHOCK(Z,Y)                                               SHOC3382
                                                                        SHOC3383
C        *** CALCULATES SUPERSONIC EXPANSION ANGLE MINUS PRANDTL-MEYER  SHOC3384
C            ANGLE                                                      SHOC3385
                                                                        SHOC3386
      DOUBLE PRECISION  TITLE                                           SHOC3387
      REAL  MACH,  MAPR,  MOLFWT,  JOULF                                SHOC3388
      DIMENSION ATAS(29,11),  FLOW(32)                                  SHOC3389
      LOGICAL  IERROR, YES                                              SHOC3390
      COMMON /MATRIX/  ALPHA(10,11),   ATAR(29,11),    B2(29),          SHOC3391
     X BETA(10,11),    BH(32),         BLADE(29),      BY(32),          SHOC3392
     X CO(10,11),      CP(32,11),      CPCO(6),        CR(32,11),       SHOC3393
     X CSLOPE(10,11),  CU2(11),        CU(32,11),      CUCO(29,5),      SHOC3394
     X CX(32,11),      CXM(10,11),     CXNEW(1 ,11),   CXRATO(29),      SHOC3395
     X CXS(10,11),     DA(10),         DELM(  ),       DEPV(10,11),     SHOC3396
     X DF(20),         DFACT(29,11),   DFL(2  ,        DFLOW(32),       SHOC3397
     X EMACH(29,11),   FOUND(20,3,10), FRDEL  0,11),   GAMMA(32,11),    SHOC3398
     X HMN(29),        HUB(32),        IKK(10),        MACH(29,11),     SHOC3399
     X OBAR(29,11),    PO(32,11),      R(32,11),         AVE(10,11),    SHOC3400
     X RH(32),         RHO(32,11),     RINT(11),       POSTAG(11),      SHOC3401
     X RS(32),         RSLOPE(10,11),  RTRAIL(11),     SOCO(29,5),      SHOC3402
     X SOLID(29,11),   SSCO(29,5),     TERM1(10,11),   TERMA(11),       SHOC3403
     X TERMB(11),      TERMC(11),      TIP(32),        TITLE(12),       SHOC3404
     X TO(32,11),      TSTAT(11),      U(32,11),       W(11),           SHOC3405
     X X(32)                                                            SHOC3406
      COMMON /SCALER/  A,      AA,     A10A0,  A202A0, A303A0, A404A0,  SHOC3407
     X A505A0, B,      BB,     CC,     CM,     CMEAN,  CMEANP, COINTG,  SHOC3408
     X CPI2,   CPI3,   CPI4,   CPI5,   CPI6,   CPO2,   CPO3,   CPO4,    SHOC3409
     X CPO5,   DAMP,   DCP,    DD,     DIFCM,  DT,     DUMMY,  ERASI,   SHOC3410
     X G,      GASK,   GJ,     GR,     GR2,    JOULE,  MAPR,   MOLEWT,  SHOC3411
     X POCO,   C,      RPM,    TCP,    TERMD,  TESTBH, TESTDS, TESTMS,  SHOC3412
     X TOCO,   TOL,    TOLAT,  TOLB2,  TOLMIN, TOLMS,  TOLTIP, TOLCP,   SHOC3413
     X TOLCX,  TOLR,   TOTINT, TOTPR,  V,      VMI                      SHOC3414
      COMMON /INTEGR/  I,      IB,     IB1,    IDUMP,  IERROR, IFIRST,  SHOC3415
     X IG,     IOUTTR, IPASS,  IS,     IT,     J,      JIN,    JJ,      SHOC3416
     X JM,     JM1,    K,      K1,     KK,     L,      LIMIT,  LSTAGE,  SHOC3417
     X MSTAGE, NLINES, NTUBES, NX,     NX1,    YES                      SHOC3418
      EQUIVALENCE  (ATAR(1,1),ATAS(1,1)),  (FLOW(1),DFLOW(1))           SHOC3419
                                                                        SHOC3420
      SHOCK= Y - TERM1(L,J)*ATAN(SQRT((Z-1.0)*(Z+1.0))/TERM1(L,J)) +    SHOC3421
     X ATAN(SQRT((Z-1.0)*(Z+1.0)))                                      SHOC3422
      RETURN                                                            SHOC3423
      END                                                               SHOC3424
```

```
     SLINE.      -  EFN   SOURCE STATEMENT  -  IFN(S)  -
   SUBROUTINE  SLINE(X,XT,YT,N,ANS)
   DIMENSION  XT(500),YT(500)
   IF (N-1)   3,3,11
11 IF (X-XT(1))    3,3,4
 2 RETURN
 3 ANS=YT(1)
   GOTO 2
 4 IF (X-XT(N))    7,5,5
 5 ANS=YT(N)
   GOTO 2
 6 ANS=(YT(N)-YT(N-1))*(X-XT(N-1))/(XT(N)-XT(N-1))+YT(N-1)
   GOTO 2
 7 K=N-1
   DO  8 I=2,K
   IF (X-XT(I))    9,10,8
 8 CONTINUE
   GOTO 6
 9 ANS=(YT(I)-YT(I-1))*(X-XT(I-1))/(XT(I)-XT(I-1))+YT(I-1)
   GOTO 2
10 ANS=YT(I)
   GOTO 2
   END
```

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

```
      SUBROUTINE STAOUT                                                 STA03447
C     *** COMPUTES STATOR EXIT GEOMETRY                                 STA03449
                                                                        STA03450
      COMMON /VGEOM/   ALH(29),        ALT(29),         ALTER,          STA03451
     X ASPECT(29),     FPATH,          SAVEA(29)                        STA03452
      LOGICAL  FPATH                                                    STA03453
      DOUBLE PRECISION  TITLE                                           STA03454
      REAL  MACH,  MAPR,  MOLEWT,  JOULE                                STA03455
      DIMENSION ATAS(29,11),  FLOW(32)                                  STA03456
      LOGICAL  IERROR, YES                                              STA03457
      COMMON /MATRIX/  ALPHA(10,11),   ATAR(29,11),    B2(29),          STA03458
     X BETA(10,11),    BH(32),         BLADE(29),      BT(32),          STA03459
     X CO(10,11),      CP(32,11),      CPCO(6),        CR(32,11),       STA03460
     X CSLOPE(10,11),  CU2(11),        CU(32,11),      CUCO(29,5),      STA03461
     X CX(32,11),      CXM(10,11),     CXNEW(10,11),   CXRATO(29),      STA03462
     X CXS(10,11),     DA(10),         DELM(11),       DEPV(10,11),     STA03463
     X DF(20),         DFACT(29,11),   DFL(29),        DFLOW(32),       STA03464
     X EMACH(29,11),   FOUND(20,3,10), FRDEL(10,11),   GAMMA(32,11),    STA03465
     X HMN(29),        HUB(32),        IKK(10),        MACH(29,11),     STA03466
     X OBAR(29,11),    PO(32,11),      R(32,11),       RCURVE(10,11),   STA03467
     X RH(32),         RHO(32,11),     RINT(11),       ROSTAG(11),      STA03468
     X RS(32),         RSLOPE(10,11),  RTRAIL(11),     SOCO(29,5),      STA03469
     X SOLID(29,11),   SSCO(29,5),     TERM1(10,11),   TERMA(11),       STA03470
     X TERMB(11),      TERMC(11),      TIP(32),        TITLE(12),       STA03471
     X TO(32,11),      TSTAT(11),      U(32,11),       W(11),           STA03472
     X X(32)                                                            STA03473
      COMMON /SCALER/  A,      AA,      A1OA0,  A2O2A0, A3O3A0, A4O4A0, STA03474
     X A5O5A0, B,      BB,     CC,      CM,     CMEAN,  CMEANP, COINTG, STA03475
     X CPI2,   CPI3,   CPI4,   CPI5,    CPI6,   CPO2,   CPO3,   CPO4,   STA03476
     X CPO5,   DAMP,   DCP,    DD,      DIFCM,  DT,     DUMMY,  ERAS1,  STA03477
     X G,      GASK,   GJ,     GR,      GR2,    JOULE,  MAPR,   MOLEWT, STA03478
     X POCO,   Q,      RPM,    TCP,     TERMD,  TESTBH, TESTDS, TESTMS, STA03479
     X TOCO,   TOL,    TOLAT,  TOLB2,   TOLMIN, TOLMS,  TOLTIP, TOLCP,  STA03480
     X TOLCX,  TOLR,   TOTINT, TOTPR,   V,      VMI                     STA03481
      COMMON /INTEGR/  I,      IB,      IB1,    IDUMP,  IERROR, IFIRST, STA03482
     X IG,     IOUTTR, IPASS,  IS,      IT,     J,      JIN,    JJ,     STA03483
     X JM,     JM1,    K,      K1,      KK,     L,      LIMIT,  LSTAGE, STA03484
     X MSTAGE, NLINES, NTUBES, NX,      NX1,    YES                     STA03485
      EQUIVALENCE  (ATAR(1,1),ATAS(1,1)),  (FLOW(1),DFLOW(1))           STA03486
                                                                        STA03487
      L= 1                                                              STA03488
      IF (LSTAGE.NE.7)  GO TO 45                                        STA03489
      IF (.NOT.FPATH)  GO TO 20                                         STA03490
                                                                        STA03491
C      *** ESTIMATE THE FIRST STATOR GEOMETRY IF REQUIRED               STA03492
                                                                        STA03493
      RS(7)= RS(6)                                                      STA03494
      DT=     (RS(6) -RH(6))/ASPECT(7)                                  STA03495
      RH(7)= RH(6) +DT*AMIN1(0.6, 0.8*ALH(7))                           STA03496
      X(7)=  X(6) +DT                                                   STA03497
      GO TO 25                                                          STA03498
                                                                        STA03499
C      *** PICK UP THE STATOR GEOMETRY                                  STA03500
                                                                        STA03501
```

```
   20 RH(I)= HUB(I)
      RS(I)= TIP(I)
   25 CALL RSTART
      DO 3 J=1,NLINES
C
C       *** INITIALIZE THE FLOW PARAMETERS
C
      TO(I,J)= TO(I-1,J)
      CP(I,J)=CP(I-1,J)
      GAMMA(I,J)= GAMMA(I-1,J)
    3 PO(I,J)= POCO*(0.89*(TO(I,J)-TOCO)/TOCO +1.0)**
     X  (GAMMA(I,1)/(GAMMA(I,1) -1.0))
      CALL INEST
      CALL STREAM
      CALL MOVE
      RETURN
C
C       *** ESTIMATE THE DOWN-STREAM STATOR PROPERTIES
C
   45 CALL COPY
      RETURN
      END
```

```
      SUBROUTINE STREAM

C         *** COMPUTES AXIAL VELOCITY DISTRIBUTIONS WHICH SATISFY
C             CONTINUITY AND LOCATES STREAMLINE POSITIONS

      DOUBLE PRECISION  TITLE
      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),    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),    FOUND(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),        ROSTAG(11),
     X RS(32),          RSLOPE(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 TO(32,11),       TSTAT(11),       U(32,11),        W(11),
     X X(32)
      COMMON /SCALER/  A,       AA,      A1CA0,   A2O2AO,  A303A0,  A404A0,
     X A505A0, B,      BB,      CC,      CM,      CMEAN,   CMEANP,  COINTG,
     X CPI2,   CPI3,   CPI4,    CPI5,    CPI6,    CPO2,    CPO3,    CPO4,
     X CPO5,   DAMP,   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,   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,       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(L,J)=CX(I,J)/CMEAN
  150 TERMA(J)=CU(I,J)**2+CR(I,J)**2
      NCOUNT=1

C         *** START OF LOOP ON CM CONVERGENCE

      INDIC=0
      J= JM
  155 H= -(CMEAN**2 +TERMA(J)) /GJ
      T= TO(I,J)
```

```
      CALL ENTALP

C        *** ERROR TRANSFER TO A NEW DATA SET

      IF (VMI.LE.0.0) CALL ERROR(27)
      VMI= SQRT(VMI)
      IF(CMEAN-VMI)205,205,160
  160 IF(INDIC)165,170,165

C        *** PROGRAM NOT SUITABLE FOR SUPERSONIC FLOW, GO TO A
C            NEW DATA SET

  165 CALL ERROR( 2)
  170 INDIC=1
      CMEAN= VMI*0.75
  205 DO 260 J=1,NLINES
      CX(I,J)=CMEAN*CXM(L,J)
      H= -(CX(I,J)**2 +TERMA(J))/GJ
      T= TO(I,J)
      CALL  ENTALP

C        *** CALCULATE STATIC DENSITY

      B= PO(I,J)*EXP((THERM3(TSTAT(J)) -THER 3(TO(I,J)))/DCP)
      RHO(I,J)= B/ TSTAT(J)/ GASK
      DEPV(L,J)=RHO(I,J)*CXM(L,J)
  260 CONTINUE

C        *** CALCULATE INTEGRAL OF RHO*CXM*R VS. R FROM HUB TO TIP,
C            (TOTINT), AND NEW VALUE OF CMEAN

  275 CALL INTEG (DEPV,1)
      TOTINT=RINT(NLINES)-RINT(1)

      CMEANP=FLOW(I)/6.2831853/TOTINT
C        *** CHECK CONVERGENCE OF CM

      DIFCM=ABS((CMEAN-CMEANP)/CMEAN)
      IF (DIFCM-TOLR)300,300,280
  280 IF (NCOUNT-30)290,290,285

C        *** ERROR WILL CAUSE TRANSFER TO NEXT DATA SET

  285 CALL ERROR( 3)
  290 NCOUNT=NCOUNT+1
      CMEAN=CMEANP
      J= JM
      GO TO 155

C        *** SUCCESSFUL CONVERGENCE ON CM

C        *** USE CONVERGED VALUES OF INTEGRAL OF RHO*CXM*R VS. R FROM
C            R(J) TO R(J+1), (DA VALUES), TO CALCULATE VALUES OF - -
C            DEPV(L,J)=(INTEGRAL RHO*CXM*R VS. R FROM RH TO R(J))/TOTINT
```

```
300 CONTINUE
    DO 400 J=1,NLINES
400 CX(I,J)=CXM(L,J)*CMEANP
700 RETURN
    END
```

```
      FUNCTION THERM1(T)
C
C     *** CALCULATES H = INTEGRAL FROM 0.0 TO T OF CP DT, WHERE CP IS
C         GIVEN AS A FIFTH DEGREE POLYNOMIAL
C
      DOUBLE PRECISION  TITLE
      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),    FOUND(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),        ROSTAG(11),
     X RS(32),          RSLOPE(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 TO(32,11),       TSTAT(11),        U(32,11),        W(11),
     X X(32)
      COMMON /SCALER/   A,      AA,      A1OAO,   A2O2AO,  A3O3AO,  A4O4AO,
     X A5O5AO, B,       BB,     CC,      CM,      CMEAN,   CMEANP,  COINTG,
     X CPI2,   CPI3,    CPI4,   CPI5,    CPI6,    CPO2,    CPO3,    CPO4,
     X CPO5,   DAMP,    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,   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,      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)*
     1T)*T)*T)*T
      RETURN
      END
```

```
      SUBROUTINE THERM2(POVER,TOP,T)

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

      DOUBLE PRECISION  TITLE
      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),   FOUND(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),      ROSTAG(11),
     X RS(32),         RSLOPE(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 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,   CP02,   CP03,   CP04,
     X CP05,   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,  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,      K1,     KK,     L,      LIMIT,  LSTAGE,
     X MSTAGE, NLINES, NTUBES, NX,     NX1,    YES
      EQUIVALENCE  (ATAR(1,1),ATAS(1,1)),  (FLOW(1),DFLOW(1))

      XA= ALOG(POVER)*DCP
      BOT= THERM3(T)
      DO 10 NN=1,50
      DT= TOP*(XA -THERM3(TOP) +BOT)/CP(1,1)
      TOP=TOP +DT
      IF (ABS(DT).LE.TOLCP)  GO TO 15
   10 CONTINUE

C        *** ERROR TRANSFER TO A NEW DATA SET

      CALL  ERROR(26)
   15 RETURN
      END
```

```
      FUNCTION THERM3(T)
C
C        *** CALCULATE THE INTEGRAL OF CP/T DT FROM 0.0 TO T
C
      DOUBLE PRECISION  TITLE
      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),   FOUND(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),      ROSTAG(11),
     X RS(32),         RSLOPE(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 TO(32,11),      TSTAT(11),      U(32,11),      W(11),
     X X(32)
      COMMON /SCALER/  A,      AA,     A1OAO,  A2O2AO, A3O3AO, A4O4AO,
     X A5O5AO, B,      BB,     CC,     CM,     CMEAN,  CMEANP, COINTG,
     X CPI2,   CPI3,   CPI4,   CPI5,   CPI6,   CPO2,   CPO3,   CPO4,
     X CPO5,   DAMP,   DCP,    DD,     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,  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,      K1,     KK,     L,      LIMIT,  LSTAGE,
     X MSTAGE, NLINES, NTUBES, NX,     NX1,    YES
      EQUIVALENCE  (ATAR(1,1),ATAS(1,1)),  (FLOW(1),DFLOW(1))

      THERM3= CPCO(1)*ALOG(T)+(CPCO(2)+(CPO2+(CPO3+(CPO4+CPO5*T)*T)*T)
     X *T)*T
      RETURN
      END
```

```
      SUBROUTINE THERMP

C        *** CALCULATE SPECIFIC HEAT AT CONSTANT PRESSURE (CP) AS A
C            FUNCTION BEING A FIFTH DEGREE POLYNOMIAL. THEN THE
C            RATIO OF SPECIFIC HEATS IS CALCULATED AS CP/(CP-.0686)

      DOUBLE PRECISION  TITLE
      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(3, 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),    FOUND(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),        ROSTAG(11),
     X RS(32),          RSLOPE(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 TO(32,11),       TSTAT(11),       U(32,11),        W(11),
     X X(32)
      COMMON /SCALER/   A,       AA,      A1OA0,   A2O2A0,  A3O3A0,  A4O4A0,
     X A5O5A0,  B,       BB,      CC,      CM,      CMEAN,   CMEANP,  COINTG,
     X CPI2,    CPI3,    CPI4,    CPI5,    CPI6,    CPO2,    CPO3,    CPO4,
     X CPO5,    DAMP,    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,   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,       K1,      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 TO(I,J))*TO(I,J))*TO(I,J))*TO(I,J))*TO(I,J)
      CV= CP(I,J) - DCP
      GAMMA(I,J)=CP(I,J)/CV
      RETURN
      END
```

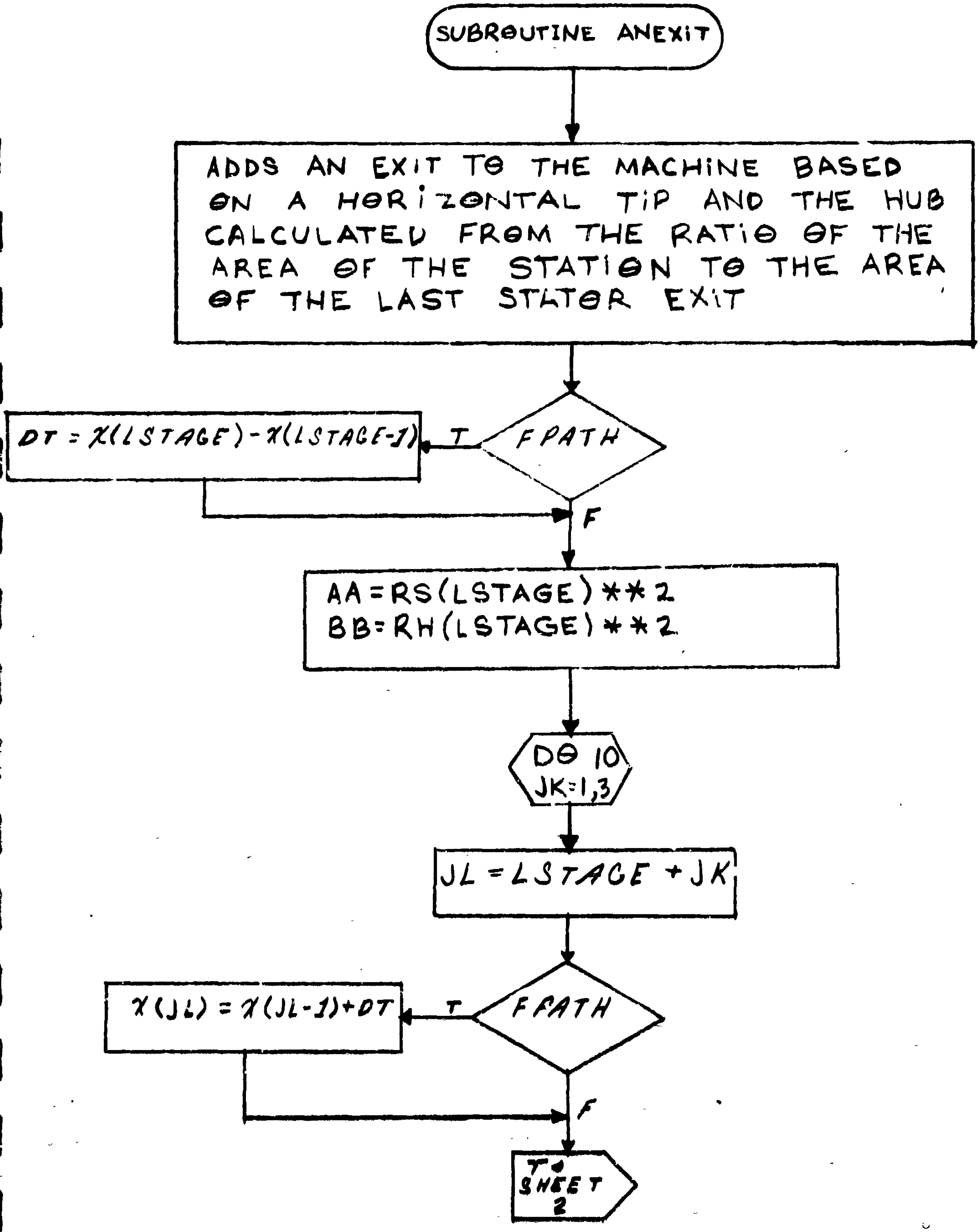
```
      SUBROUTINE  XDERIV(Y,DYDX)

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

      DIMENSION  Y(32,11), DYDX(10,11)
      DOUBLE PRECISION  TITLE
      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),   FOUND(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),       ROSTAG(11),
     X RS(32),         RSLOPE(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 TO(32,11),      TSTAT(11),      U(32,11),       W(11),
     X Y(32)
      COMMON /SCALER/  A,       AA,      A1OA0,   A2O2A0,  A3O3A0,  A4O4A0,
     X A5O5A0, B,      BB,      CC,      CM,      CMEAN,   CMEANP,  COINTG,
     X CPI2,   CPI3,   CPI4,    CPI5,    CPI6,    CPO2,    CPO3,    CPO4,
     X CPO5,   DAMP,   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,   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,       K1,      KK,      L,       LIMIT,   LSTAGE,
     X MSTAGE, NLINES, NTUBES,  NX,      NX1,     YES
      EQUIVALENCE  (ATAR(1,1),ATAS(1,1)),  (FLOW(1),DFLOW(1))

      DYDX(10,J)=0.0

      L=1
    3 DO 5 I=IB1,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 CONTINUE
    6 RETURN
      END
```

APPENDIX C

PROGRAM FLOW CHARTS

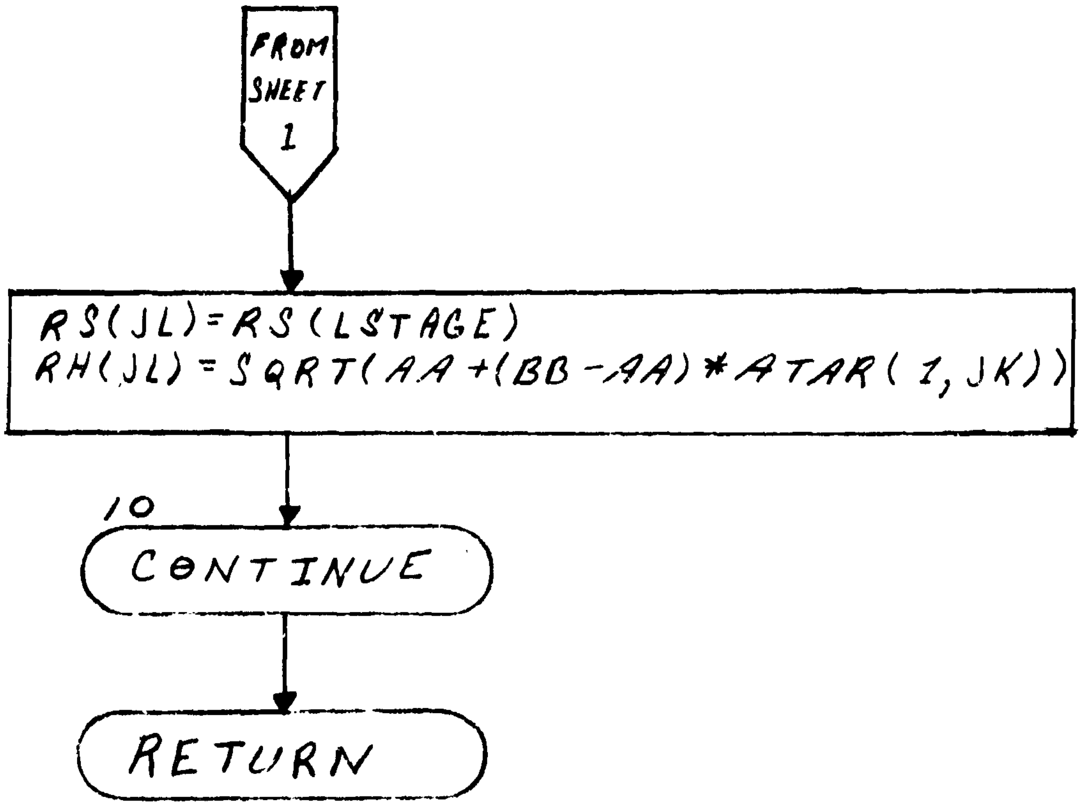
AN EXIT

SHEET 1 OF 2

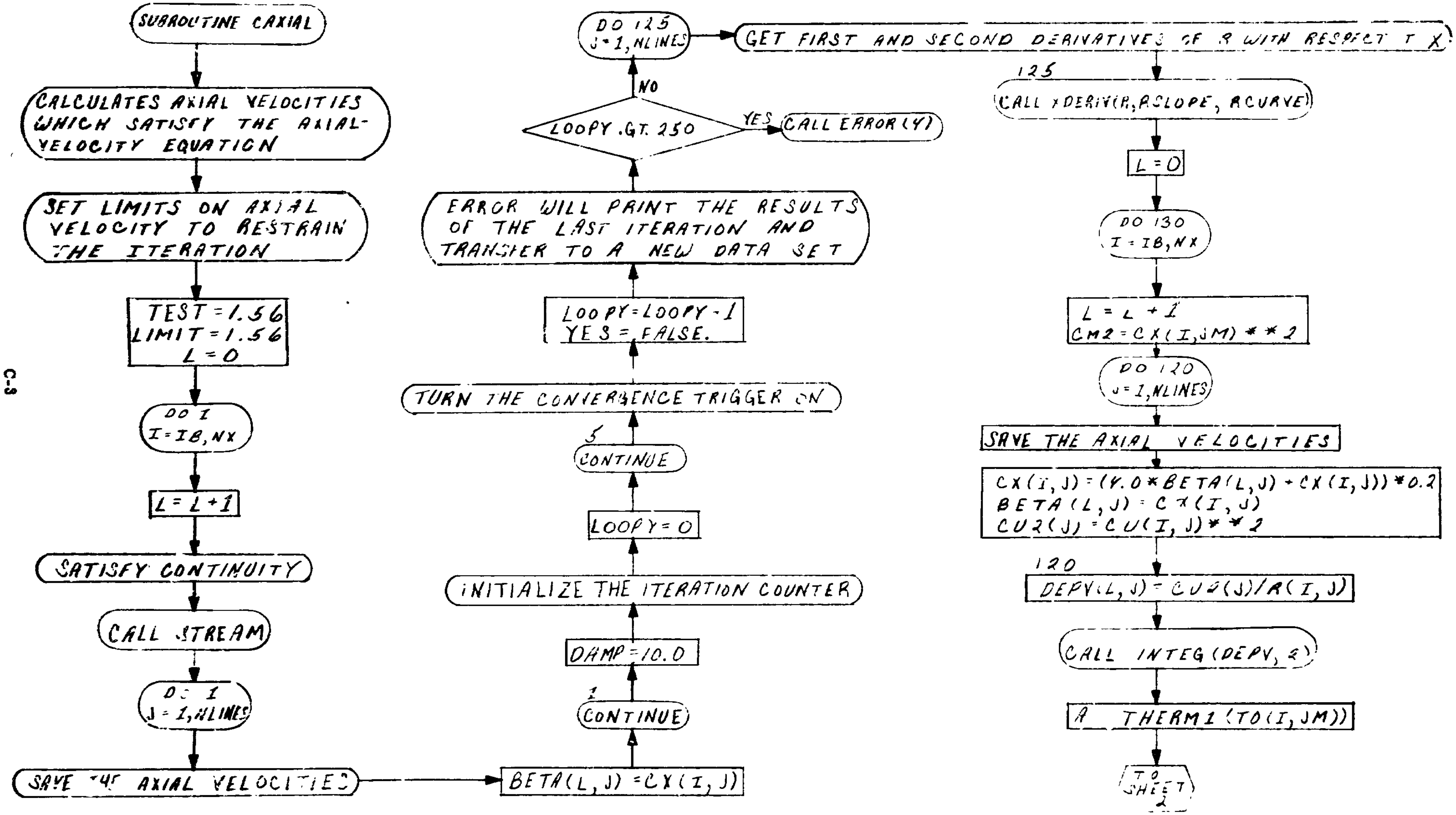


AN EXIT

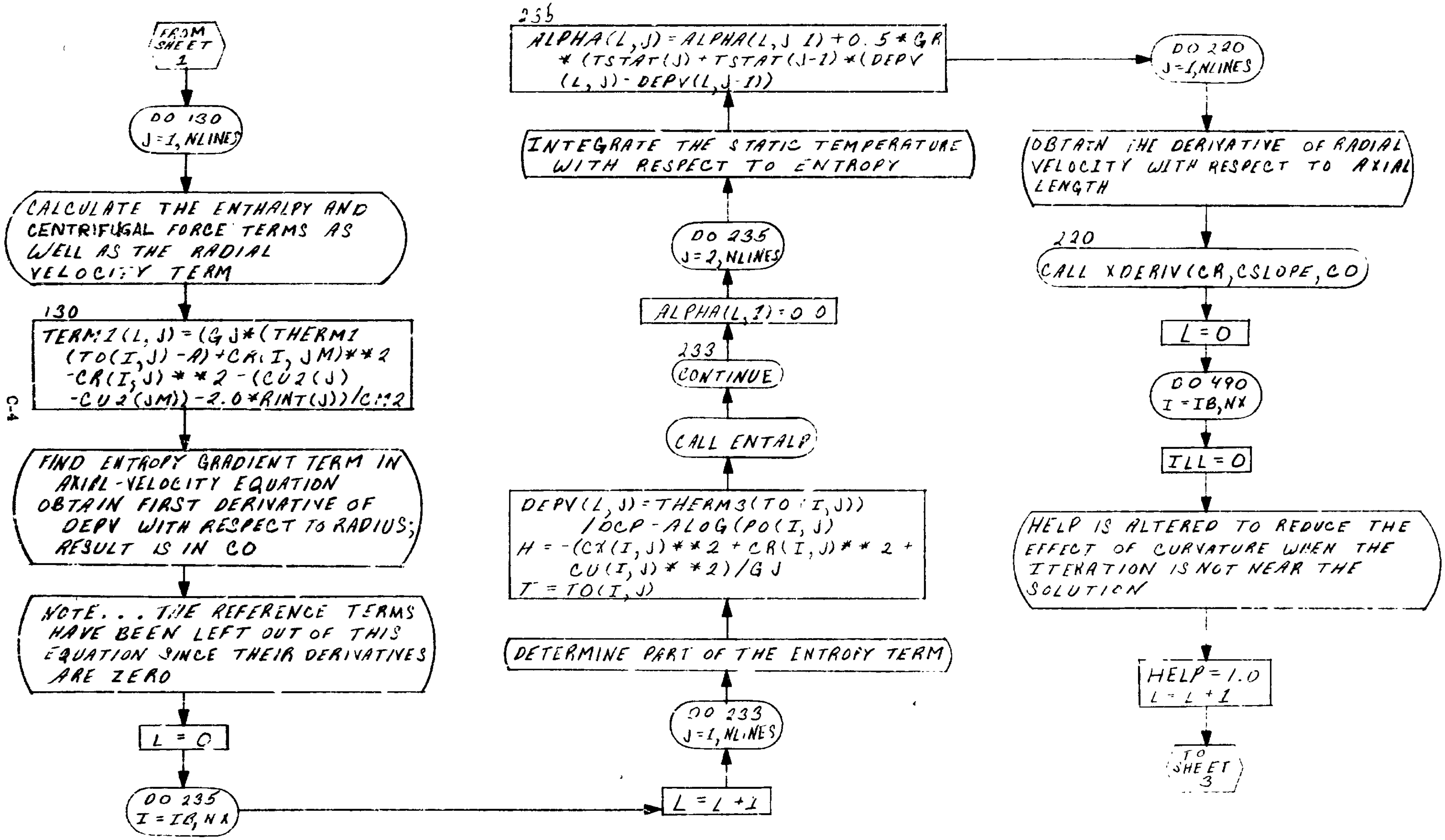
SHEET 2 OF 2

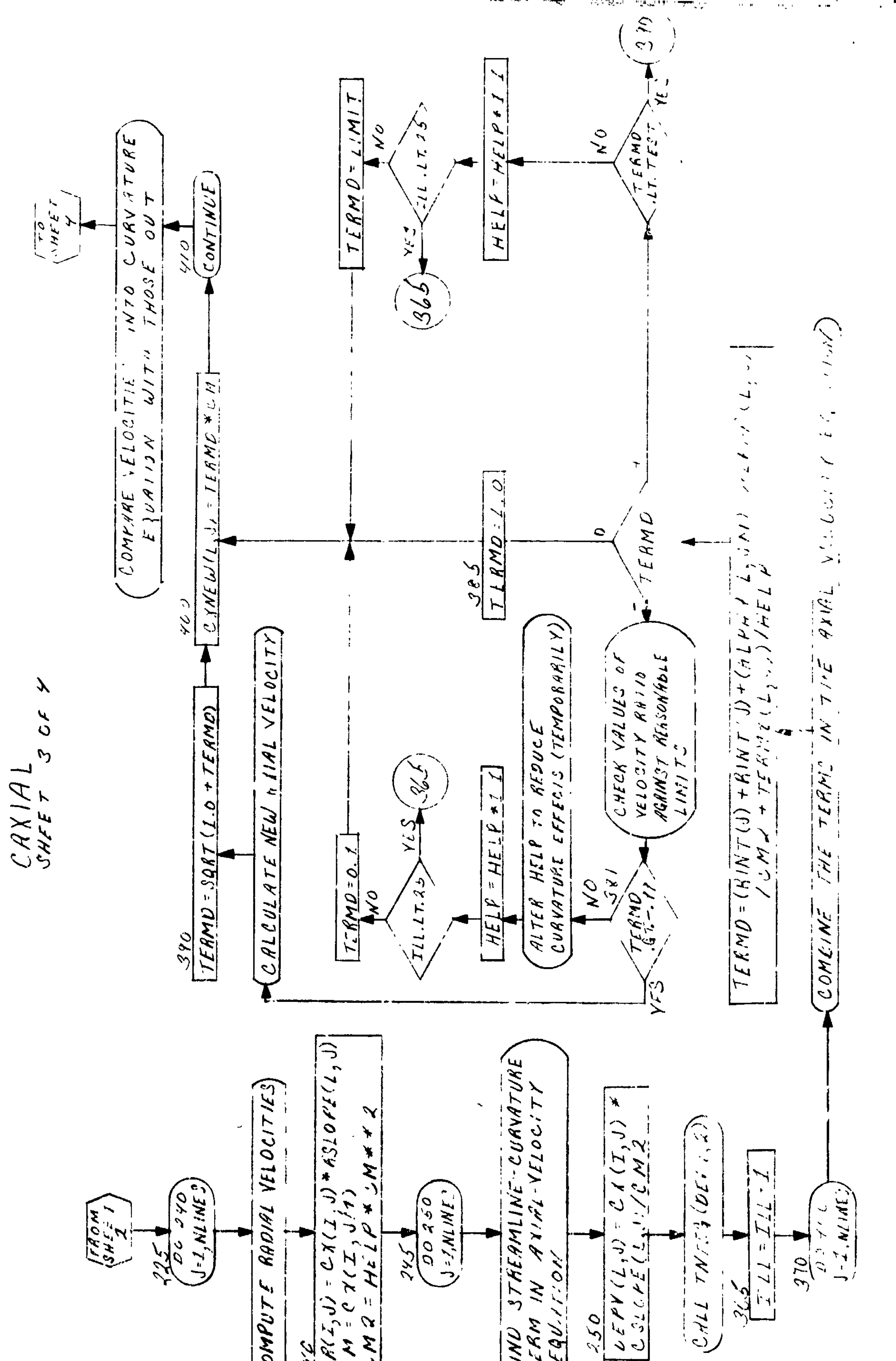


CAXIAL
SHEET 1 OF 4

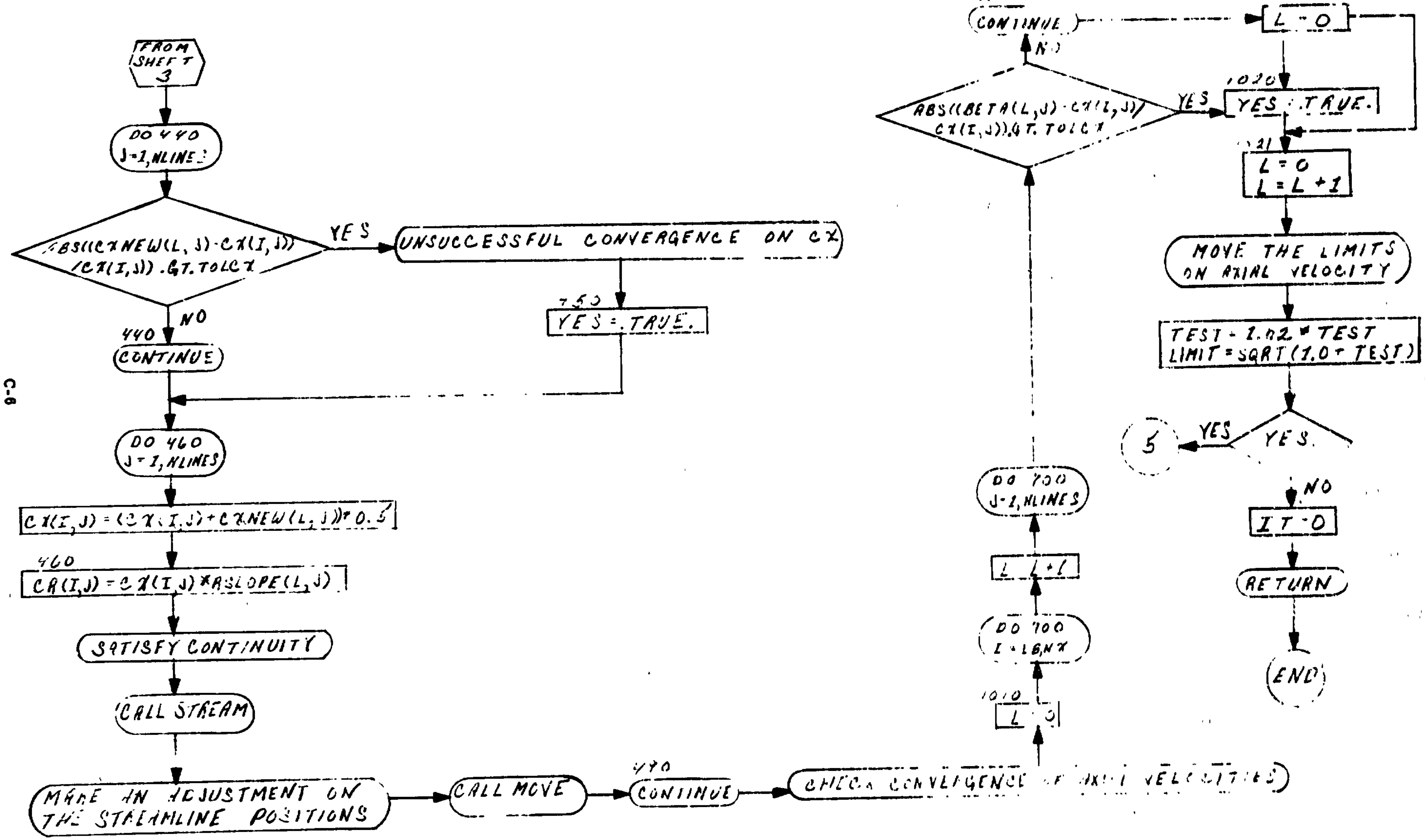


CAXIAL
SHEET 2 OF 4

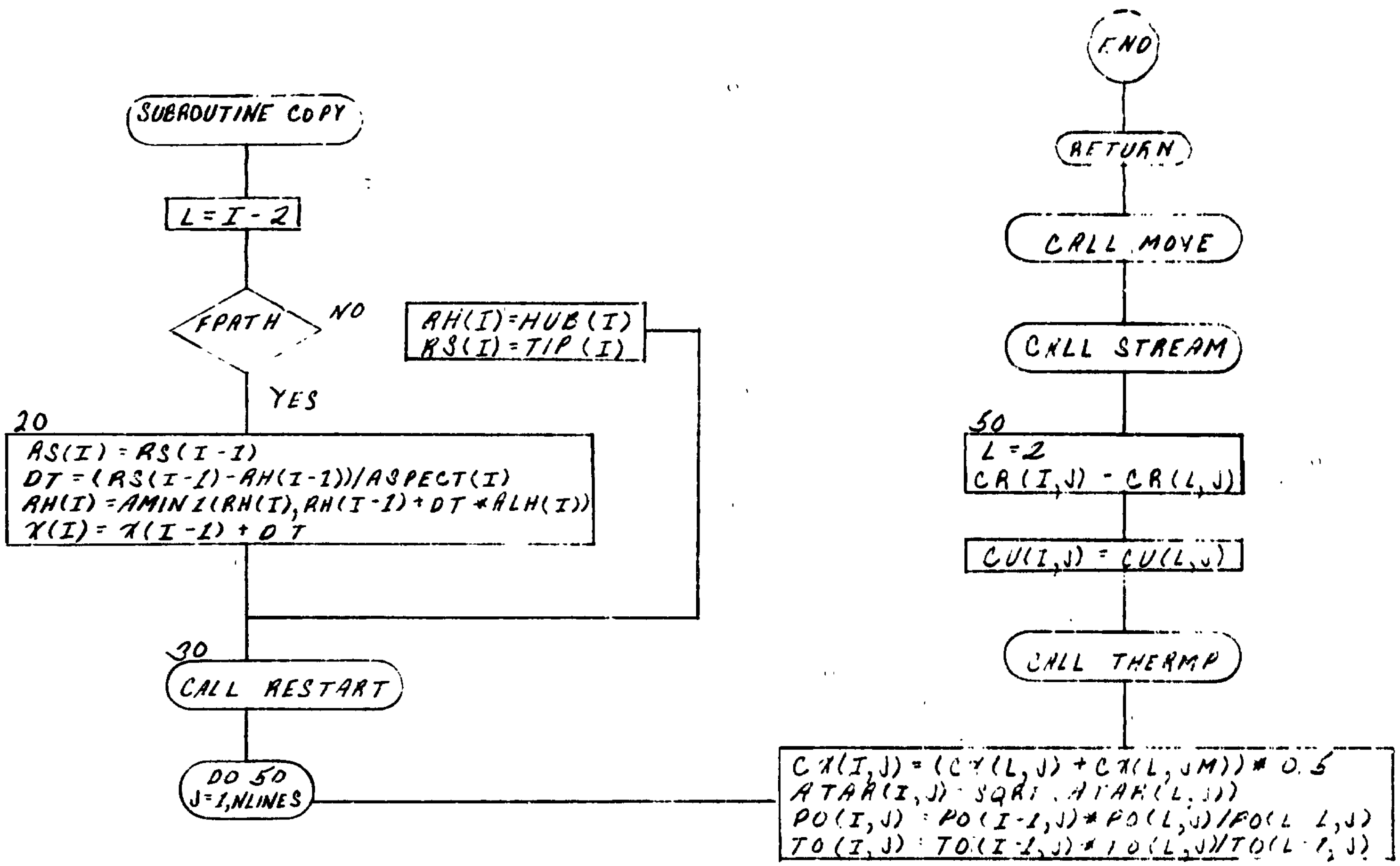



CAXIAL
SHEET 3 OF 4
FROM SHEET 2
225 DO 240 J=1,NLINES
COMPUTE RADIAL VELOCITIES
240 CR(I,J) = CX(I,J)*RSLOPE(L,J)
CM = CX(I,J)
CM2 = HELP*CM**2
245 DO 250 J=1,NLINES
FIND STREAMLINE-CURVATURE TERM IN AXIAL-VELOCITY EQUATION
250
CALL
365 ILL = ILL - 1
370 DO J=1,NLINES
COMBINE THE TERMS IN THE AXIAL VELOCITY
TERMD = (RINT(J) + RINT(J)) + (ALPHA(L,J)
/CM2 + TERM
)/HELP
TERMD
385 TERMD = 1.0
CHECK VALUES OF VELOCITY RATIO AGAINST REASONABLE LIMITS
TERMD GT -1
381
NO
YES
ALTER HELP TO REDUCE CURVATURE EFFECTS (TEMPORARILY)
HELP = HELP * 1.1
ILL.LT.25
TERMD = 0.1
365
TERMD .LT. TEST
HELP = HELP * 1.1
ILL.LT.25
TERMD = LIMIT
390 TERMD = SQRT(1.0 + TERMD)
CALCULATE NEW AXIAL VELOCITY
400 CXNEW(L,J) = TERMD * CM
410 CONTINUE
COMPARE VELOCITIES INTO CURVATURE EQUATION WITH THOSE OUT
TO SHEET 4

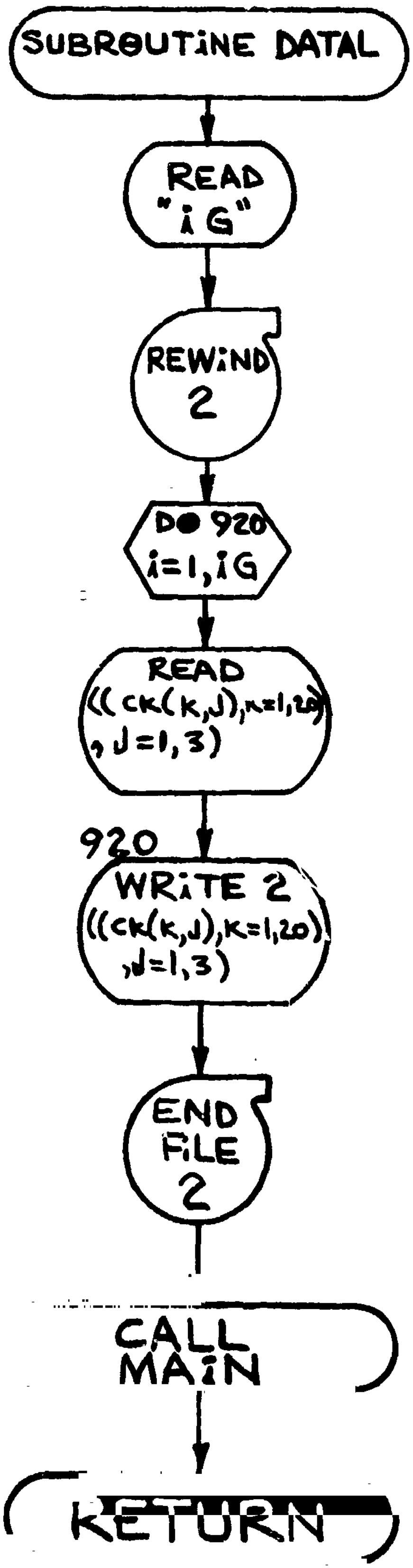
CAXIAL
SHEET 4 OF 4



COPY


SUBROUTINE COPY
L=I-2
FPATH
NO
YES
AH(I)=HUB(I)
RS(I)=TIP(I)
20
RS(I) = RS(I-1)
DT = (RS(I-1)-AH(I-1))/ASPECT(I)
AH(I) = AMIN1(RH(I), AH(I-1)+DT*ALH(I))
X(I) = X(I-1) + DT
30
CALL RESTART
DO 50 J=1,NLINES
END
RETURN
CALL MOVE
CALL STREAM
50
L=2
CR(I,J) = CR(L,J)
CU(I,J) = CU(L,J)
CALL THERMP

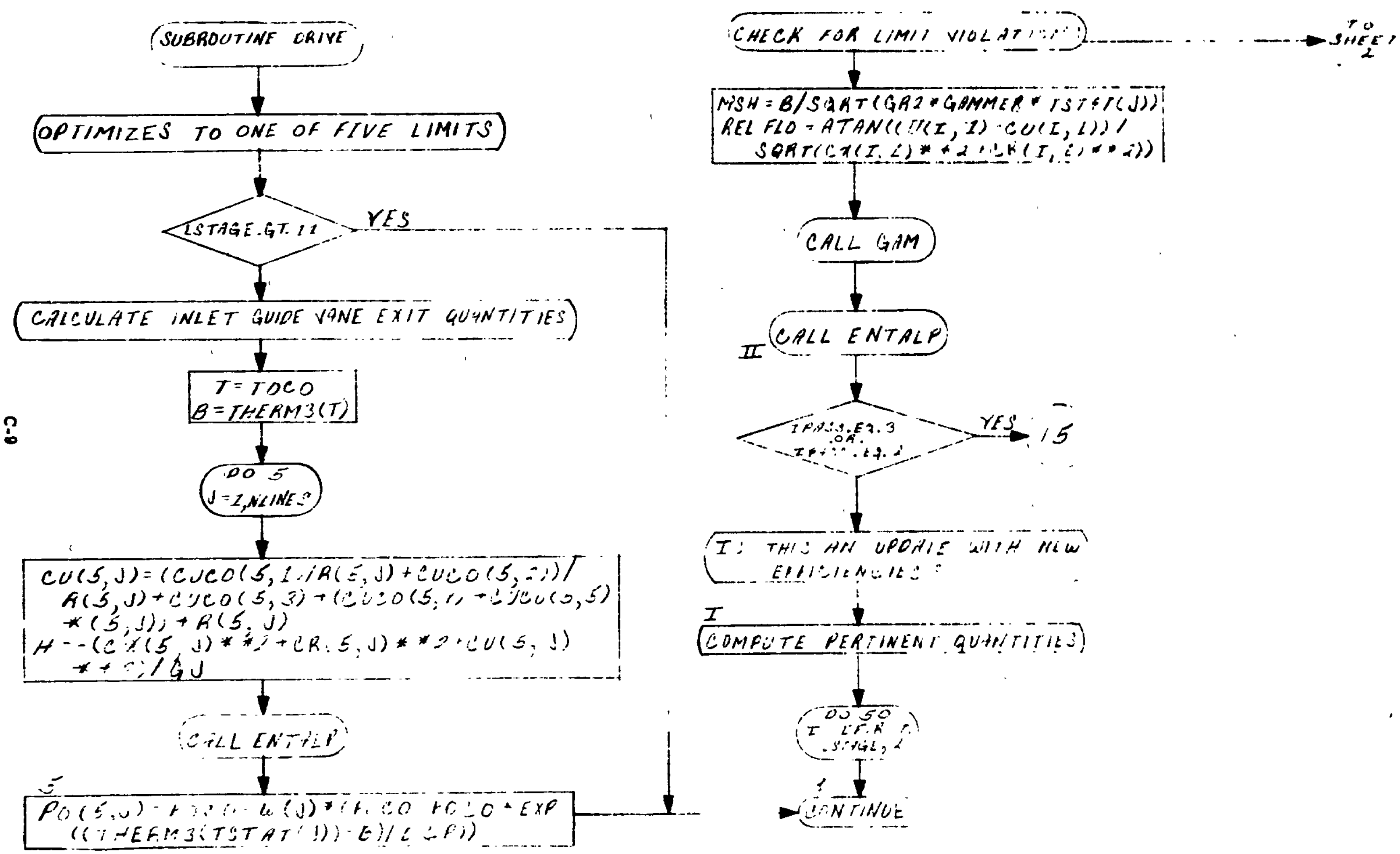
DATAL S.R.



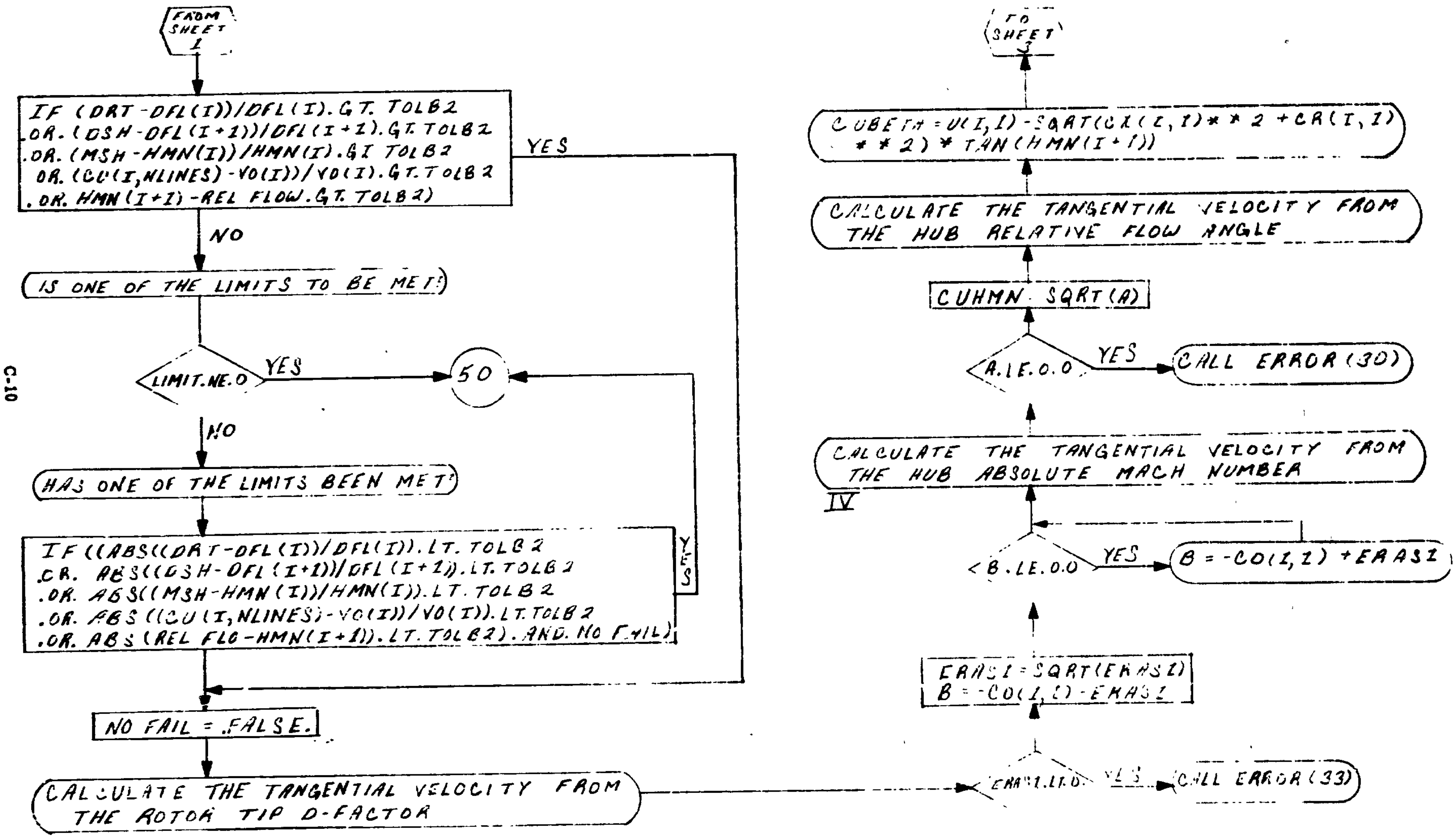
PREPARES A MASTER TAPE OF LOSS DATA.

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

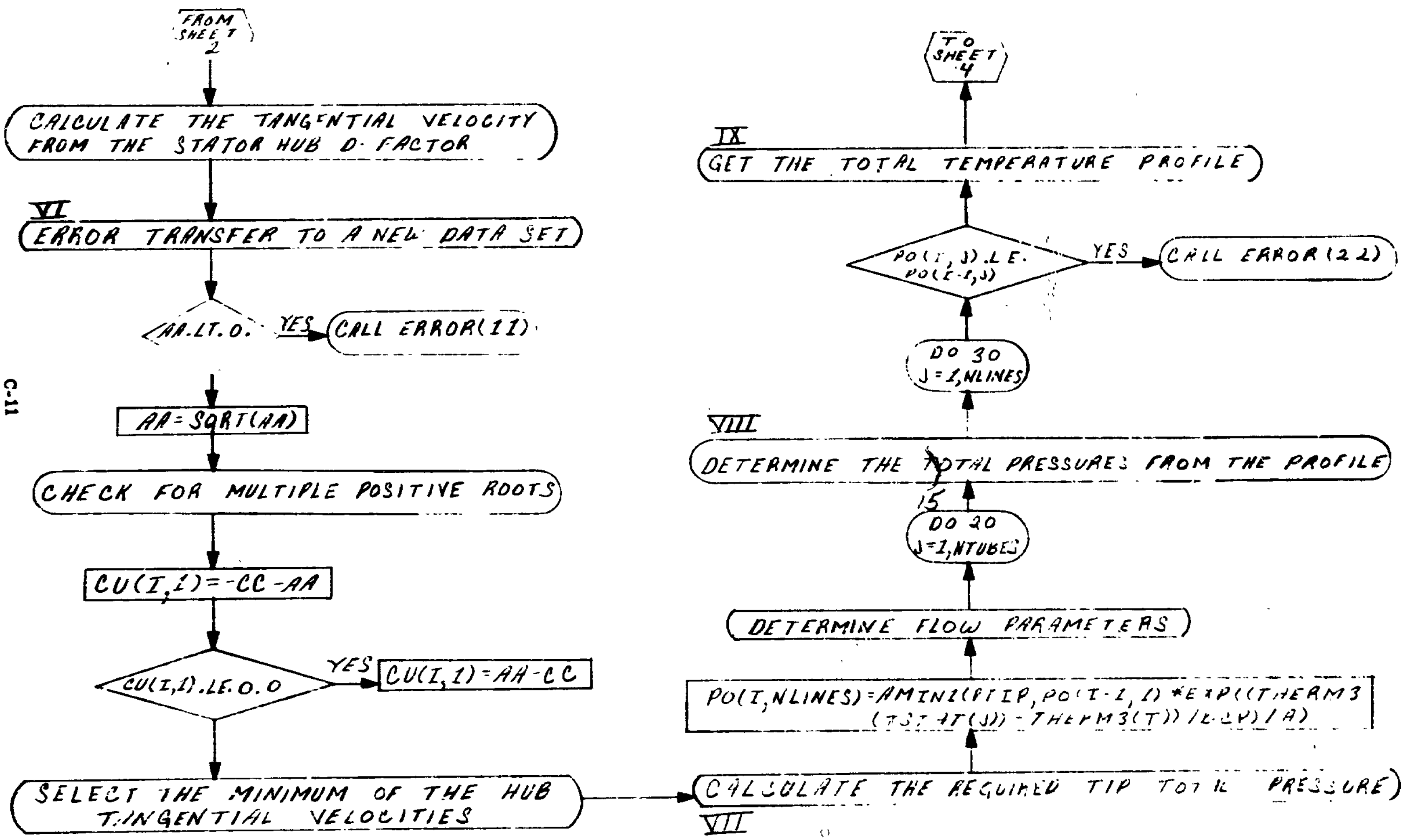
DRIVE
SHEET 1 OF 7



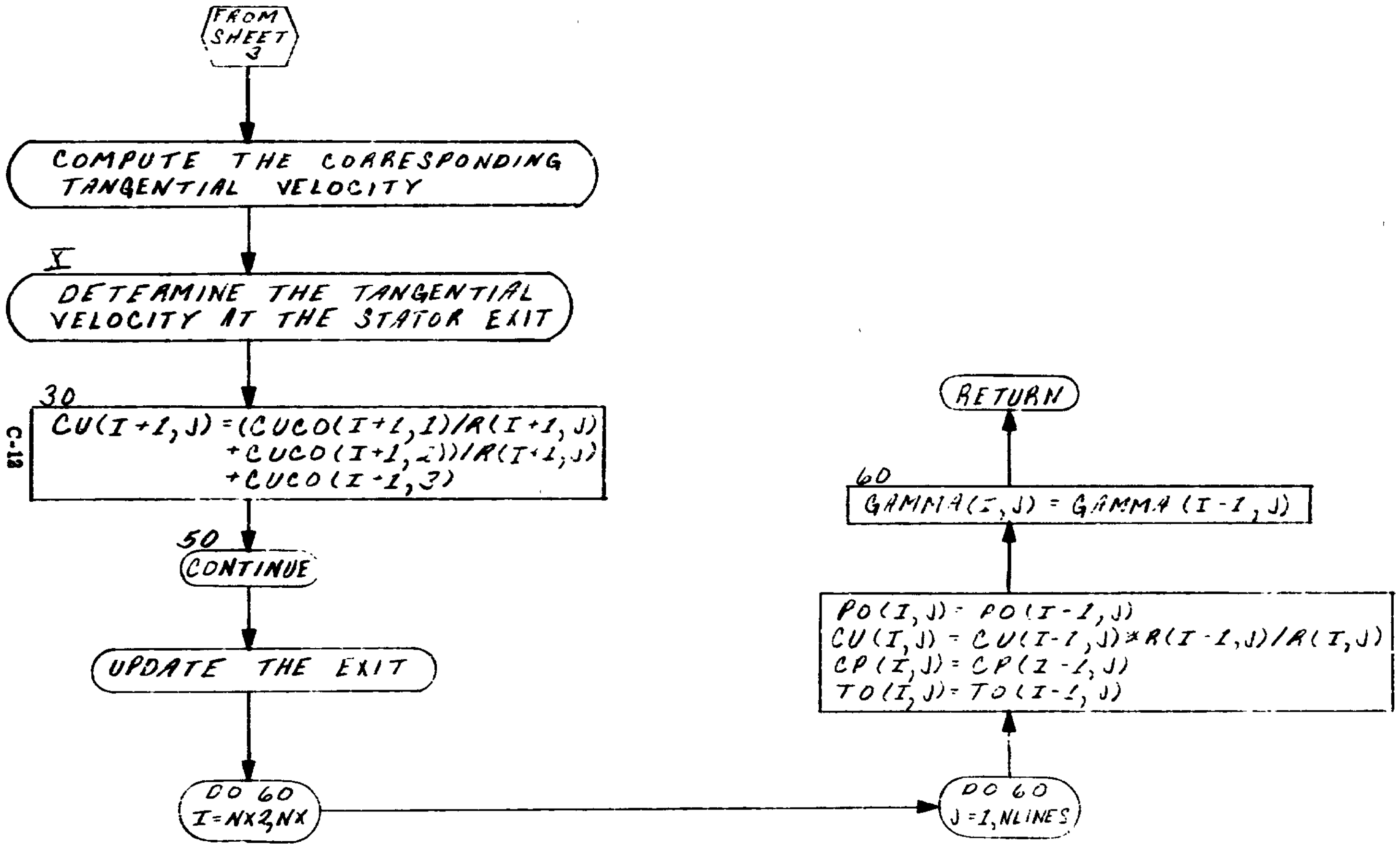
DRIVE
SHEET 2 OF 1



DRIVE
SHEET 3 OF 7



DRIVE
SHEET 4 OF 7



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TITLE DRIVE
SHEET 5 OF 7

```
I.   J = 1
     K = I/2
     A = (R(I,NLINES)+R(I-1,NLINES)-(RH(I)+
        RH(I-1)))/(RS(I)+RS(I-1)-(RH(I)+RH(I-1)))
     SOLID(I,NLINES)=SOCO(I,1)/(SOCO(I,2)+A)+
        SOCO(I,3)+(SOCO(I,4)+SOCO(I,5)*A)*A
     A = (R(I,1)+R(I+1,1)-RH(I)-RH(I+1))/(RS(I)
        +RS(I+1)-RH(I)-RH(I+1))
     SOLID(I+1,1)=SOCO(I+1,1)/(SOCO(I+1,2)+A)
        +SOCO(I+1,3)+(SOCO(I+1,4)+SOCO(I+1,5)
        *A)*A)
     V= SQRT(CX(I-1,NLINES)**2+CR(I-1,NLINES)
        **2+(CU(I-1,NLINES)-U(I-1,NLINES))**2)

II.  A=SQRT(CX(I,NLINES)**2+CR(I,NLINES)**2
        +(CU(I,NLINES)-U(I,NLINES))**2)
     DRT = 1.0-A/V+(U(I-1,NLINES)-CU(I-1,NLINES)
        -U(I,NLINES)+CU(I,NLINES))/V/SOLID
        (I,NLINES)/2.0
     A = SQRT(CX(I+1,1)**2+CR(I+1,1)**2+
        CU(I+1,1)**2)
     B = SQRT(CX(I,1)**2+CR(I,1)**2+CU(I,1)
        **2)
     DSH =1.0-A/B+(CU(I,1)-CU(I+1,1))/B/
        SOLID(I+1,1)/2.0
     H = -B*B/GJ
     T= TO(I,1)

III. Q=0.5/SOLID(I,NLINES)
     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)/(1.0-Q*Q)
     ERAS1=CO(1,1)**2-4.*CO(1,2)
```

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TITLE DRIVE
SHEET 6 OF 7

```
IV.  B=0.5*B
     B=AMIN1(VO(I),B)
     H=(U(I,NLINES)*B-U(I-1,NLINES)*CU(I-1,
       NLINES))*ATAR(I,NLINES)*2.0/GJ
     T=TO(I-1,NLINES)
     CALL ENTALP
     PTIP=PO(I-1,NLINES)*EXP((THERM3
       (TSTAT(J))-THERM3(T))/DCP)

V.   SQCO=CX(I,1)**2+CR(I,1)**2
     V=SQCO+CU(I,1)**2
     H=-V/GJ
     T=TO(I,1)
     CALL ENTALP
     CALL GAM
     VMI=GR2*GAMMER*TSTAT(J)
     A=VMI*HMN(I)**2-SQCO

VI.  AA=(-SQRT(CX(I+1,1)**2+CU(I+1,1)**2
         +CR(I+1,1)**2)-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

VII  CU(I,1)=AMIN1(CU(I,1),CUHMN,CUBETA
     H=(CU(I,1)*U(I,1)-CU(I-1,1)*U(I,1))*
        ATAR(I,1)*2.0/GJ
     T=TO(I-1,1)
     CALL ENTALP
     A=(R(I,1)-RH(I))/RS(I)-RH(I))
     A=NORM(K)*(CUCO(I,1)/(CUCO(I,2)+A)
        +CUCO(I,3)+(CUCO(I,4)+CUCO(I,5)
        *A)*A)
```

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		CHECKED		
		APPROVED		

```
VIII.  A =(R(I,J)-RH(I))/(RS(I)-RH(I))
  20   PO(I,J)=PO(I,NLINES)*NORM(K) *(CUCO(I,1)
          /(CUCO(I,2)+A)+CUCO(I,3)+CUCO
          (I,4)+CUCO(I,5)*A)*A)

IX.    CALL THERM2(PO(I,J)/PO(I-1,J),TO(I,J),
          TO(I-1,J))
       H=THERM1(TO(I,J))-THERM1(TO(I-1,J))
       H=H/ATAR(I,J)

X.     CU(I,J)=(0.5*H*GJ+CU(I-1,J)*U(I-1,J))
          /U(I,J)
       TO=TO(I-1,J)
       CALL ENTALP
       TO(I,J)=TSTAT(J)
       H=ATAS(I+1,J)*H
       CALL ENTALP
       PO(I+1,J)=PO(I-1,J)*EXP((THERM3
          (TSTAT(J))-THERM3(T))/DCP)
       CALL THERMP
       TO(I+1,J)=TO(I,J)
       CP(I+1,J)=CP(I,J)
       GAMMA(I+1,J)=GAMMA(I,J)
```

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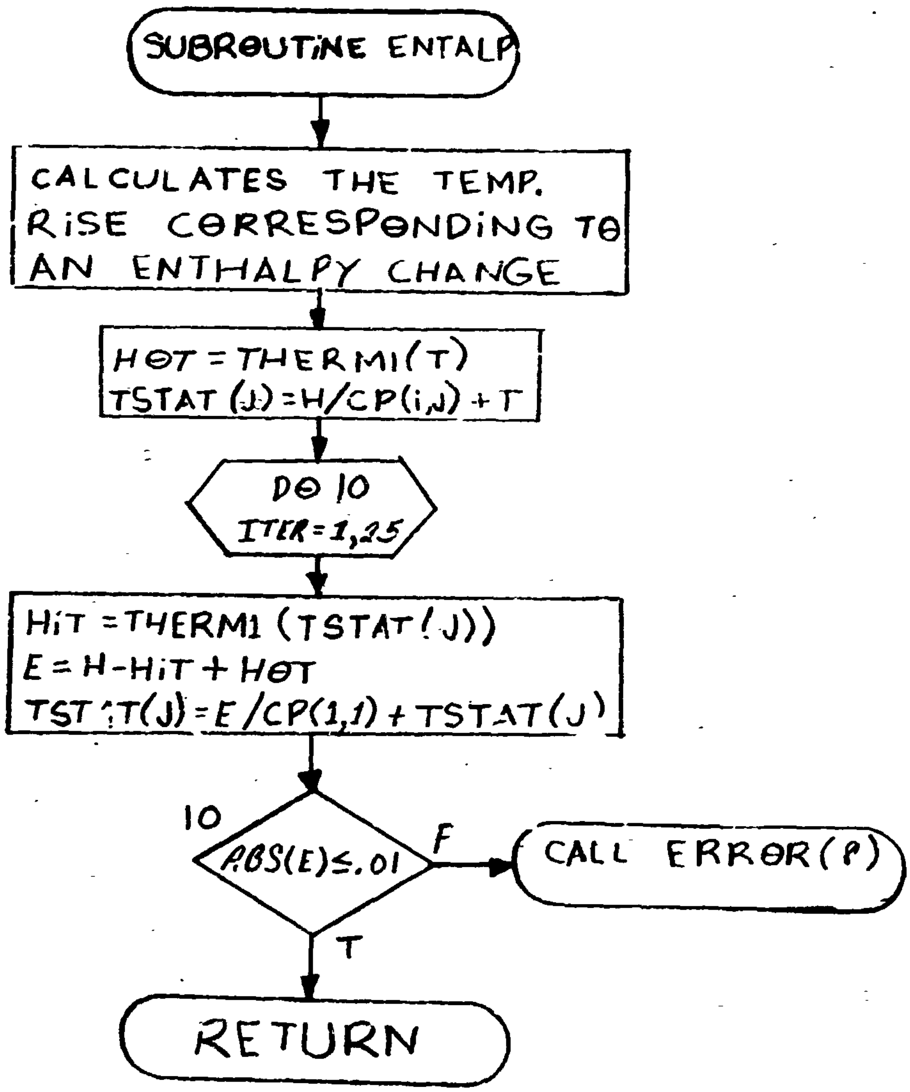
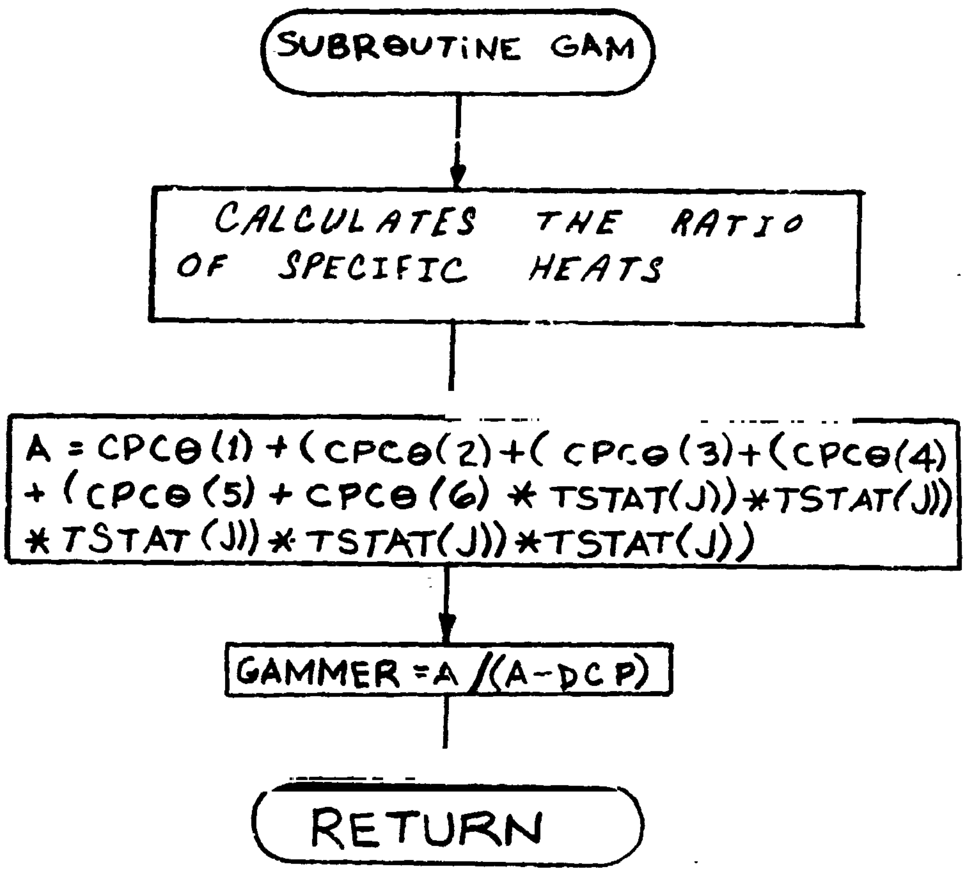
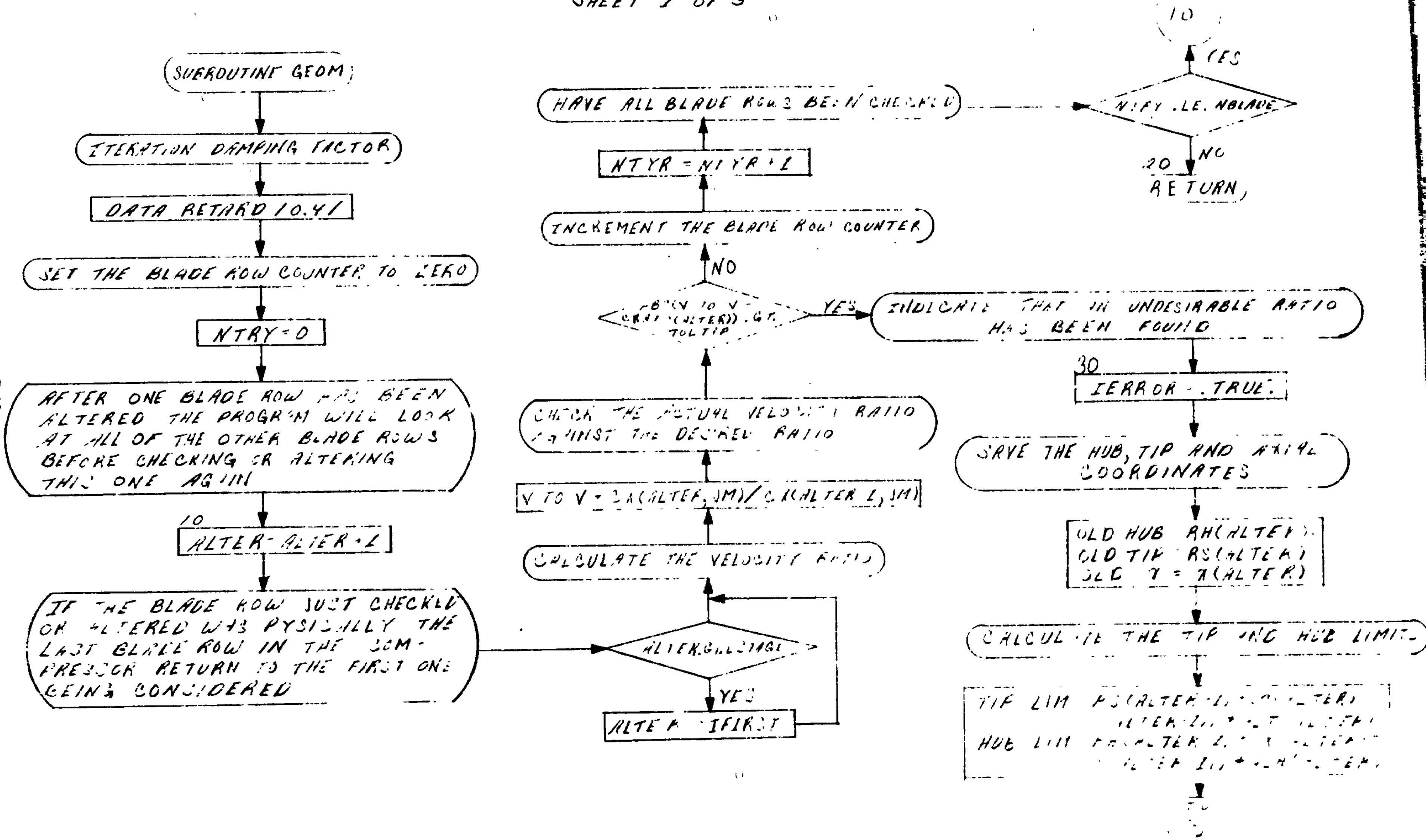
ENTALP

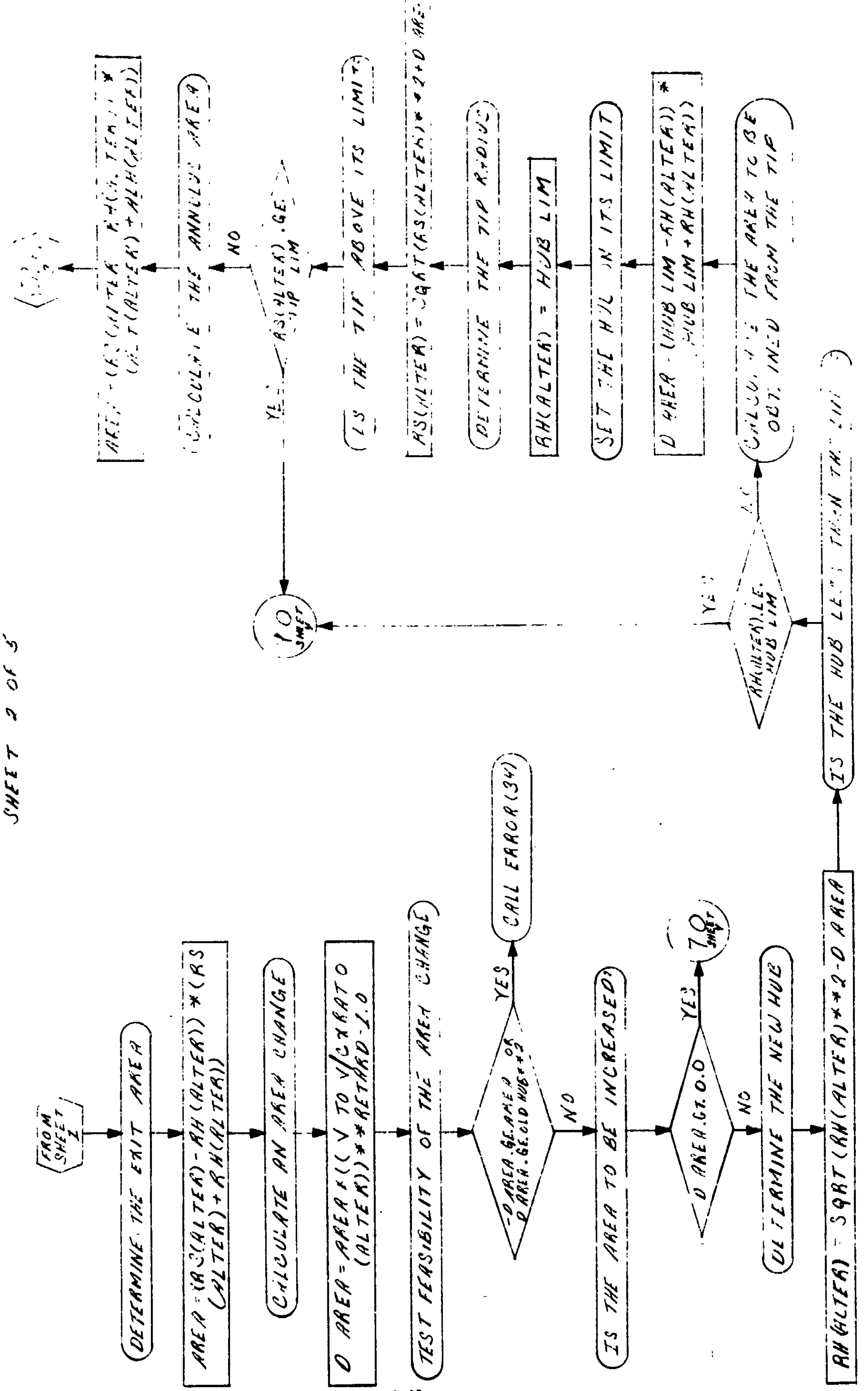

SUBROUTINE ENTALP
CALCULATES THE TEMP. RISE CORRESPONDING TO AN ENTHALPY CHANGE
HOT = THERMI(T)
TSTAT (J) = H/CP(I,J) + T
DO 10
ITER = 1,25
HIT = THERMI (TSTAT (J))
E = H-HIT + HOT
TSTAT(J) = E/CP(1,1) + TSTAT(J)
10
ABS(E) ≤ .01
F
CALL ERROR(P)
T
RETURN

GAM

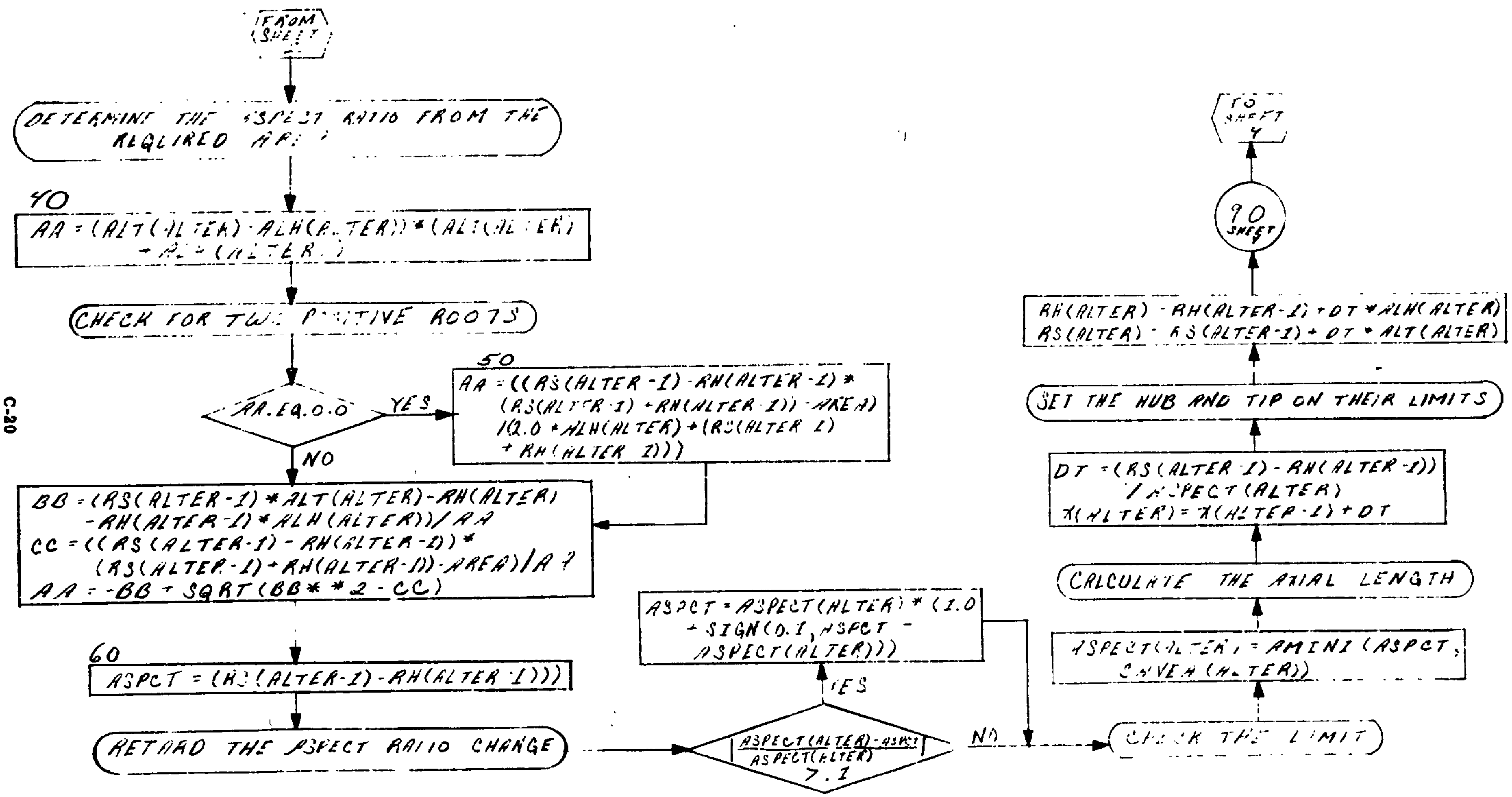

SUBROUTINE GAM
CALCULATES THE RATIO OF SPECIFIC HEATS
A = CPCΘ(1) + (CPCΘ(2) + (CPCΘ(3) + (CPCΘ(4) + (CPCΘ(5) + CPCΘ(6) * TSTAT(J)) * TSTAT(J)) * TSTAT(J)) * TSTAT(J)) * TSTAT(J))
GAMMER = A /(A-DCP)
RETURN

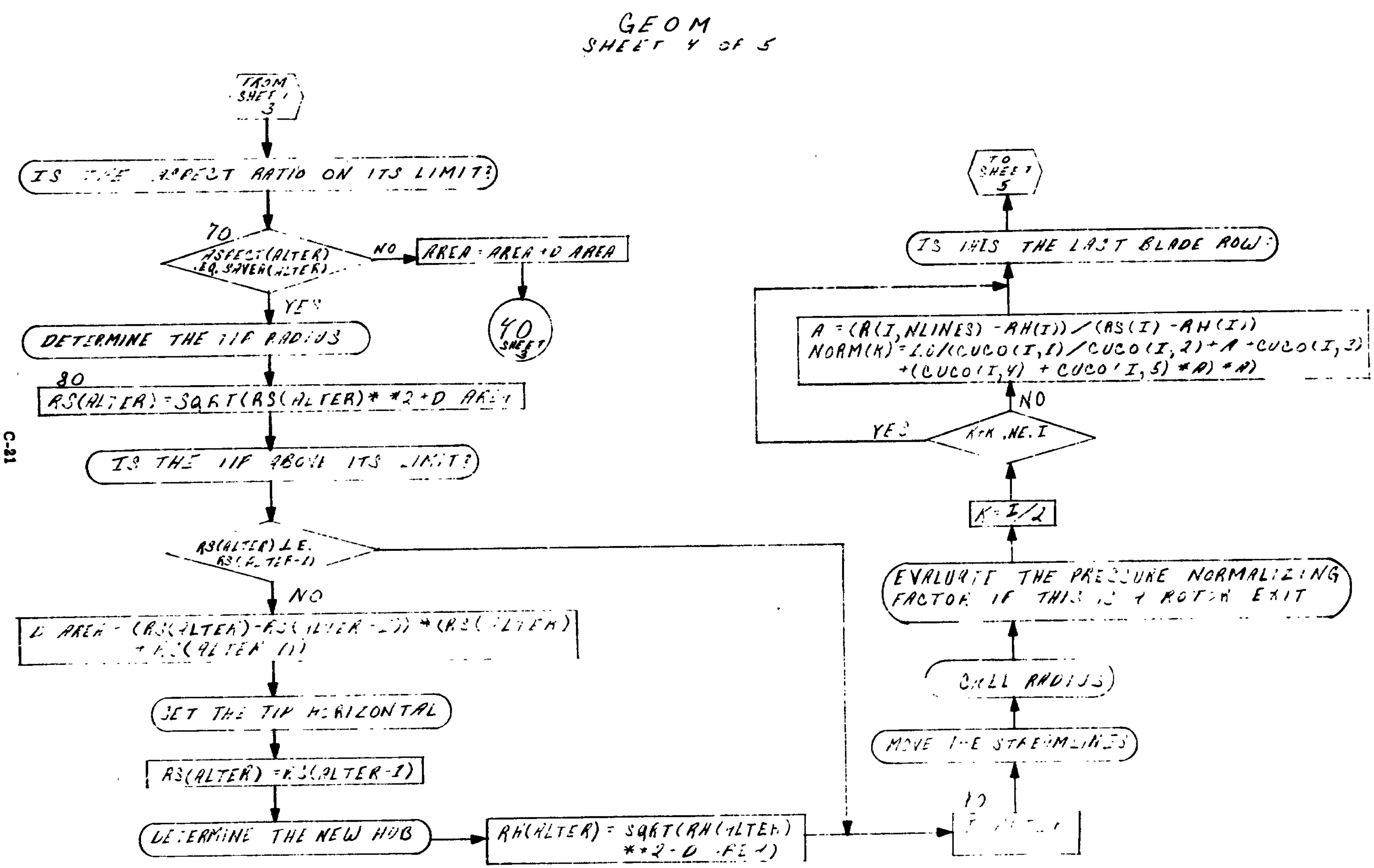
GEOM
SHEET 1 OF 5



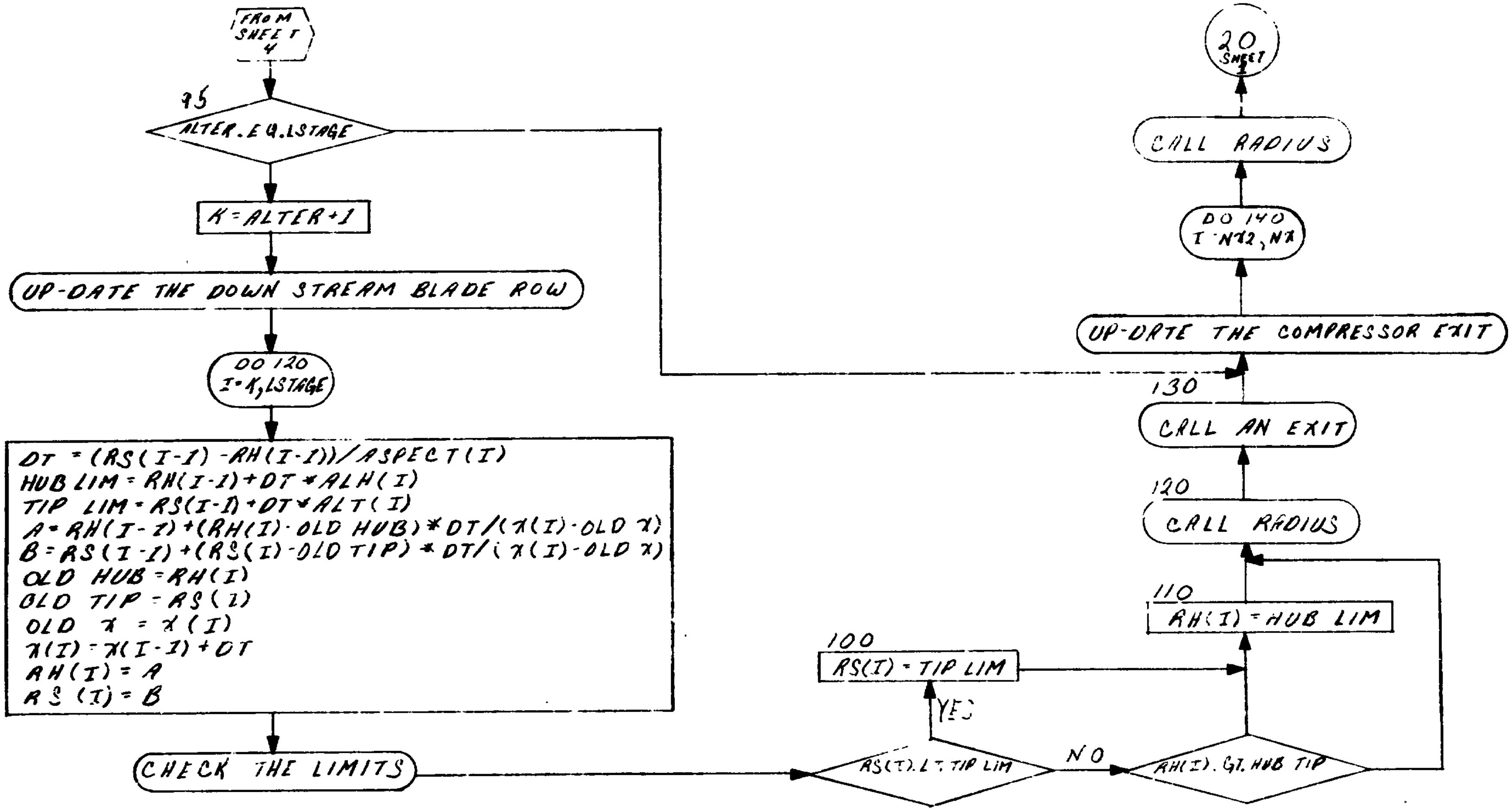

GEOM
SHEET 2 OF 5
FROM SHEET 1
DETERMINE THE EXIT AREA
AREA=(RS(ALTER)-RH(ALTER))*(RS(ALTER)+RH(ALTER))
CALCULATE AN AREA CHANGE
D AREA=AREA*((V TO V/CXRATO(ALTER))**RETARD-1.0
TEST FEASIBILITY OF THE AREA CHANGE
-D AREA.GE.AREA OR D AREA.GE.OLD HUB**2
YES
CALL ERROR(34)
NO
IS THE AREA TO BE INCREASED
D AREA.GT.0.0
YES
NO
DETERMINE THE NEW HUB
RH(ALTER)=SQRT(RH(ALTER)**2-D AREA
IS THE HUB LESS THAN THE LIMIT
RH(ALTER).LE.HUB LIM
YES
NO
CALCULATE THE AREA TO BE OBTAINED FROM THE TIP
D AREA=(HUB LIM-RH(ALTER))*(HUB LIM+RH(ALTER))
SET THE HUB AT ITS LIMIT
RH(ALTER)=HUB LIM
DETERMINE THE TIP RADIUS
RS(ALTER)=SQRT(RS(ALTER)**2+D AREA
IS THE TIP ABOVE ITS LIMIT
RS(ALTER).GE.TIP LIM
YES
NO
CALCULATE THE ANNULUS AREA
AREA=(RS(ALTER)-RH(ALTER))*(RS(ALTER)+RH(ALTER))
SHEET

GEOM
SHEET 3 OF 5

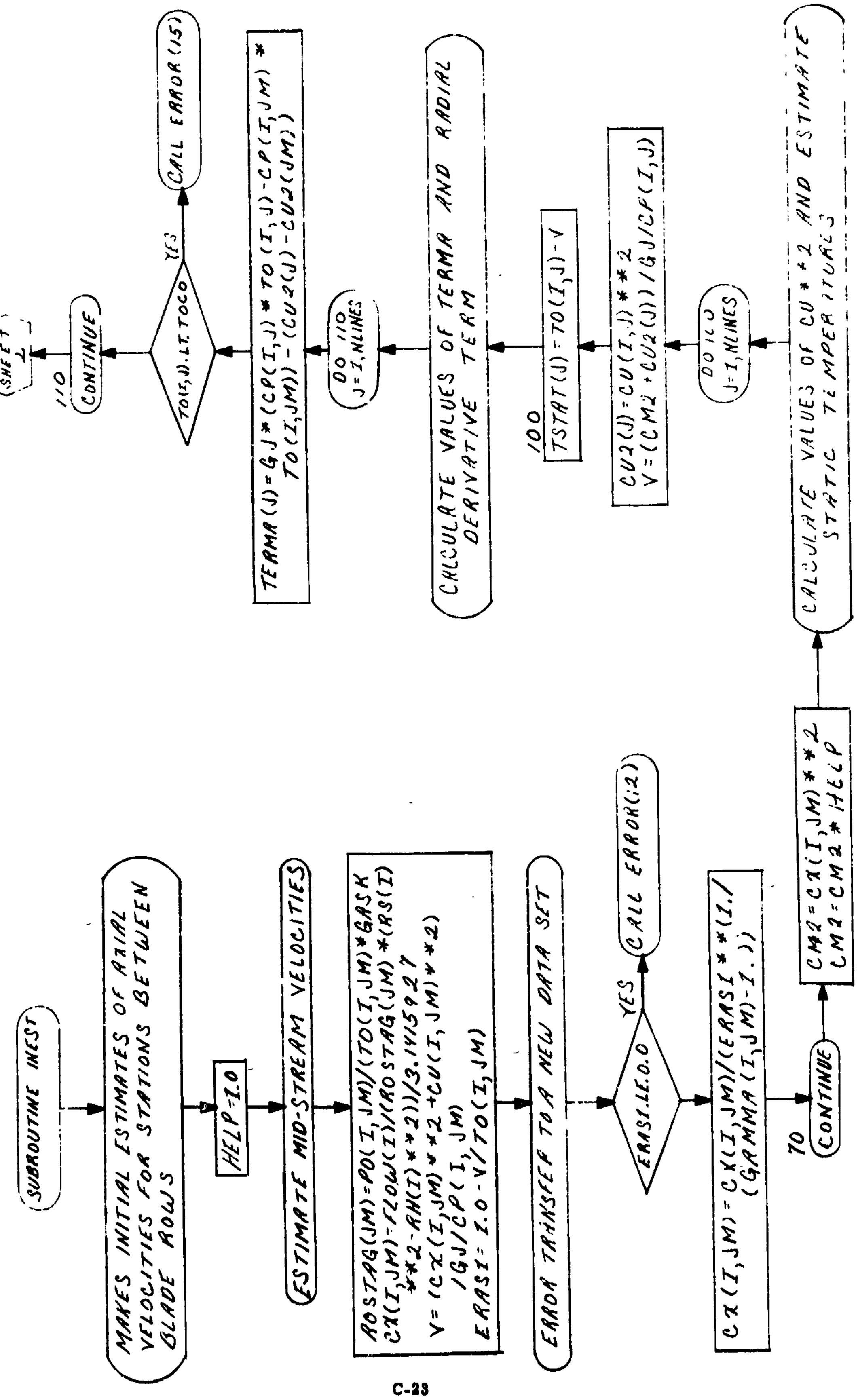



GEOM
SHEET 4 OF 5
FROM SHEET 3
IS THE ASPECT RATIO ON ITS LIMIT?
70
ASPECT(ALTER) .EQ. SAVER(ALTER)
NO
AREA = AREA + D AREA
40 SHEET 3
YES
DETERMINE THE TIP RADIUS
80
RS(ALTER) = SQRT(RS(ALTER)**2 + D AREA)
IS THE TIP ABOVE ITS LIMIT?
RS(ALTER) .LE. RS(ALTER-1)
NO
D AREA = (RS(ALTER) - RS(ALTER-1)) * (RS(ALTER) + RS(ALTER-1))
SET THE TIP HORIZONTAL
RS(ALTER) = RS(ALTER-1)
DETERMINE THE NEW HUB
RH(ALTER) = SQRT(RH(ALTER)**2 - D AREA)
MOVE THE STREAMLINES
CALL RADIUS
EVALUATE THE PRESSURE NORMALIZING FACTOR IF THIS IS A ROTOR EXIT
K = I/2
K*K .NE. I
YES
NO
A = (R(I,NLINES) - RH(I)) / (RS(I) - RH(I))
NORM(K) = 1.0/(CUCO(I,1)/CUCO(I,2) + A * CUCO(I,3) + (CUCO(I,4) + CUCO(I,5) * A) * A)
IS THIS THE LAST BLADE ROW?
TO SHEET 5

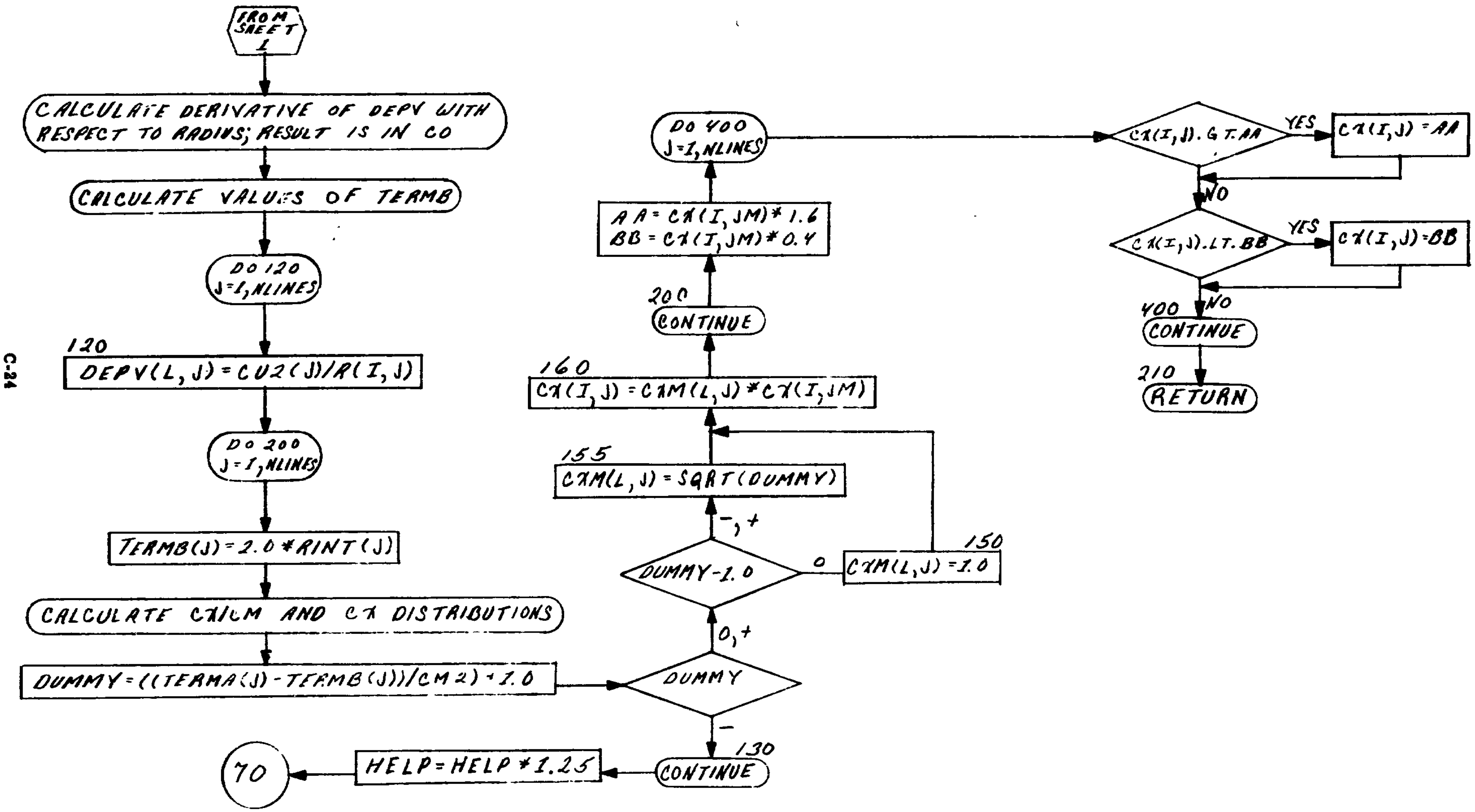
GEOM
SHEET 5 OF 5

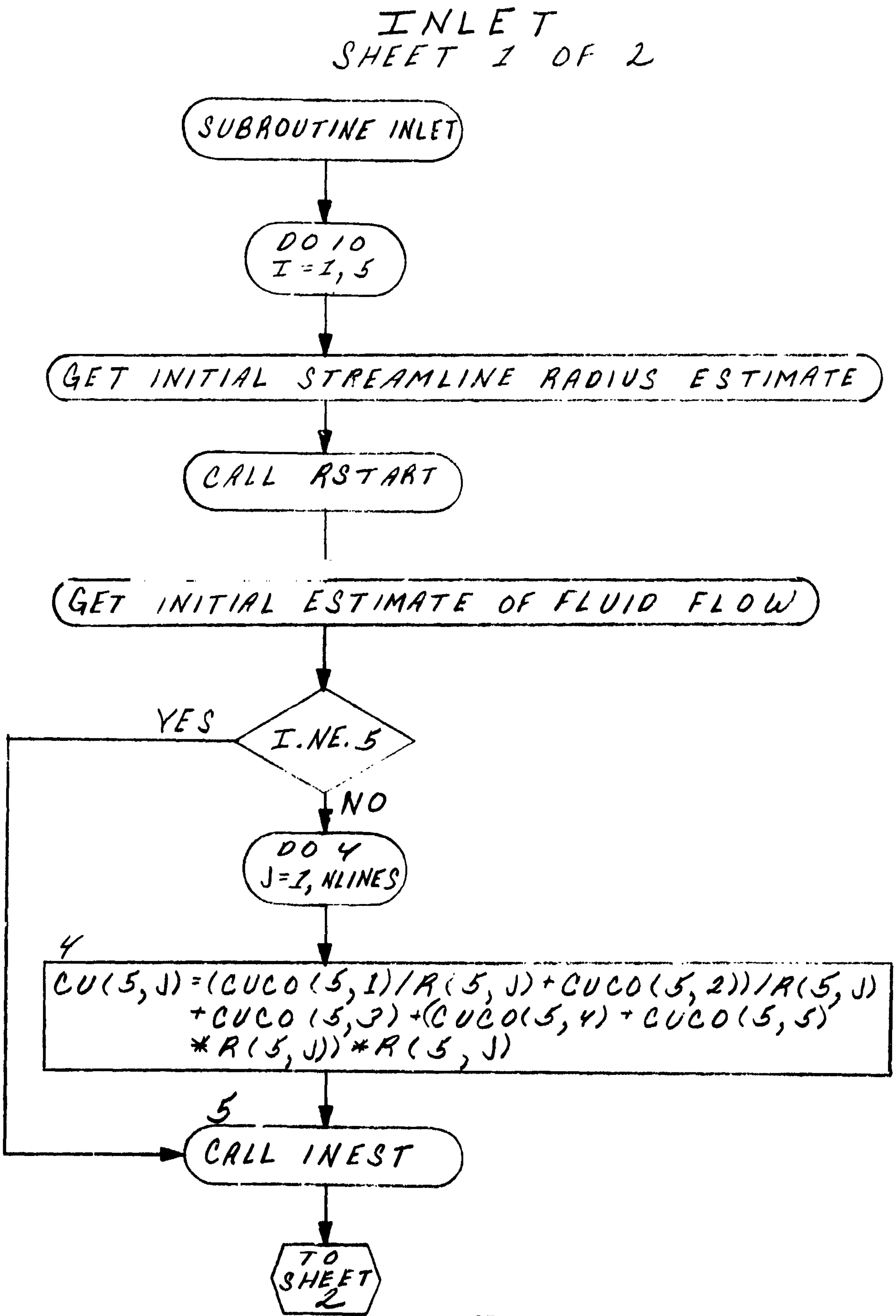


INEST
SHEET 1 OF 2

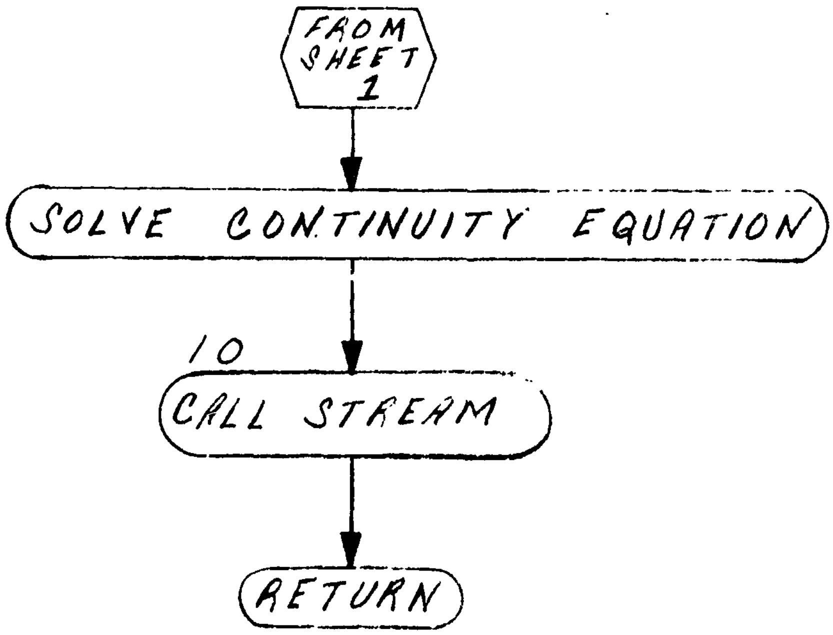


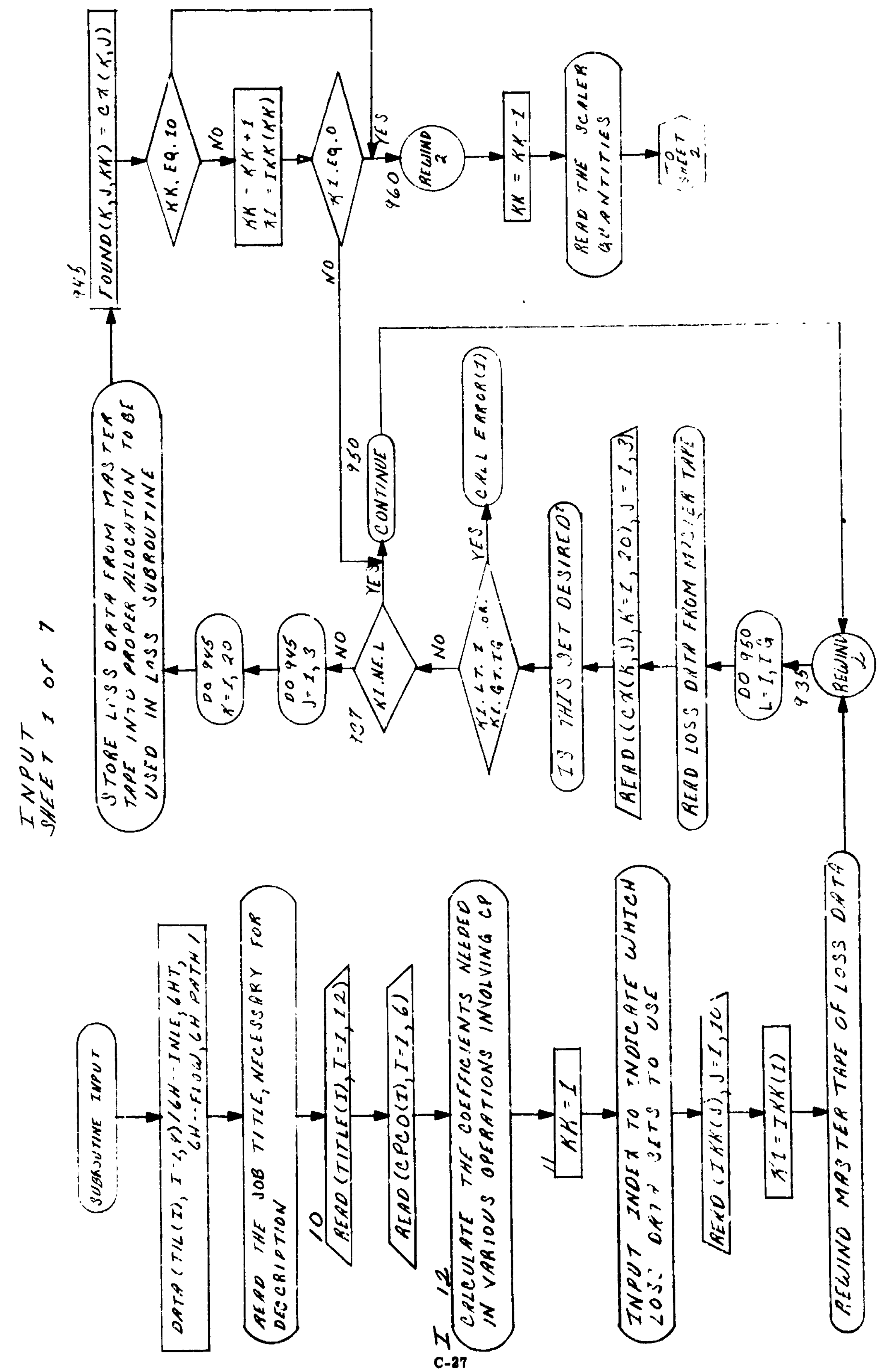
INEST
SHEET 2 OF 2



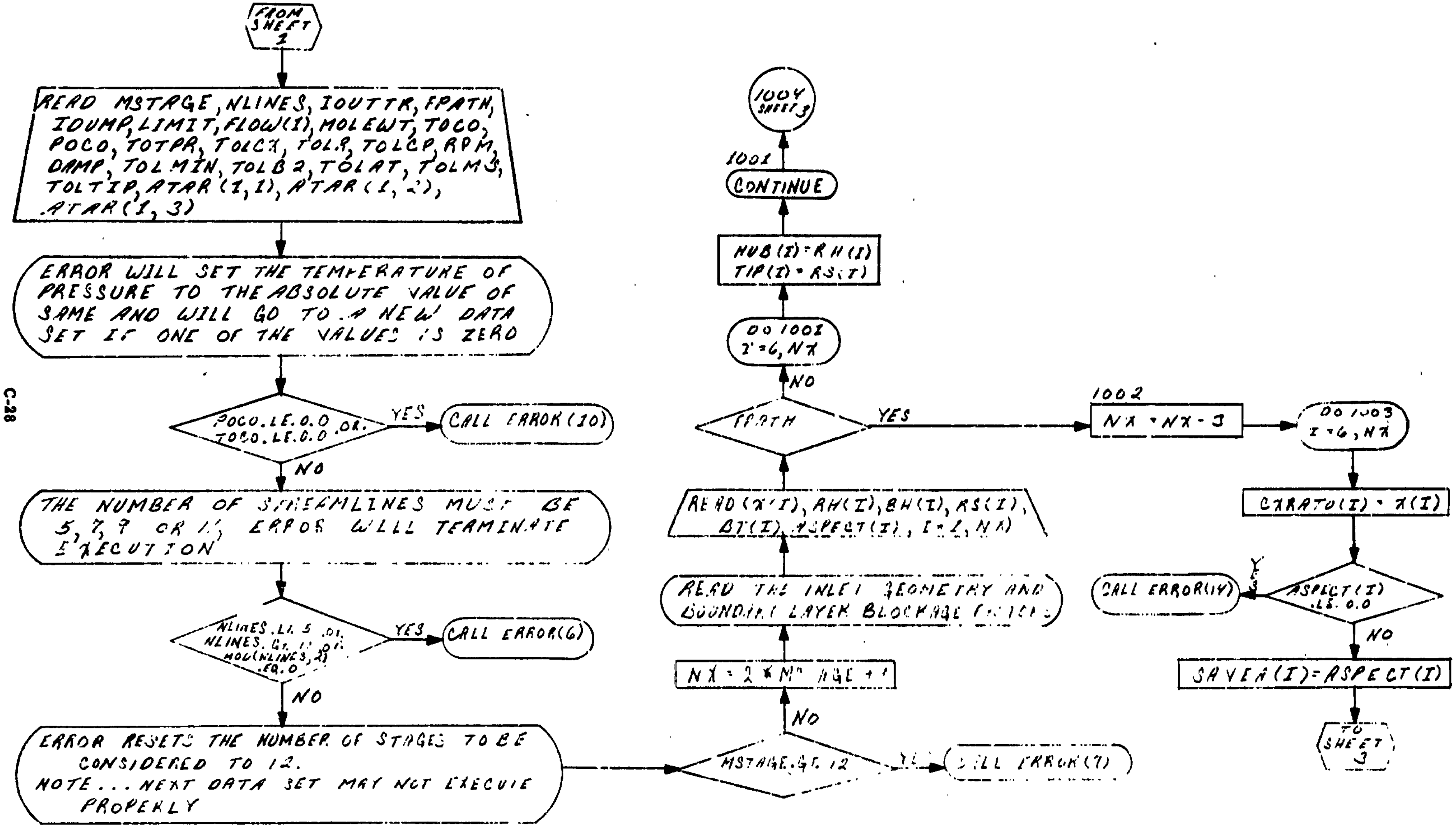

INLET
SHEET 1 OF 2
SUBROUTINE INLET
DO 10
I = 1, 5
GET INITIAL STREAMLINE RADIUS ESTIMATE
CALL RSTART
GET INITIAL ESTIMATE OF FLUID FLOW
YES
I.NE.5
NO
DO 4
J=1, NLINES
4
CU(5, J) = (CUCO(5, 1)/R(5, J) + CUCO(5, 2))/R(5, J)
+ CUCO(5, 3) + (CUCO(5, 4) + CUCO(5, 5)
* R(5, J)) * R(5, J)
5
CALL INEST
TO
SHEET
2

INLET
SHEET 2 OF 2

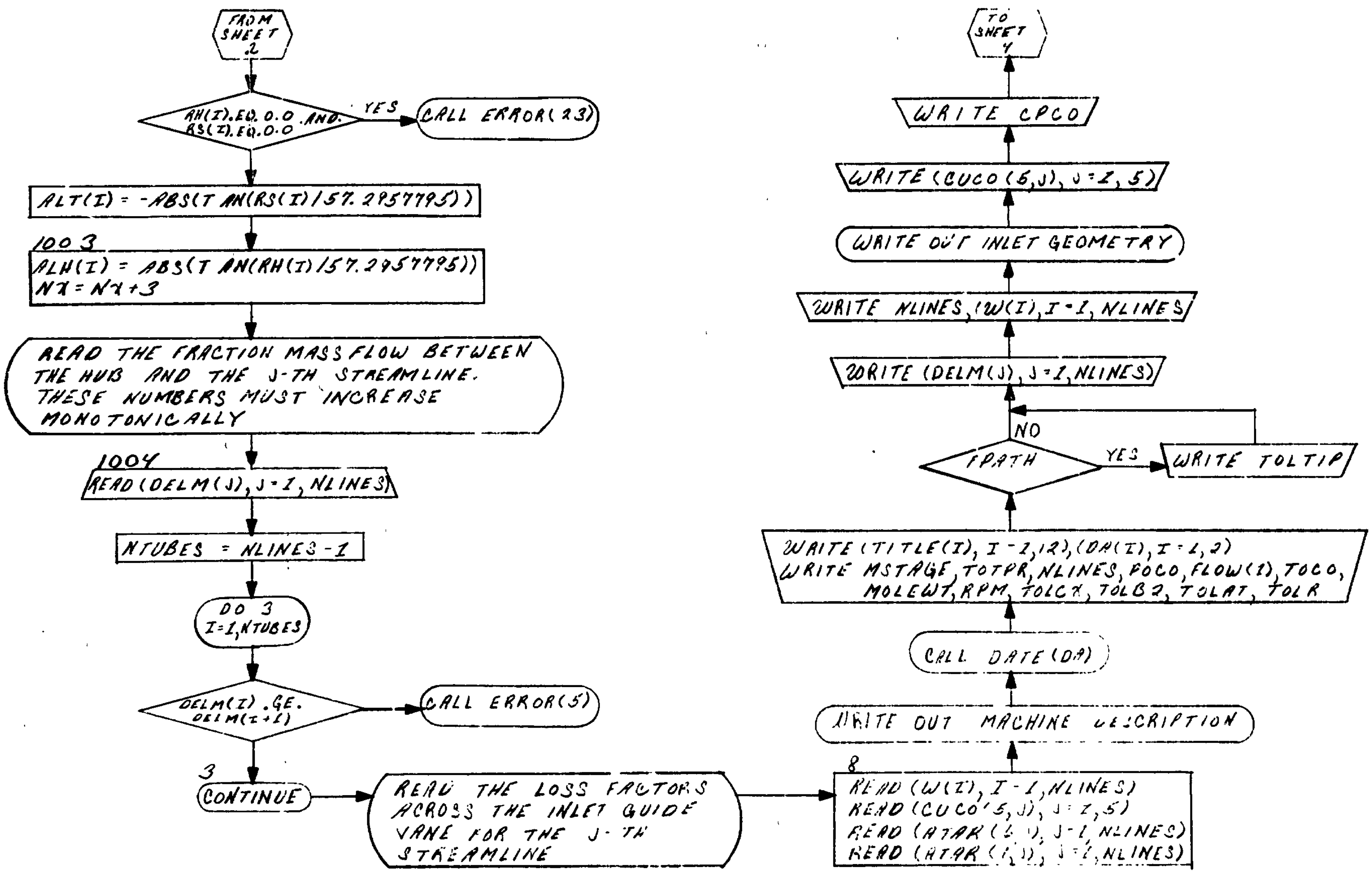



INPUT
SHEET 1 OF 7
SUBROUTINE INPUT
DATA (TIL(I), I=1,9)/6H-INLE,6HT, 6H-FLOW,6H PATH /
10
READ THE JOB TITLE, NECESSARY FOR DESCRIPTION
READ (TITLE(I), I=1,12)
READ (CPCO(I), I=1,6)
12
CALCULATE THE COEFFICIENTS NEEDED IN VARIOUS OPERATIONS INVOLVING CP
11
KK=1
INPUT INDEX TO INDICATE WHICH LOSS DATA SETS TO USE
READ (IKK(J), J=1,10)
K1=IKK(1)
REWIND MASTER TAPE OF LOSS DATA
REWIND 1
935
DO 950 L=1,19
READ LOSS DATA FROM MASTER TAPE
READ ((CX(K,J),K=1,20),J=1,3)
IS THIS SET DESIRED?
K1.LT.1 .OR. K1.GT.19
YES
CALL ERROR(1)
NO
737
K1.NE.L
YES
950
CONTINUE
NO
DO 945 J=1,3
DO 945 K=1,20
STORE LOSS DATA FROM MASTER TAPE INTO PROPER ALLOCATION TO BE USED IN LOSS SUBROUTINE
945
FOUND(K,J,KK) = CX(K,J)
KK.EQ.10
NO
KK=KK+1
K1=IKK(KK)
K1.EQ.0
NO
YES
960
REWIND 2
KK=KK-1
READ THE SCALER QUANTITIES
TO SHEET 2

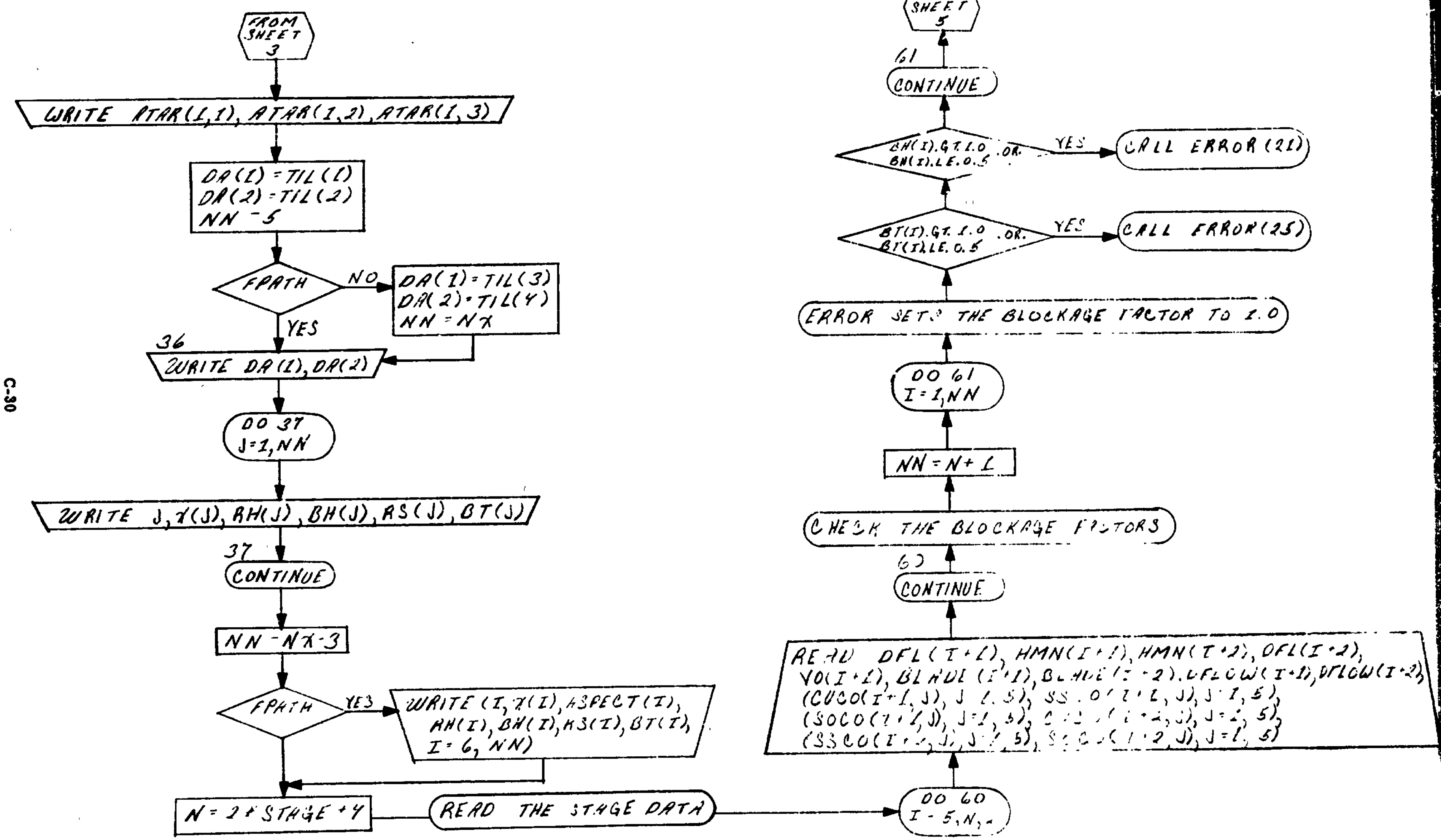
INPUT
SHEET 2 OF 7



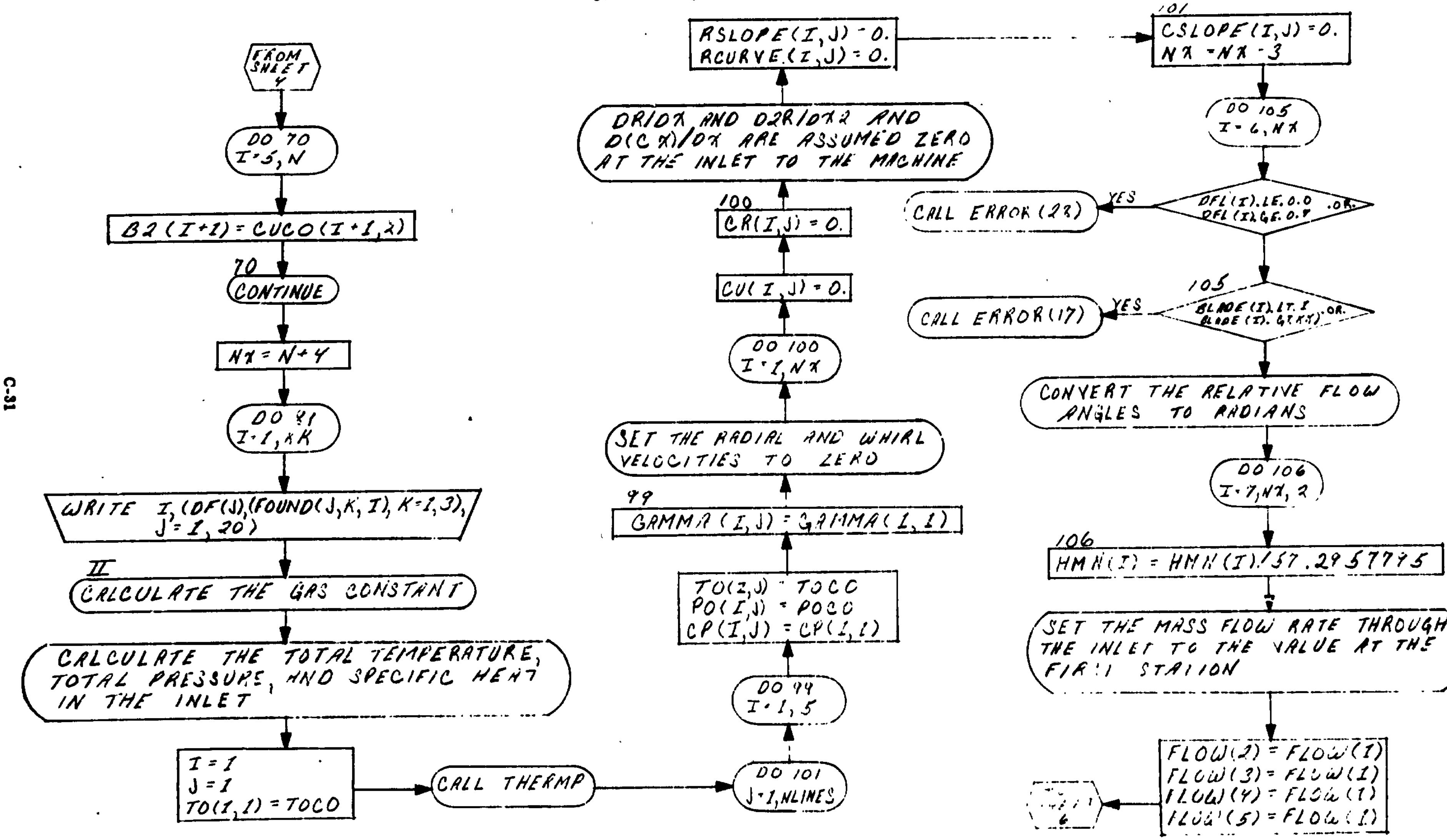
INPUT
SHEET 3 OF 7

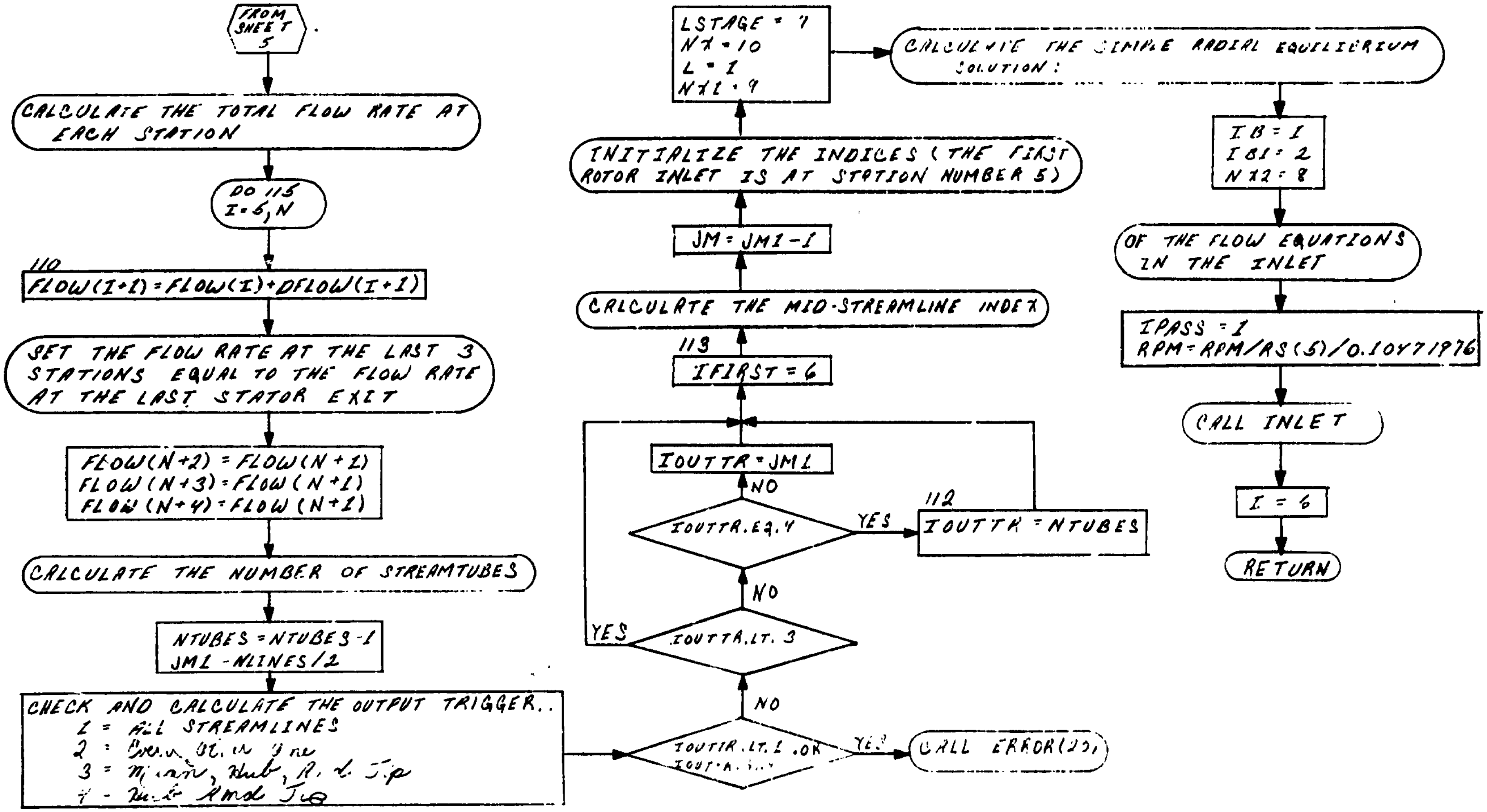


INPUT
SHEET 4 OF 7



INPUT
SHEET 5 OF 7




FROM SHEET 5
CALCULATE THE TOTAL FLOW RATE AT EACH STATION
DO 115 I=6,N
110
FLOW(I+1)=FLOW(I)+DFLOW(I+1)
SET THE FLOW RATE AT THE LAST 3 STATIONS EQUAL TO THE FLOW RATE AT THE LAST STATOR EXIT
FLOW(N+2)=FLOW(N+1)
FLOW(N+3)=FLOW(N+1)
FLOW(N+4)=FLOW(N+1)
CALCULATE THE NUMBER OF STREAMTUBES
NTUBES=NTUBES-1
JML-NLINES/2
CHECK AND CALCULATE THE OUTPUT TRIGGER..
1 = ALL STREAMLINES
NO
IOUTTR.LT.3
YES
NO
IOUTTR.EQ.4
YES
112
IOUTTR=NTUBES
NO
IOUTTR=JML
113
IFIRST=6
CALCULATE THE MID-STREAMLINE INDEX
JM=JML-1
INITIALIZE THE INDICES (THE FIRST ROTOR INLET IS AT STATION NUMBER 5)
LSTAGE=7
NX=10
L=1
NXL=9
SOLUTION:
IB=1
IB1=2
NX2=8
OF THE FLOW EQUATIONS IN THE INLET
IPASS=1
RPM=RPM/RS(5)/0.10471976
CALL INLET
I=6
RETURN

DIV. ALLISON GMC.	REPORT NO.	PAGE	JOB NO.	PAGE
TITLE		PREPARED		DATE
INPUT SHEET 7 OF 7		CHECKED		
		APPROVED		

```
I.  CPO2=CPCO(3)/2.
    CPO3=CPCO(4)/3.
    CPO4=CPCO(5)/4.
    CPO5=CPCO(6)/5.
    A1OAO=CPCO(2)/CPCO(1)
    A2O2AO=CPO2/CPCO(1)
    A3O3AO=CPO3/CPCO(1)
    A4O4AO=CPO4/CPCO(1)
    A5O5AO=CPO5/CPCO(1)
    COINTG=THERM3(518.688)
    CPI2=CPCO(2)/2.
    CPI3=CPCO(3)/3.
    CPI4=CPCO(4)/4.
    CPI5=CPCO(5)/5.
    CPI6=CPCO(6)/6.

II. GASK=G/MOLEWT
    DCP=GASK/JOULE
    GR=67.348*GASK
    GR2=GR*.5
```

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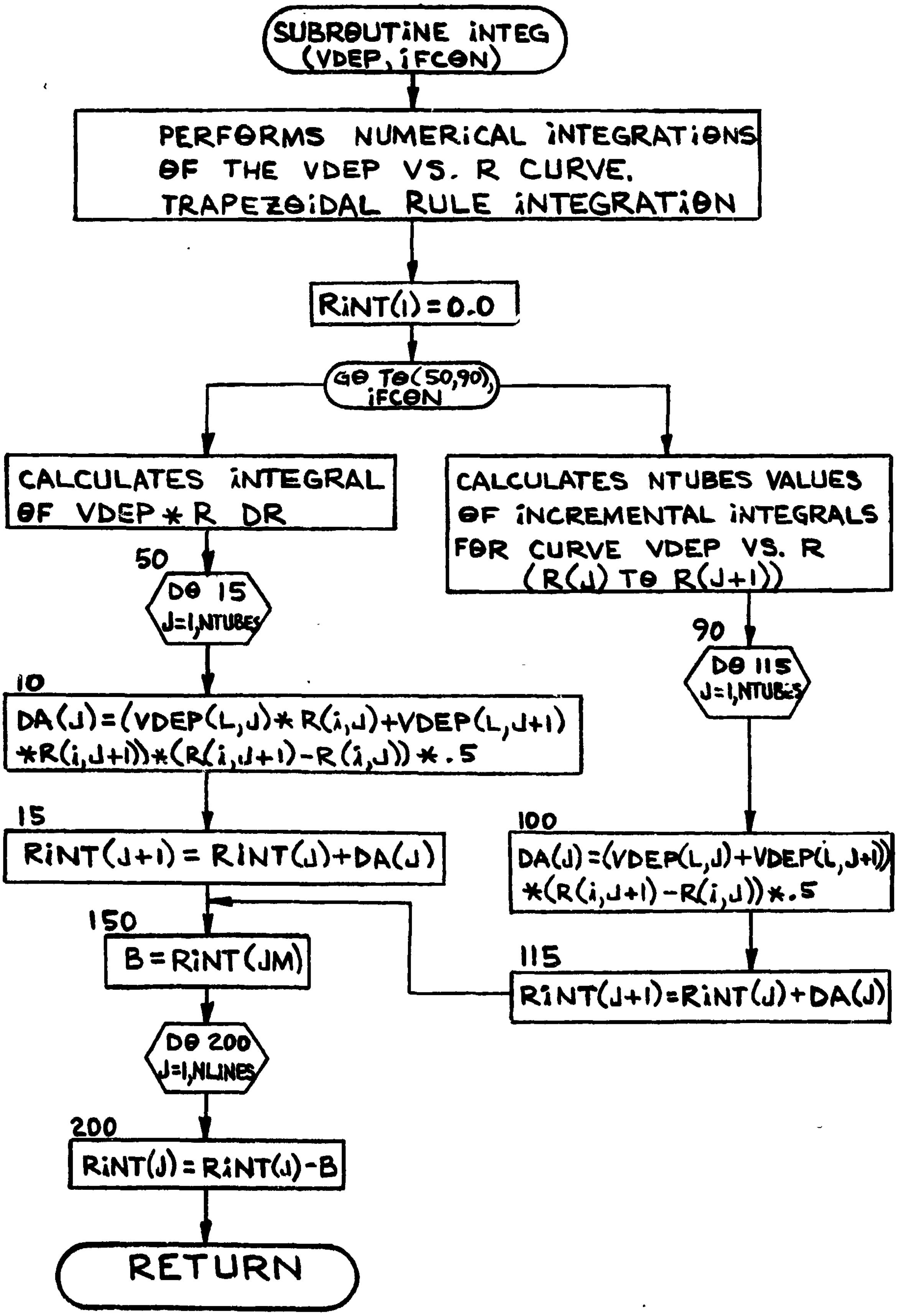
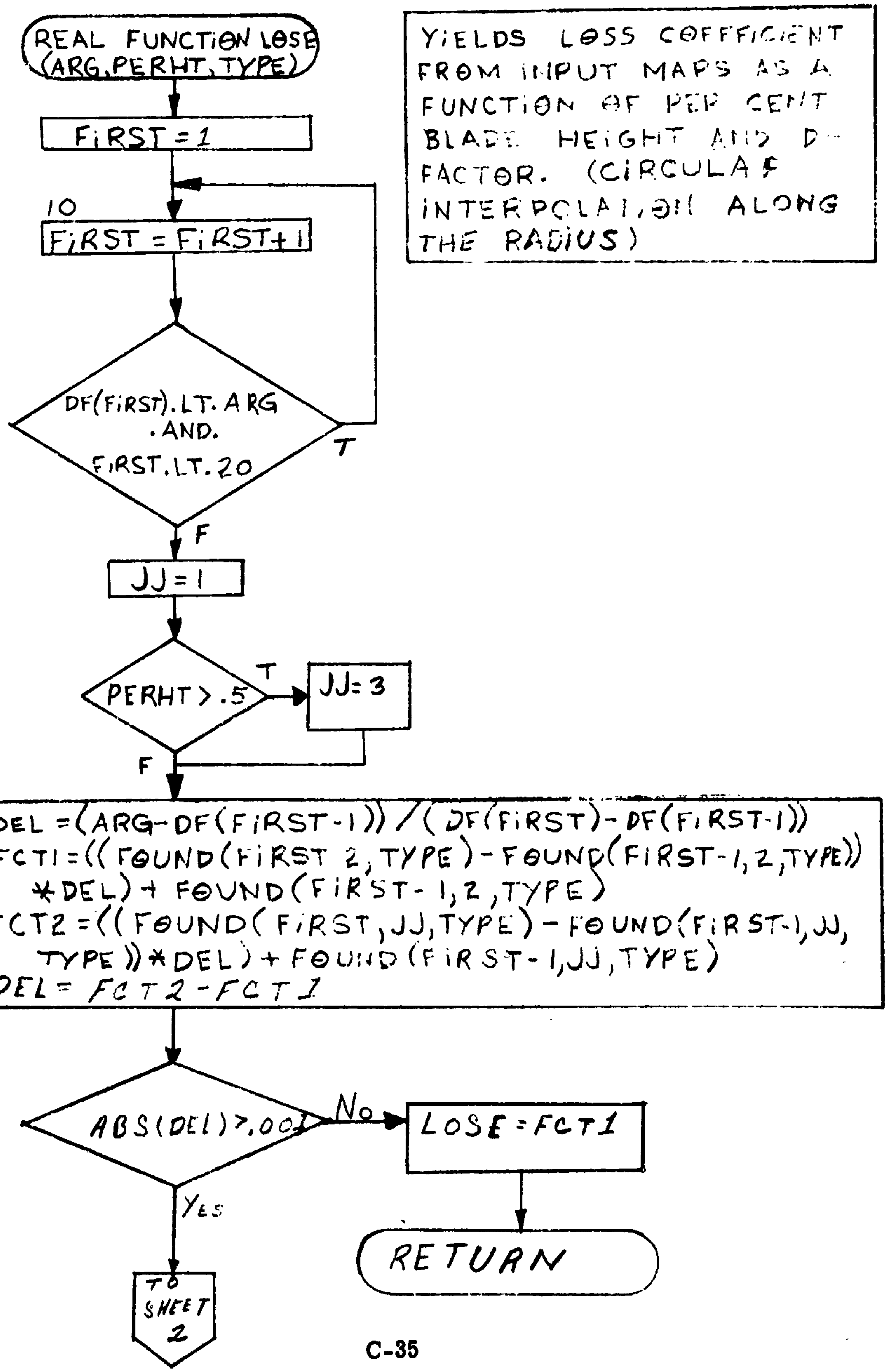
FORM 1877 REV. 7-57

INTEG S.R.


SUBROUTINE INTEG (VDEP, IFCON)
PERFORMS NUMERICAL INTEGRATIONS OF THE VDEP VS. R CURVE. TRAPEZOIDAL RULE INTEGRATION
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))*.5
15
RINT(J+1) = RINT(J)+DA(J)
150
B=RINT(JM)
DO 200 J=1,NLINES
200
RINT(J)=RINT(J)-B
RETURN
CALCULATES NTUBES VALUES OF INCREMENTAL INTEGRALS FOR CURVE VDEP VS. R (R(J) TO R(J+1))
90
DO 115 J=1,NTUBES
100
DA(J)=(VDEP(L,J)+VDEP(L,J+1)) *(R(I,J+1)-R(I,J))*.5
115
RINT(J+1)=RINT(J)+DA(J)

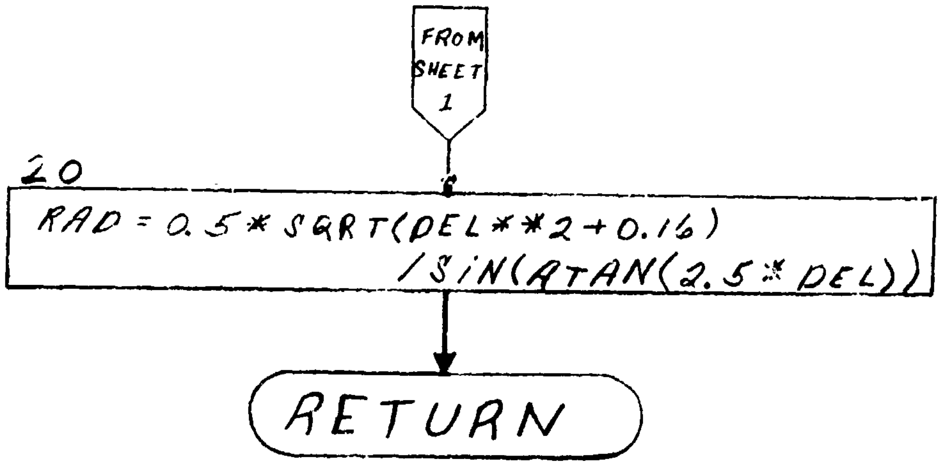
LOSE FUNCTION

PAGE 1 OF 2

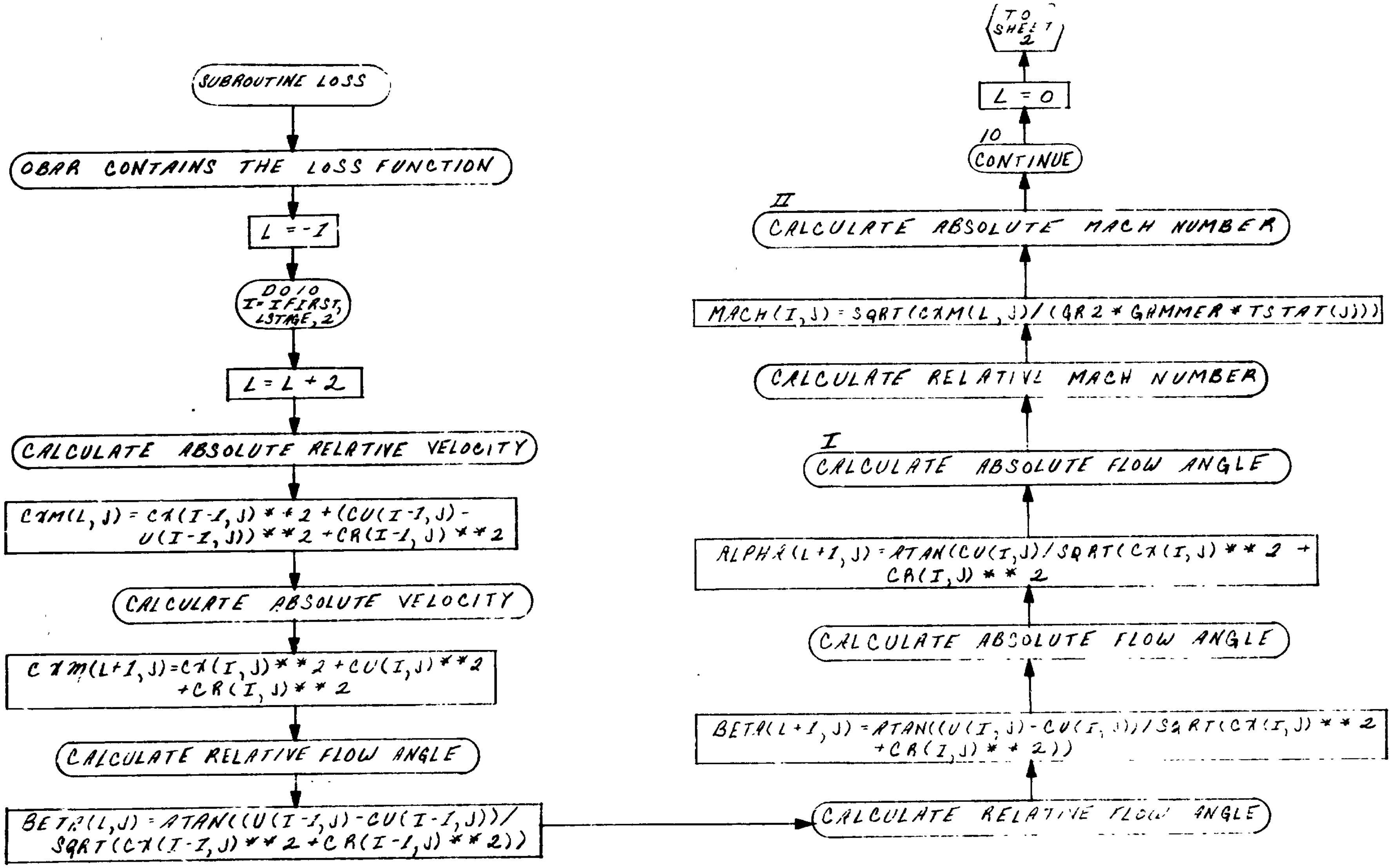


LOSE FUNCTION

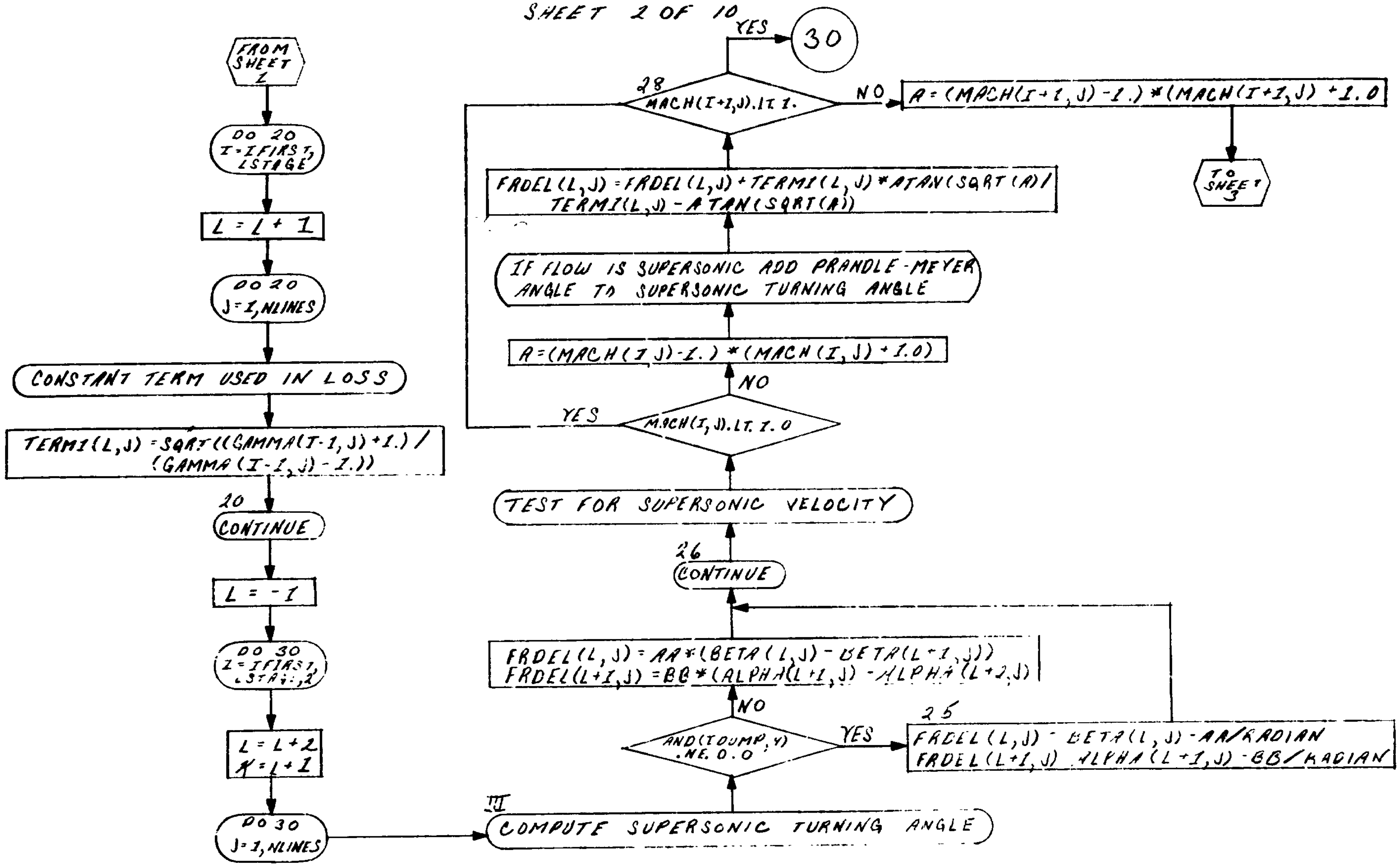
PAGE 2 OF 2



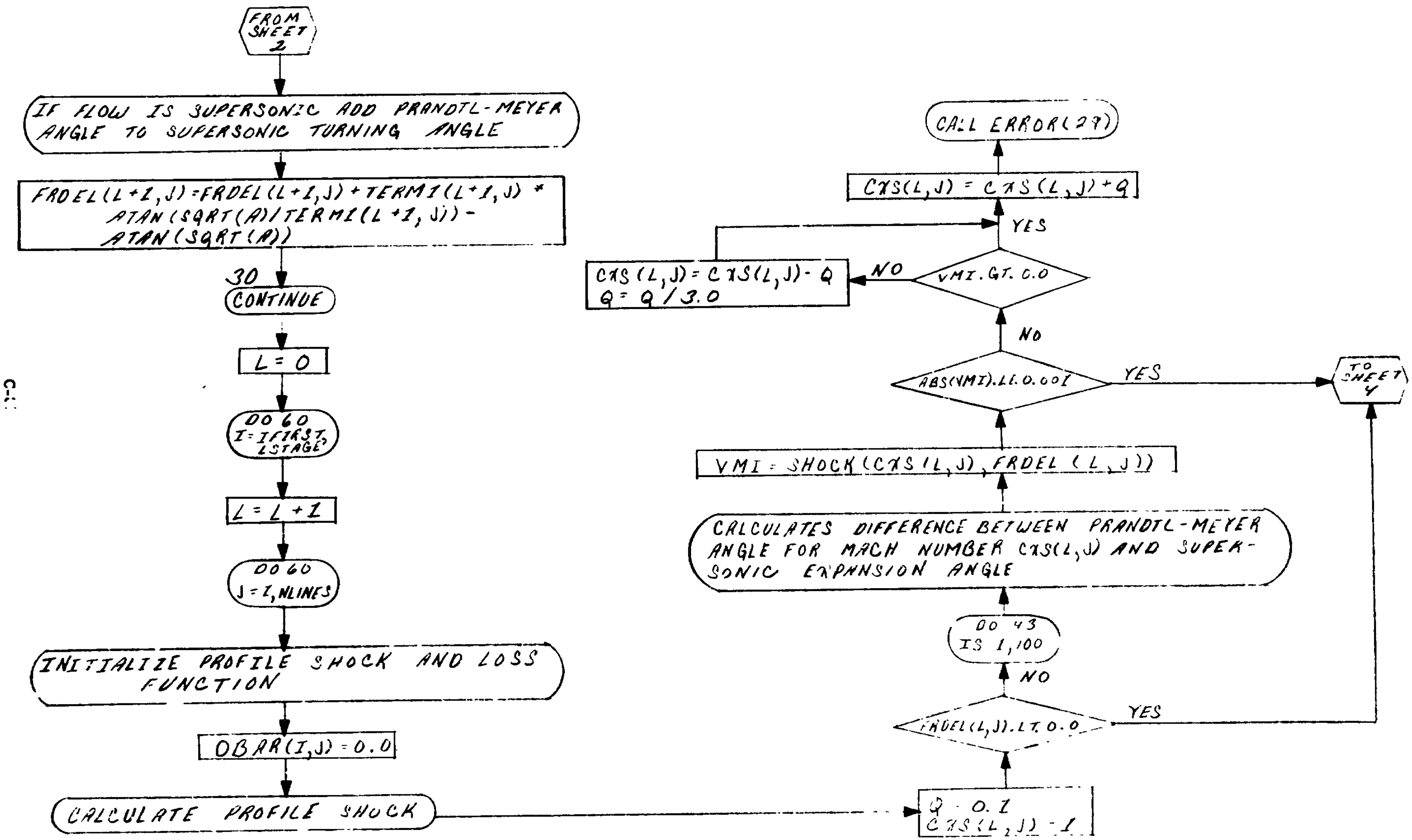
LOSS
SHEET 1 OF 10



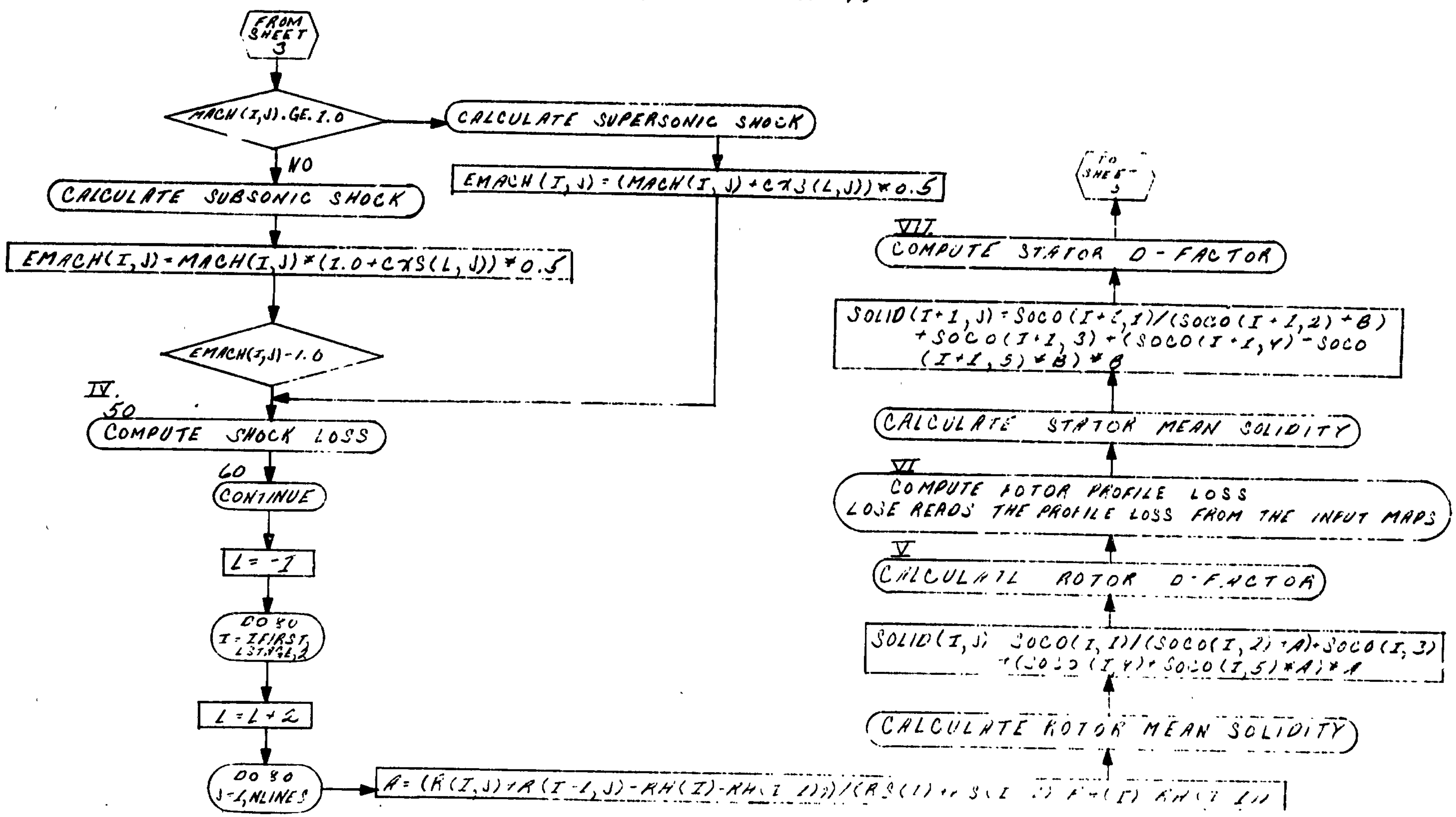
LOSS
SHEET 2 OF 10



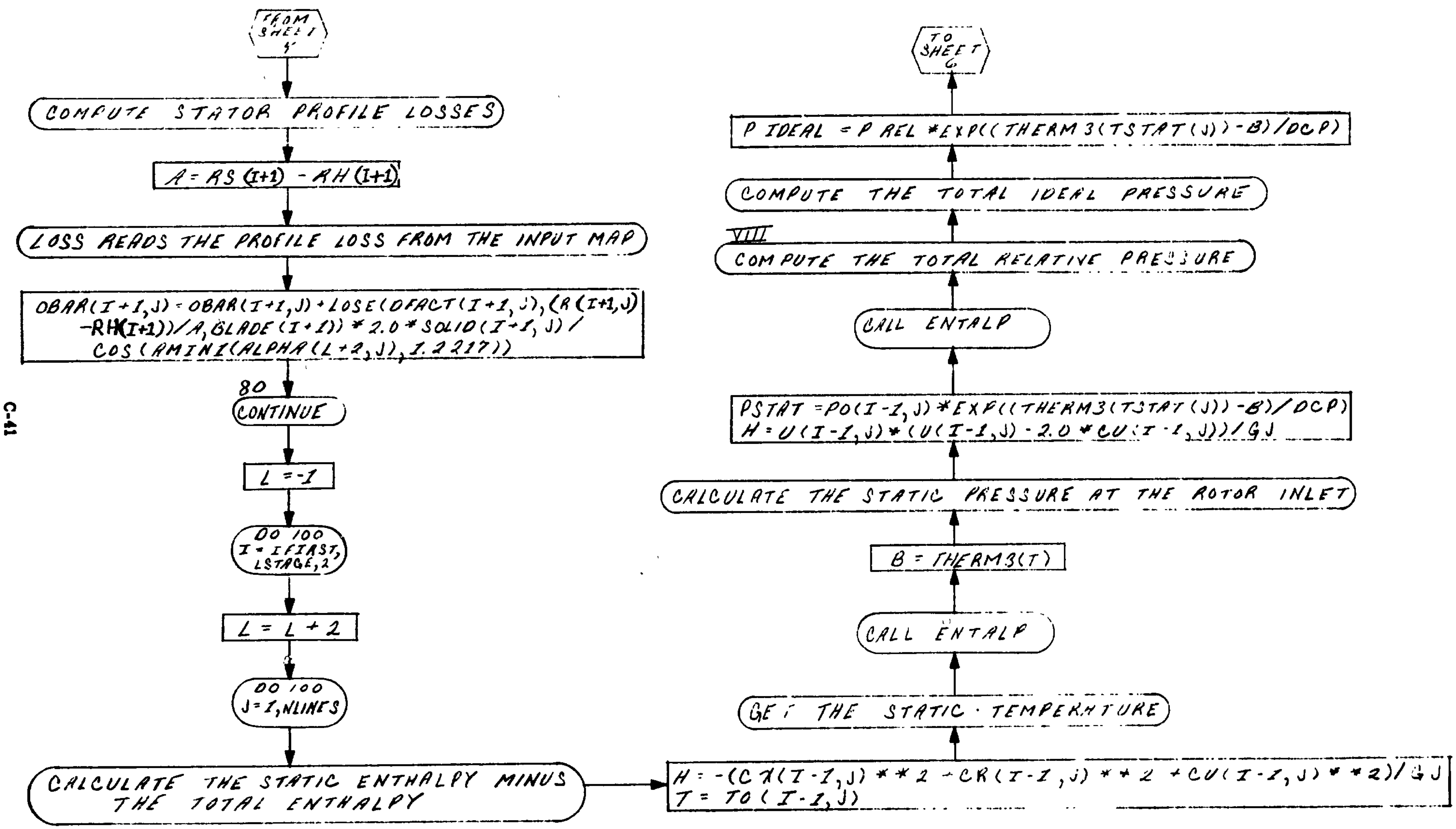
LOSS
SHEET 3 OF 10



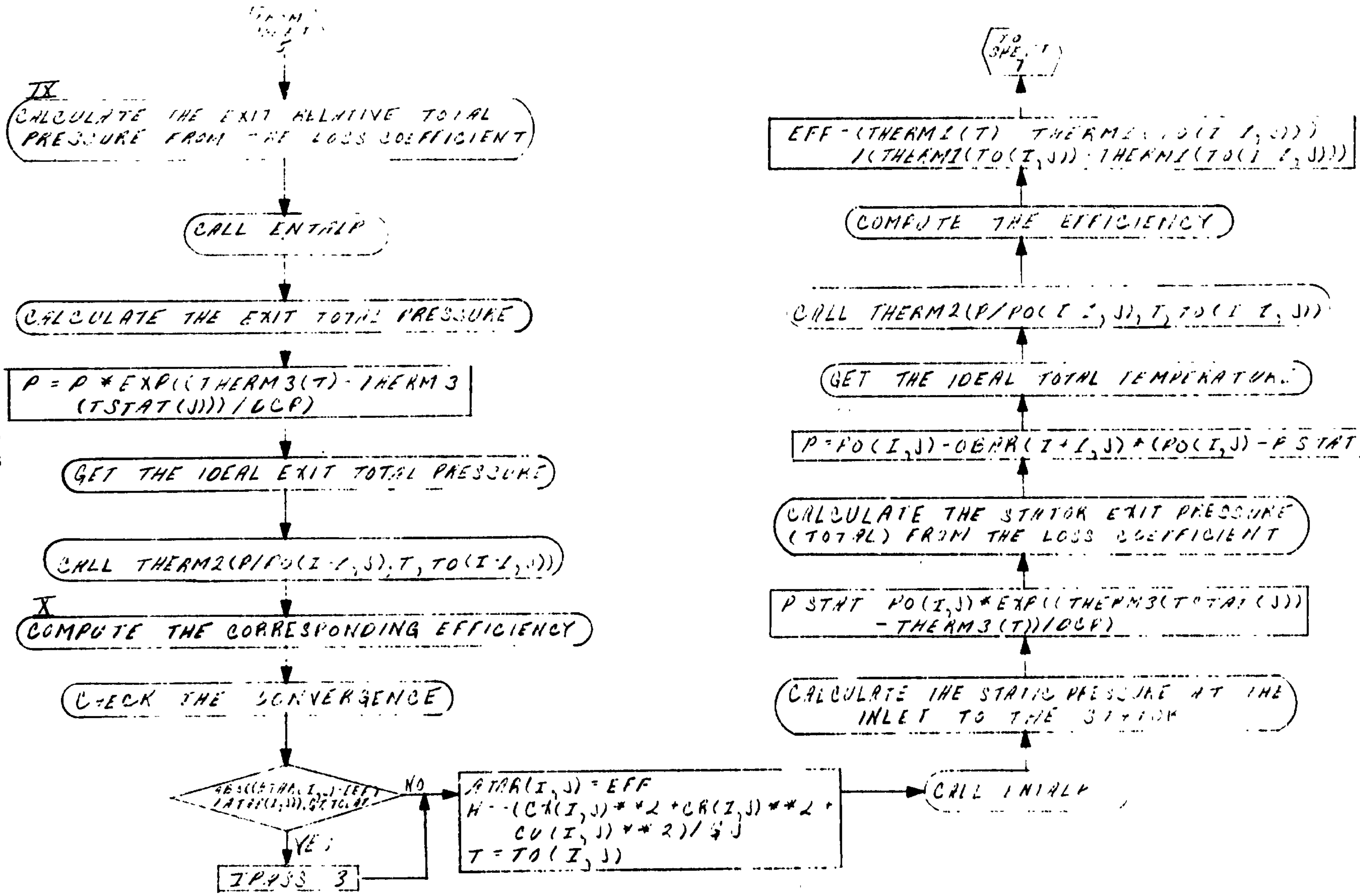
LOSS
SHEET 4 of 10

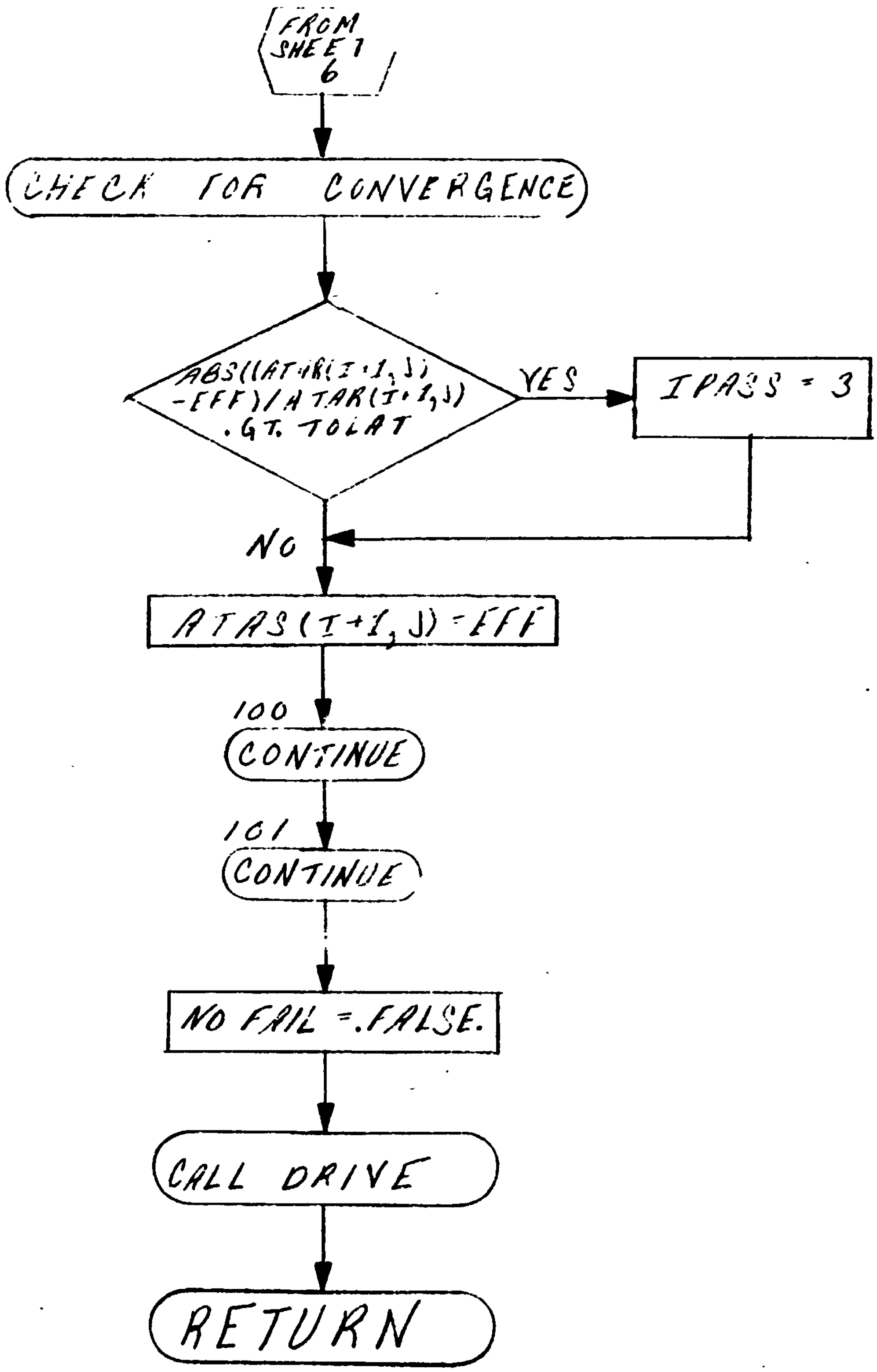


LOSS
SHEET 5 OF 10



LOSS
SHEET 6 OF 12




FROM SHEET 6
CHECK FOR CONVERGENCE
ABS((ATAR(I+1,J)-EFF)/ATAR(I+1,J)) .GT. TOLAT
YES
IPASS = 3
NO
ATAS(I+1, J) = EFF
100
CONTINUE
101
CONTINUE
NO FAIL = .FALSE.
CALL DRIVE
RETURN

DIV. ALLISON GMC.	REPORT NO.	PAGE	JOB NO	PAGE
TITLE LOSS SHEET 8 OF 10		PREPARED		DATE
		CHECKED		
		APPROVED		

```
I.   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=TO(I-1,J)
     CALL ENTALP
     CALL GAM

II.  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)))

III. A=(R(I,J)+R(I-1,J)-RH(I)-RH(I-1))/
      (RS(I)+RS(I-1)-RH(I)-RH(I-1))
     B=(R(I,J)+R(I-1,J)-RH(I)-RH(I+1))/
      (RS(I)+RS(I+1)-RH(I)-RH(I-1))
     AR=(SSCO(I,1)/(SSCO(I,2)+A)+
        SSCO(I,3)+(SSCO(I,4)+SSCO(I,5)
        *A)*A)
     BB=SSCO(I+1,1)/(SSCO(I+1,2)+B+
        SSCO(I+1,3)+(SSCO(I+1,4)+
        SSCO(I+1,5)*B)*B

IV.  OBAR(I,J)=(1.0-(((GAMMA(I-1,J)+1.0)*0.5
      *EMACH(I,J)**2)/(1.0+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)/(GAMMA
      (I-1,J)+1.0))**(1.0/(1.0-GAMMA
      (I-1,J)))/(1.0-1.0/(1.0+(GAMMA
```

FORM 1877 REV. 7-67

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```
     (I-1,J)-1.0)*MACH(I,J)**2*0.5)
     **(GAMMA(I-1,J)/(GAMMA(I-1,J)
     -1.0)))

V.   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))
        /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)

VI   OBAR(I,J)=OBAR(I,J)+LOSE(DFACT(I,J),
        (R(I,J)-RH(I) )/A,BLADE(I))*2.0
        *SOLID(I,J)/COS(AMIN1(BETA(L+1,J),
        1.2217))
     A=(R(I+1,J)+R(I,J))*.5
     B=(R(I,J)+R(I+1,J)-RH(I)-RH(I+1))/
        (RS(I)+RS(I+1)-RH(I)-RH(I+1))

VII  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))/
        AA+(CU(I,J)-CU(I+1,J))/2./
        SOLID(I+1,J)/AA

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

IX.  P=PIDEAL-OBAR(I,J)*(PREL-PSTAT)
     H=-U(I,J)*(2.0*CU(I,J)-U(I,J))/GJ
     T=TO(I,J)
```

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TITLE LOSS SHEET 10 OF 10		PREPARED		DATE
		CHECKED		
		APPROVED		

```
X.  EFF =(THERM1(T) - THERM1(TO(I-1, J)))
        /(THERM1(TO(I, J)) - THERM1 (TO
        (I-1, J)))
    PO(I, J) = P
```

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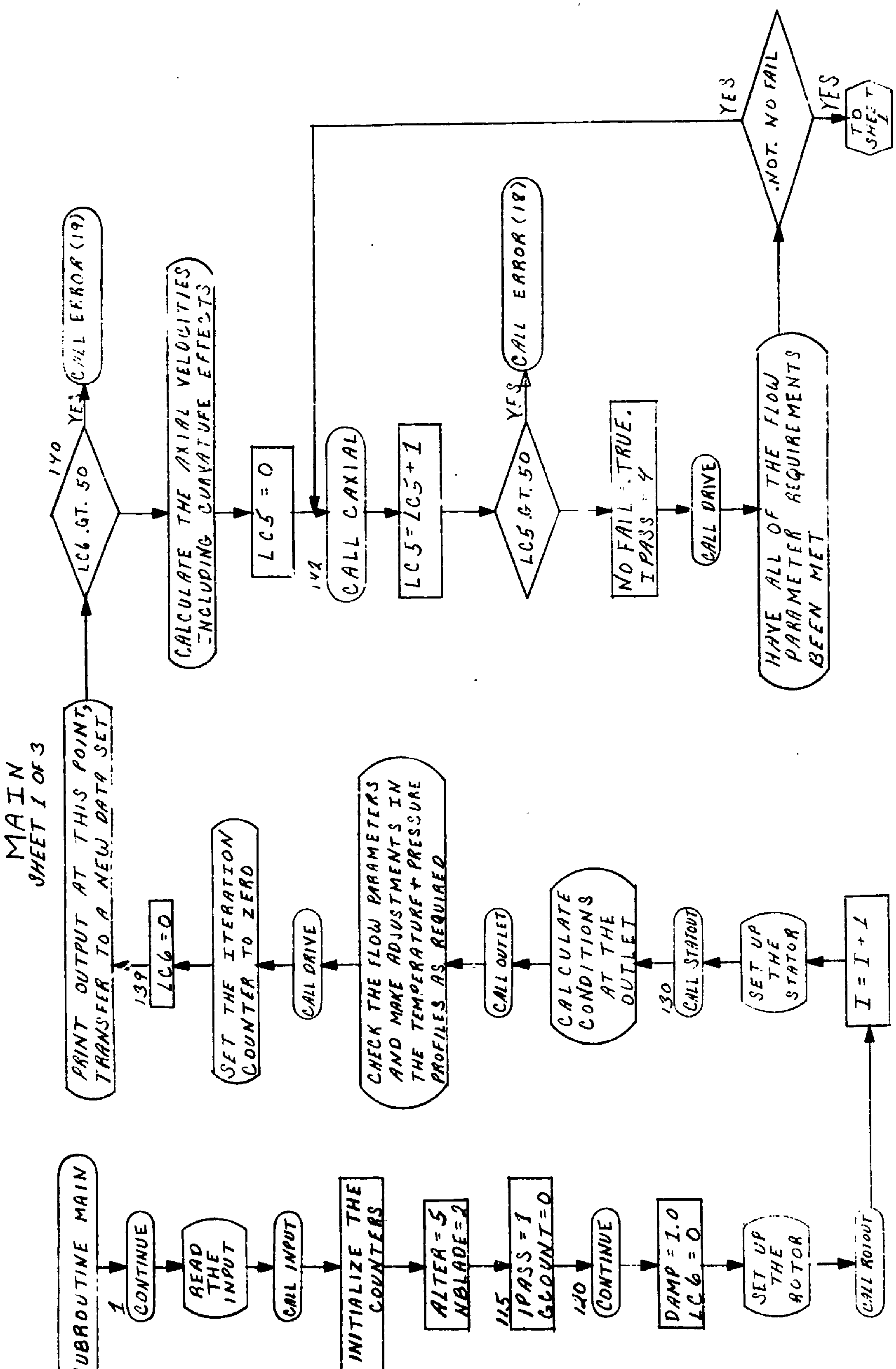
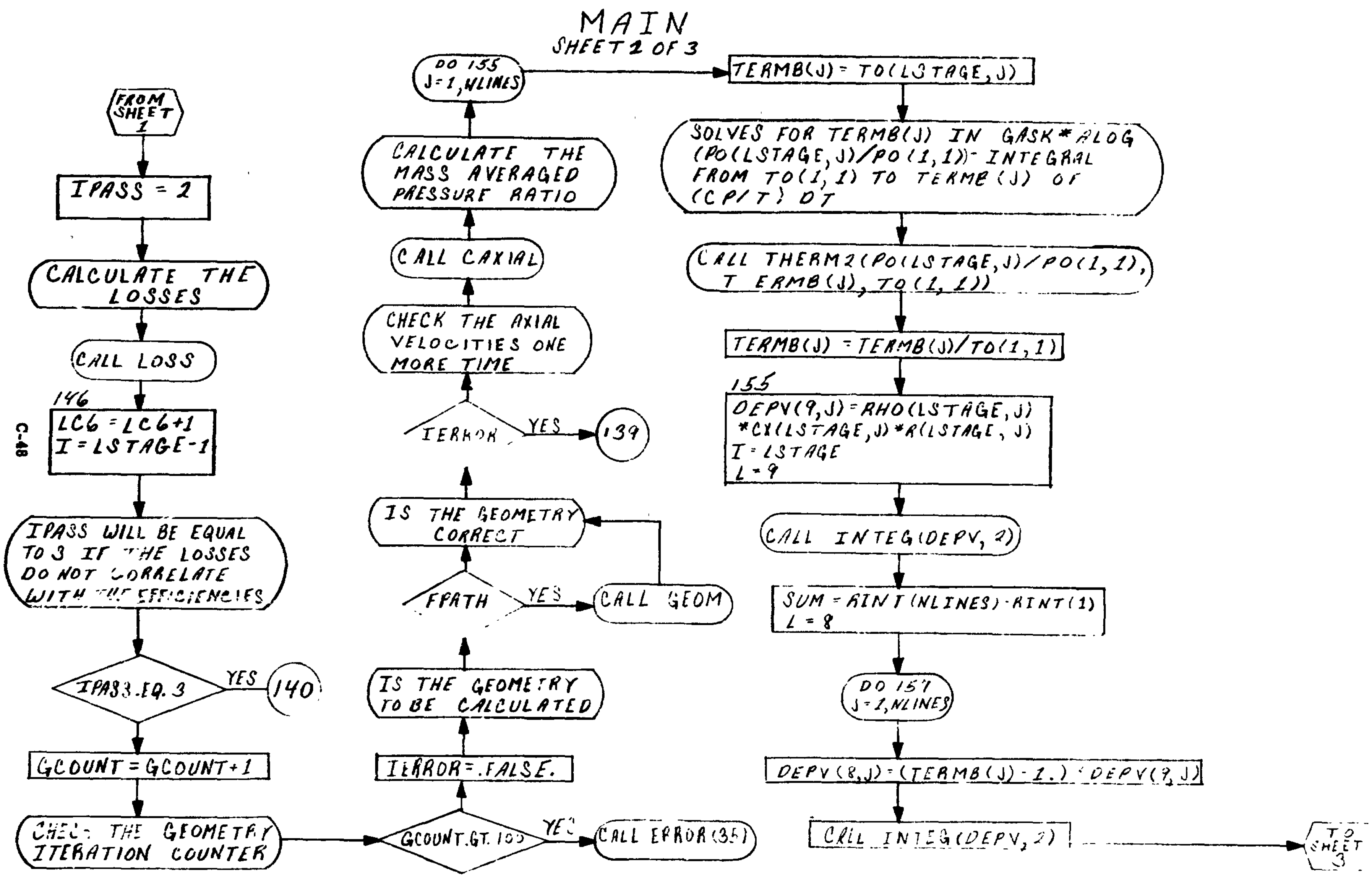
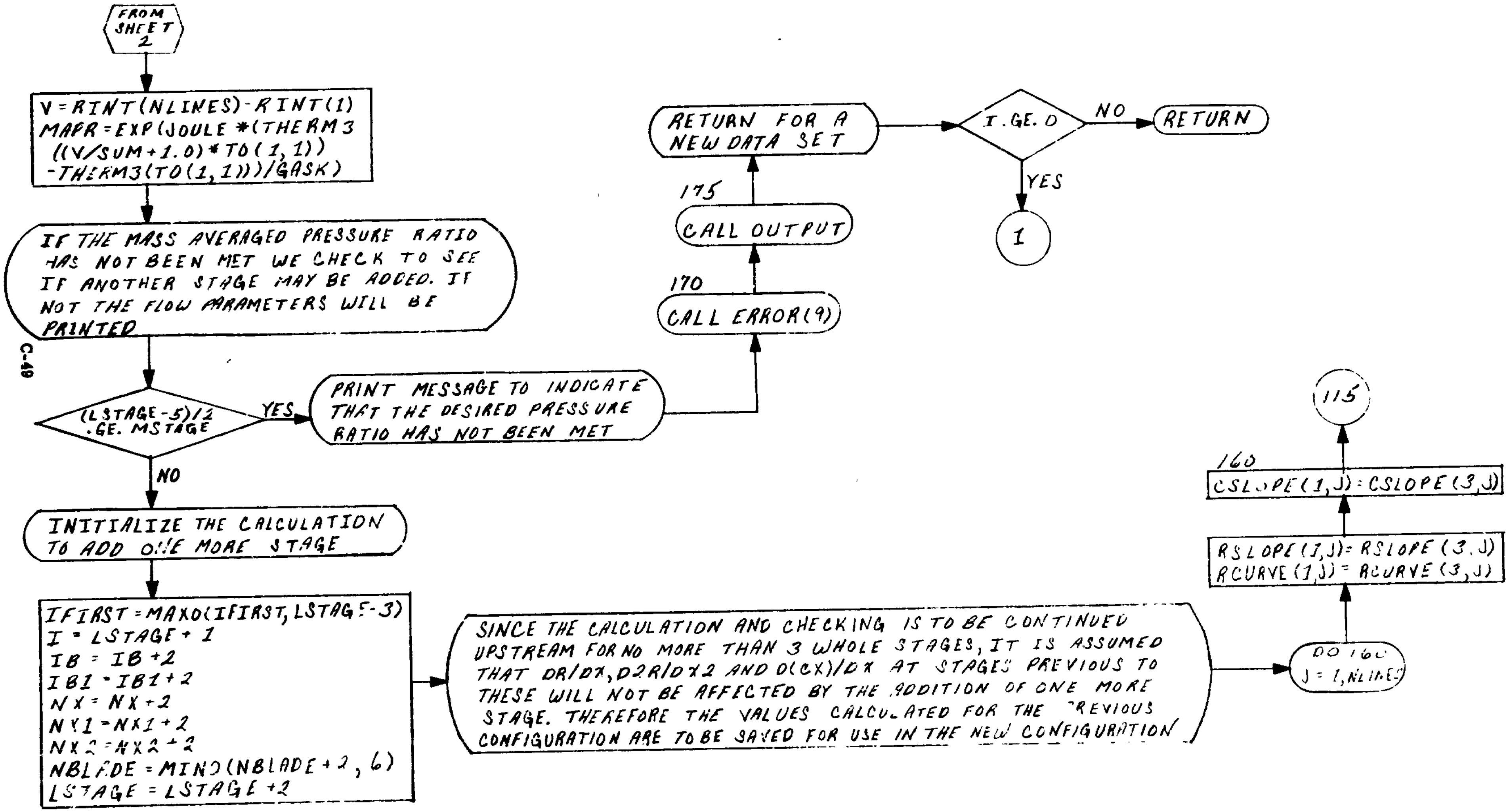
FORM 1577 REV. 7-57

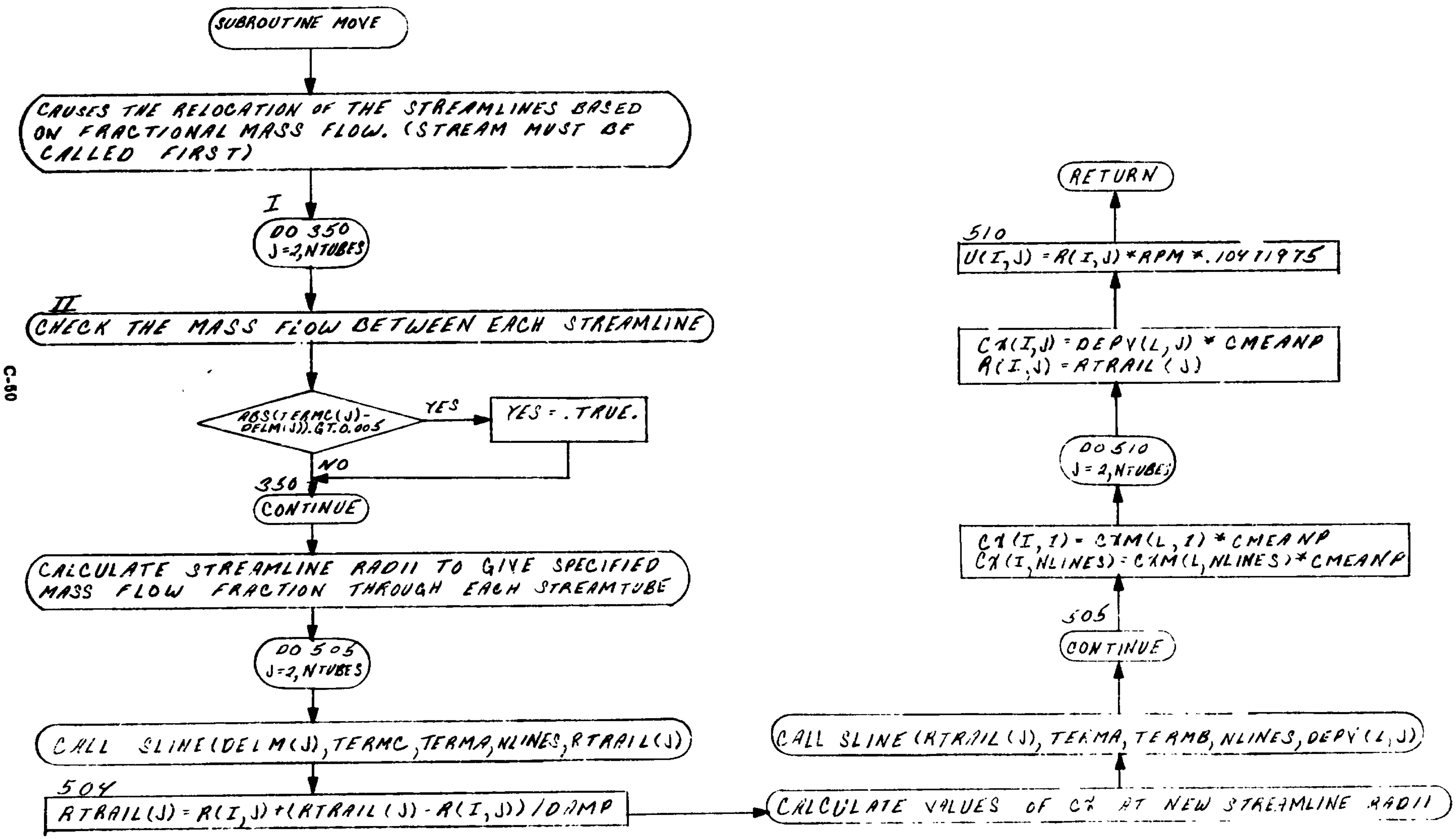

MAIN
SHEET 1 OF 3
SUBROUTINE MAIN
1
CONTINUE
READ THE INPUT
CALL INPUT
INITIALIZE THE COUNTERS
ALTER = 5
NBLADE = 2
115
IPASS = 1
GCOUNT = 0
120
CONTINUE
DAMP = 1.0
LC6 = 0
SET UP THE ROTOR
CALL ROTOUT
I = I + 1
SET UP THE STATOR
130
CALL STATOUT
CALCULATE CONDITIONS AT THE OUTLET
CALL OUTLET
CHECK THE FLOW PARAMETERS AND MAKE ADJUSTMENTS IN THE TEMPERATURE + PRESSURE PROFILES AS REQUIRED
CALL DRIVE
SET THE ITERATION COUNTER TO ZERO
139
LC6 = 0
PRINT OUTPUT AT THIS POINT, TRANSFER TO A NEW DATA SET
140
LC6 .GT. 50
YES
CALL ERROR (19)
CALCULATE THE AXIAL VELOCITIES INCLUDING CURVATURE EFFECTS
LC5 = 0
142
CALL CAXIAL
LC5 = LC5 + 1
LC5 .GT. 50
YES
CALL ERROR (18)
NO FAIL = TRUE.
IPASS = 4
CALL DRIVE
HAVE ALL OF THE FLOW PARAMETER REQUIREMENTS BEEN MET
.NOT. NO FAIL
YES
YES
TO SHEET 1


MAIN
SHEET 2 OF 3
FROM SHEET 1
IPASS = 2
CALCULATE THE LOSSES
CALL LOSS
146
LC6 = LC6+1
I = LSTAGE-1
IPASS WILL BE EQUAL TO 3 IF THE LOSSES DO NOT CORRELATE WITH THE EFFICIENCIES
IPASS.EQ.3
YES
140
GCOUNT = GCOUNT+1
CHECK THE GEOMETRY ITERATION COUNTER
GCOUNT.GT.100
YES
CALL ERROR(35)
IERROR = .FALSE.
IS THE GEOMETRY TO BE CALCULATED
FPATH
YES
CALL GEOM
IS THE GEOMETRY CORRECT
IERROR
YES
139
CHECK THE AXIAL VELOCITIES ONE MORE TIME
CALL CAXIAL
CALCULATE THE MASS AVERAGED PRESSURE RATIO
DO 155 J=1,NLINES
TERMB(J) = TO(LSTAGE,J)
SOLVES FOR TERMB(J) IN GASK*ALOG (PO(LSTAGE,J)/PO(1,1))- 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) = RHO(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
DEPV(8,J) = (TERMB(J)-1.)*DEPV(9,J)
CALL INTEG(DEPV,2)
TO SHEET 3

MAIN
SHEET 3 OF 3



MOVE
SHEET 1 OF 2



DIV. ALLISON GMC.	REPORT NO	PAGE	JOB NO	PAGE
TITLE MOVE SHEET 2 OF 2		PREPARED		DATE
		CHECKED		
		APPROVED		

I. 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)

II. TERMA(J) = R(I, J)
TERMB(J) = CXM(L, J)
TERMC(J) = TERMC(J-1) + DA(J-1)/TOTINT

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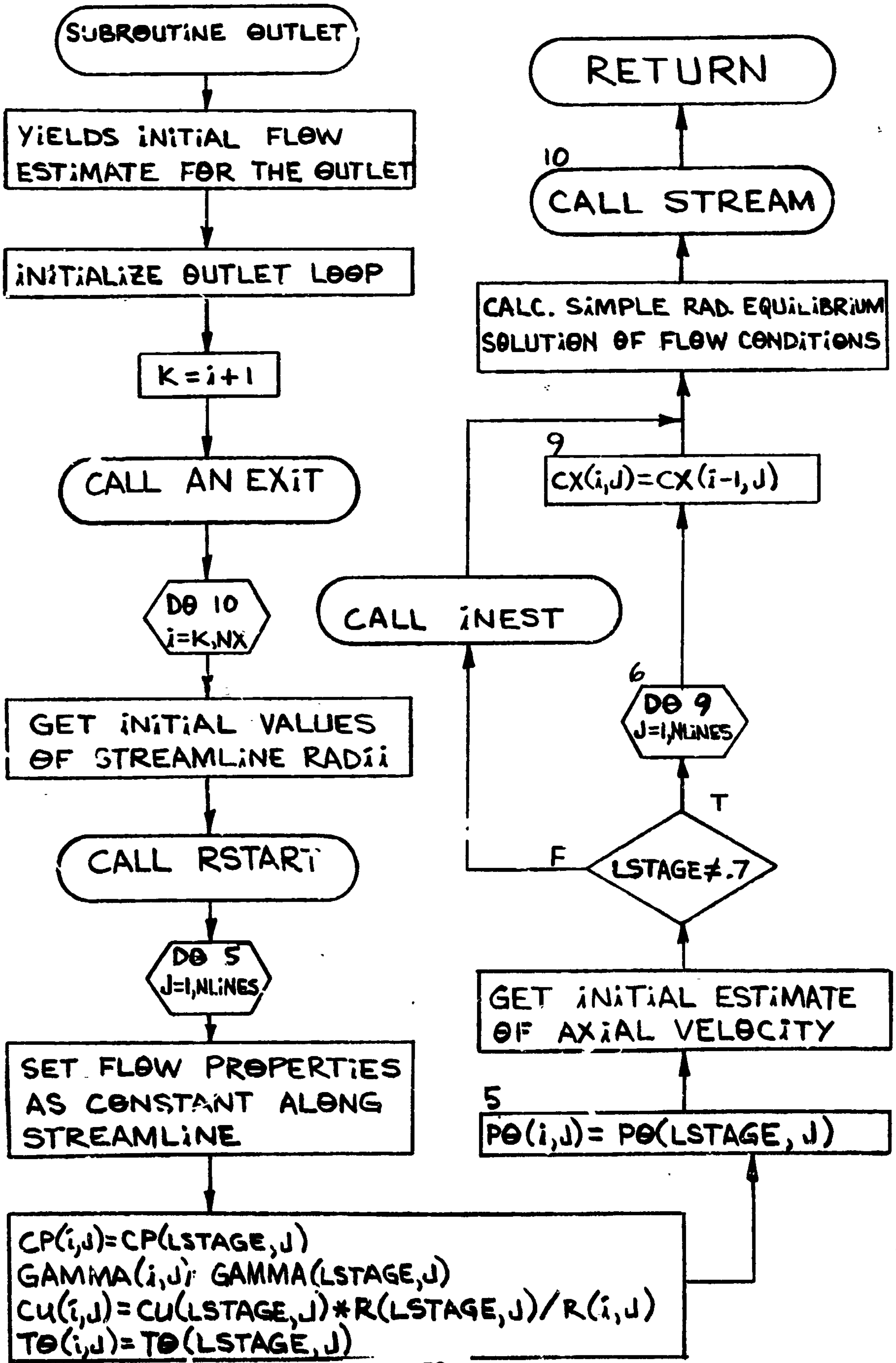
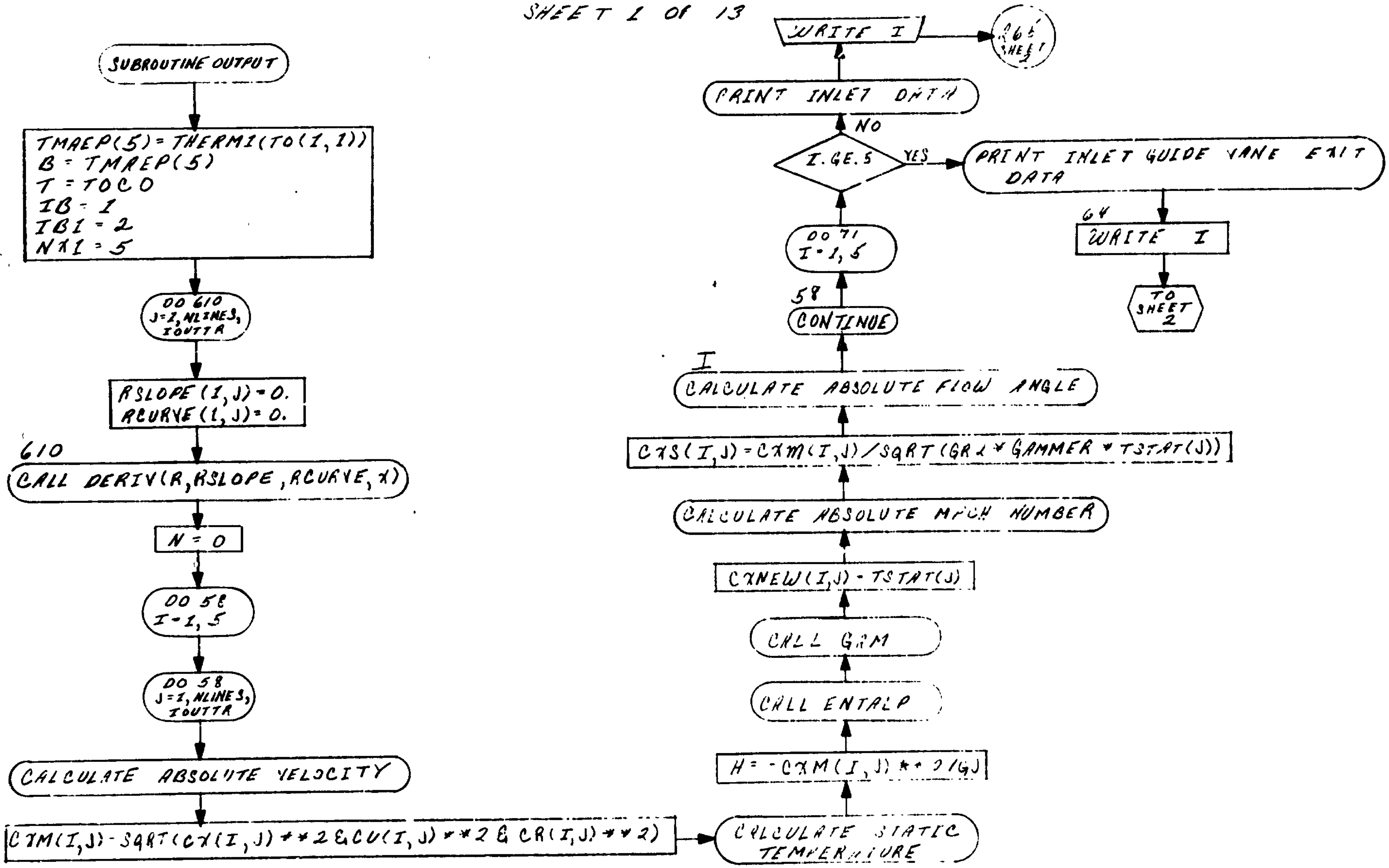
FORM 1577 REV. 7-57

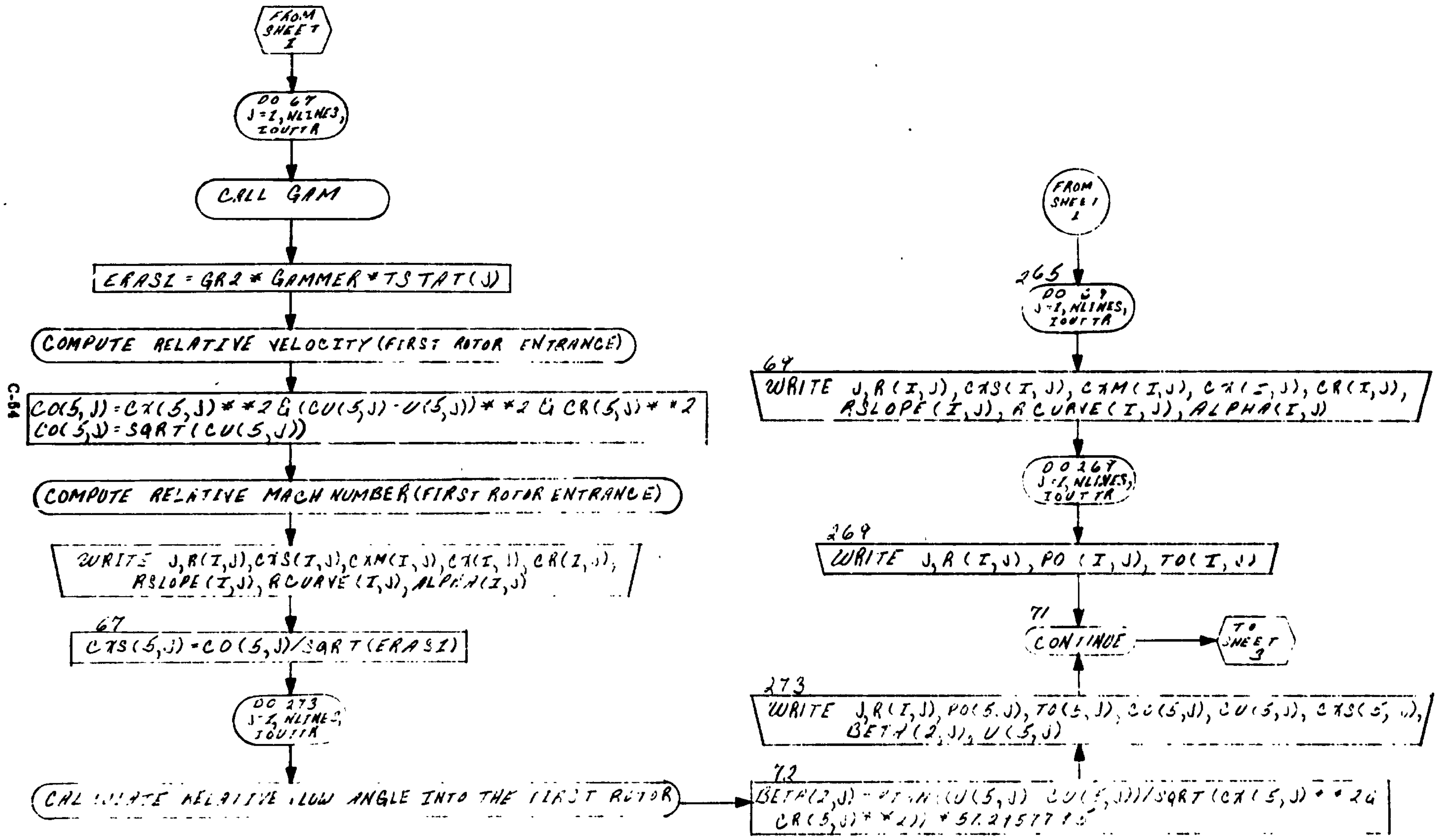
OUTLET S.R.


SUBROUTINE OUTLET
YIELDS INITIAL FLOW ESTIMATE FOR THE OUTLET
INITIALIZE OUTLET LOOP
K=i+1
CALL AN EXIT
DO 10 i=K,NX
GET INITIAL VALUES OF STREAMLINE RADII
CALL RSTART
DO 5 J=1,NLINES
SET FLOW PROPERTIES AS CONSTANT ALONG STREAMLINE
CP(i,J)=CP(LSTAGE,J)
GAMMA(i,J)=GAMMA(LSTAGE,J)
CU(i,J)=CU(LSTAGE,J)*R(LSTAGE,J)/R(i,J)
TO(i,J)=TO(LSTAGE,J)
5
PO(i,J)= PO(LSTAGE,J)
GET INITIAL ESTIMATE OF AXIAL VELOCITY
LSTAGE≠.7
T
F
6
DO 9 J=1,NLINES
CALL INEST
9
CX(i,J)=CX(i-1,J)
CALC. SIMPLE RAD. EQUILIBRIUM SOLUTION OF FLOW CONDITIONS
10
CALL STREAM
RETURN

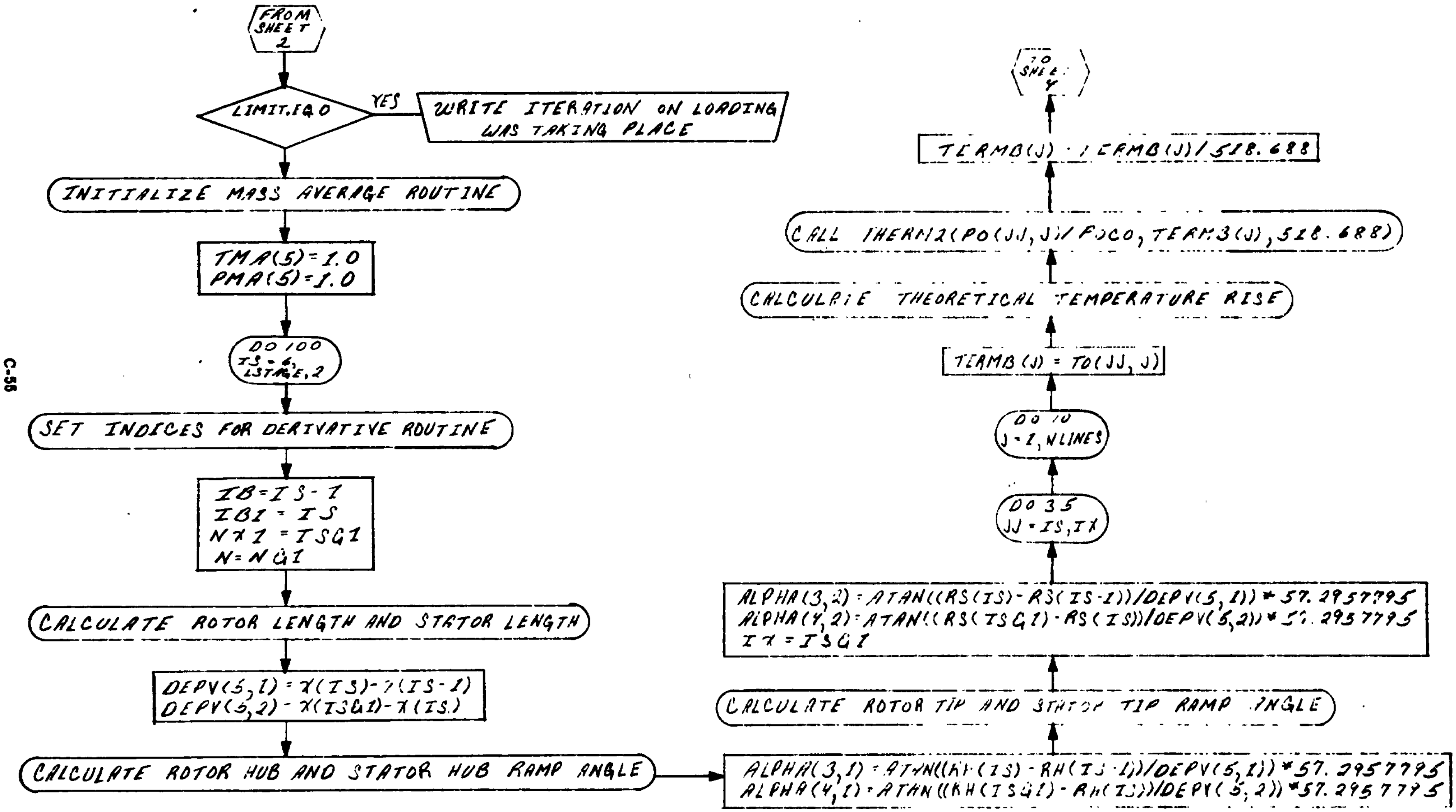
OUTPUT
SHEET 1 OF 13



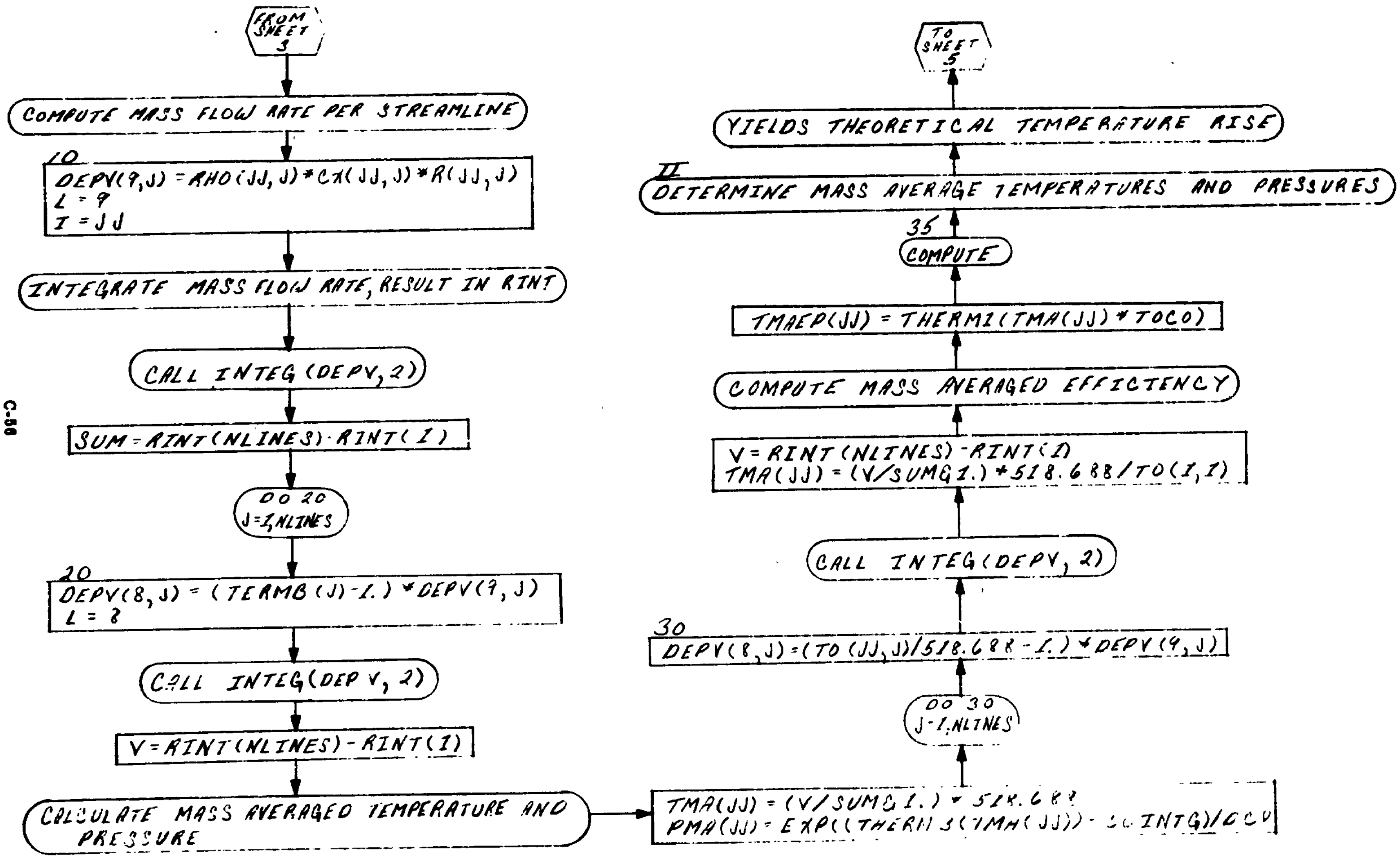
OUTPUT
SHEET 2 OF 13



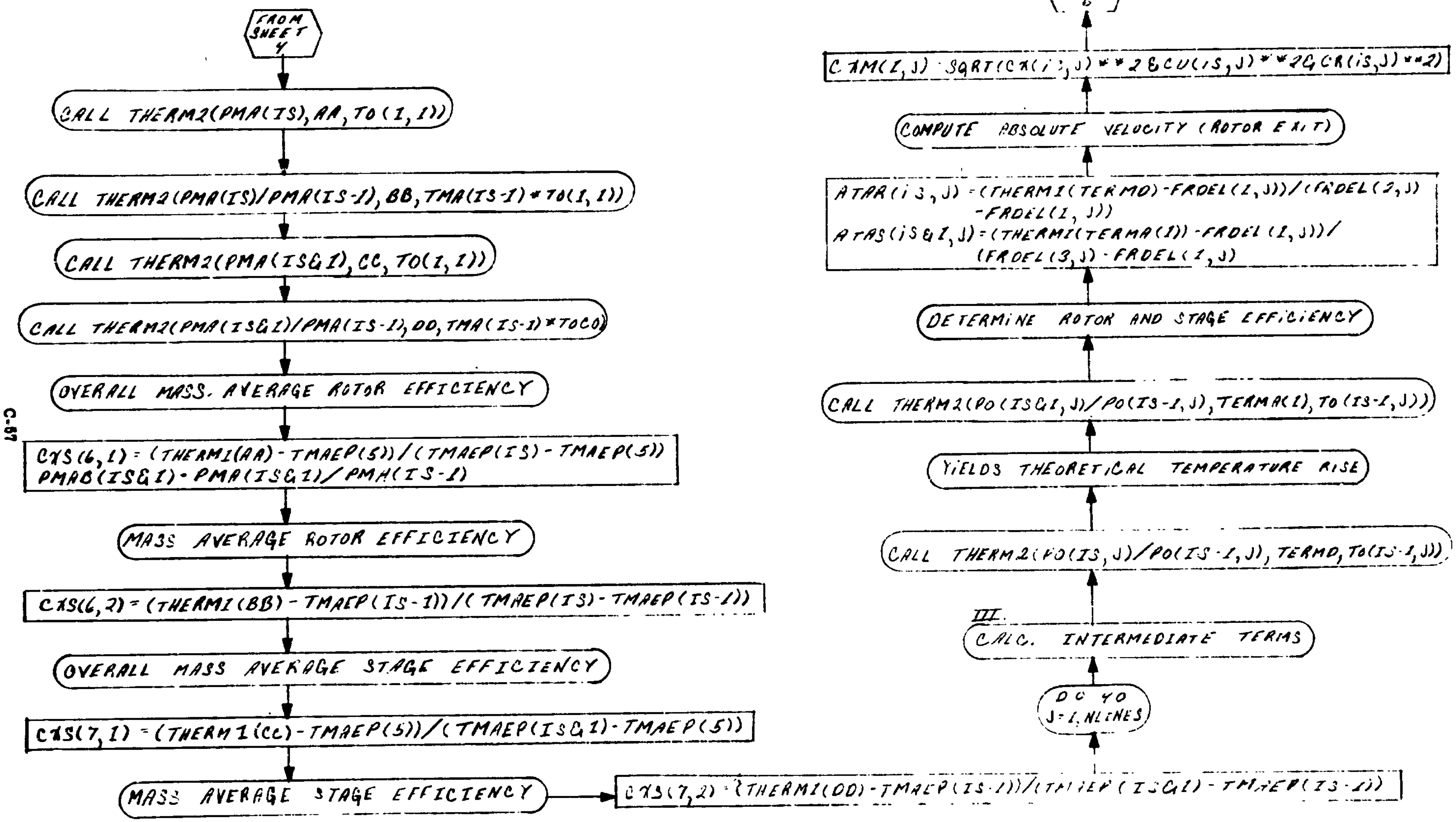
OUTPUT
SHEET 3 OF 13



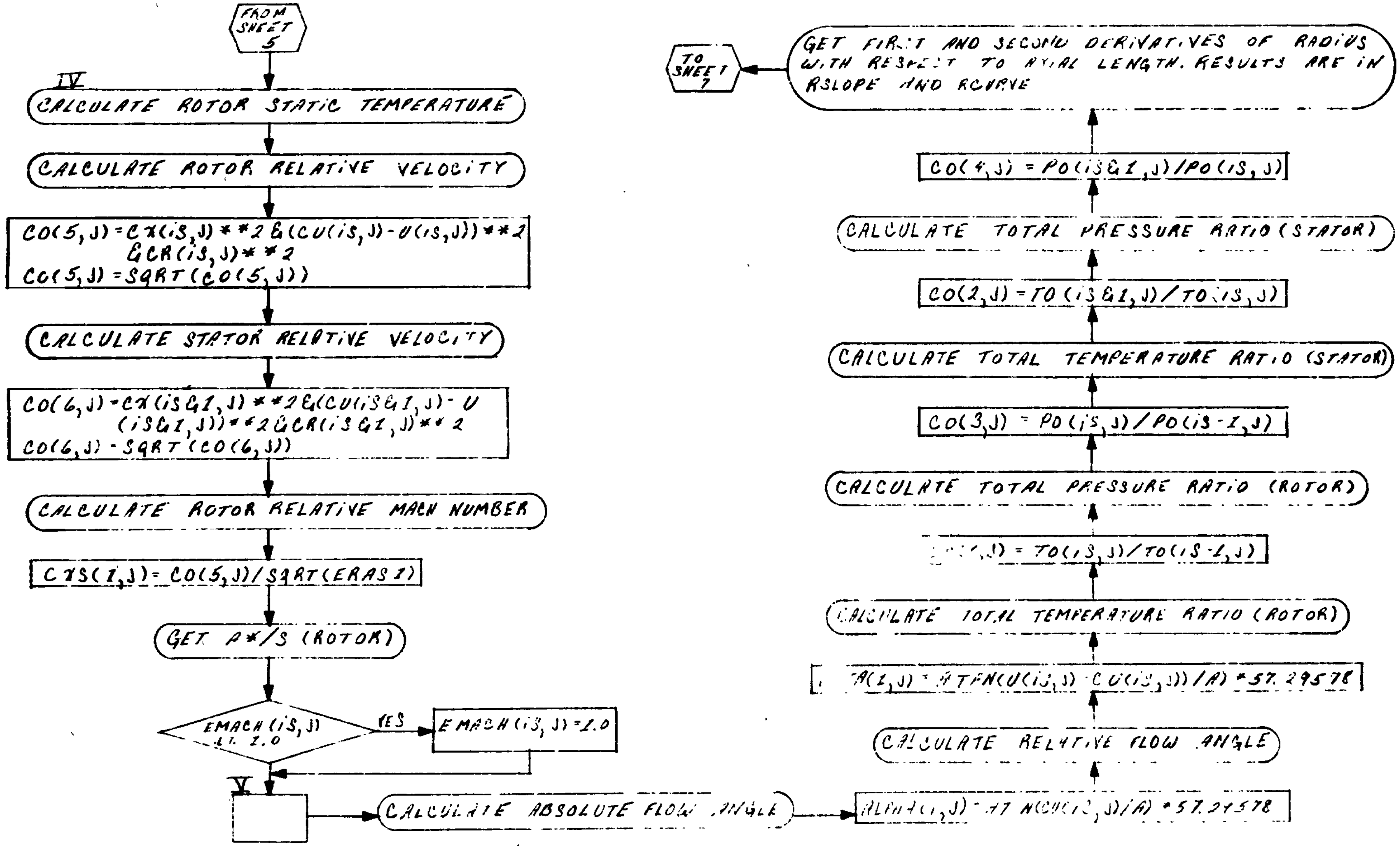
OUTPUT
SHEET 4 OF 13



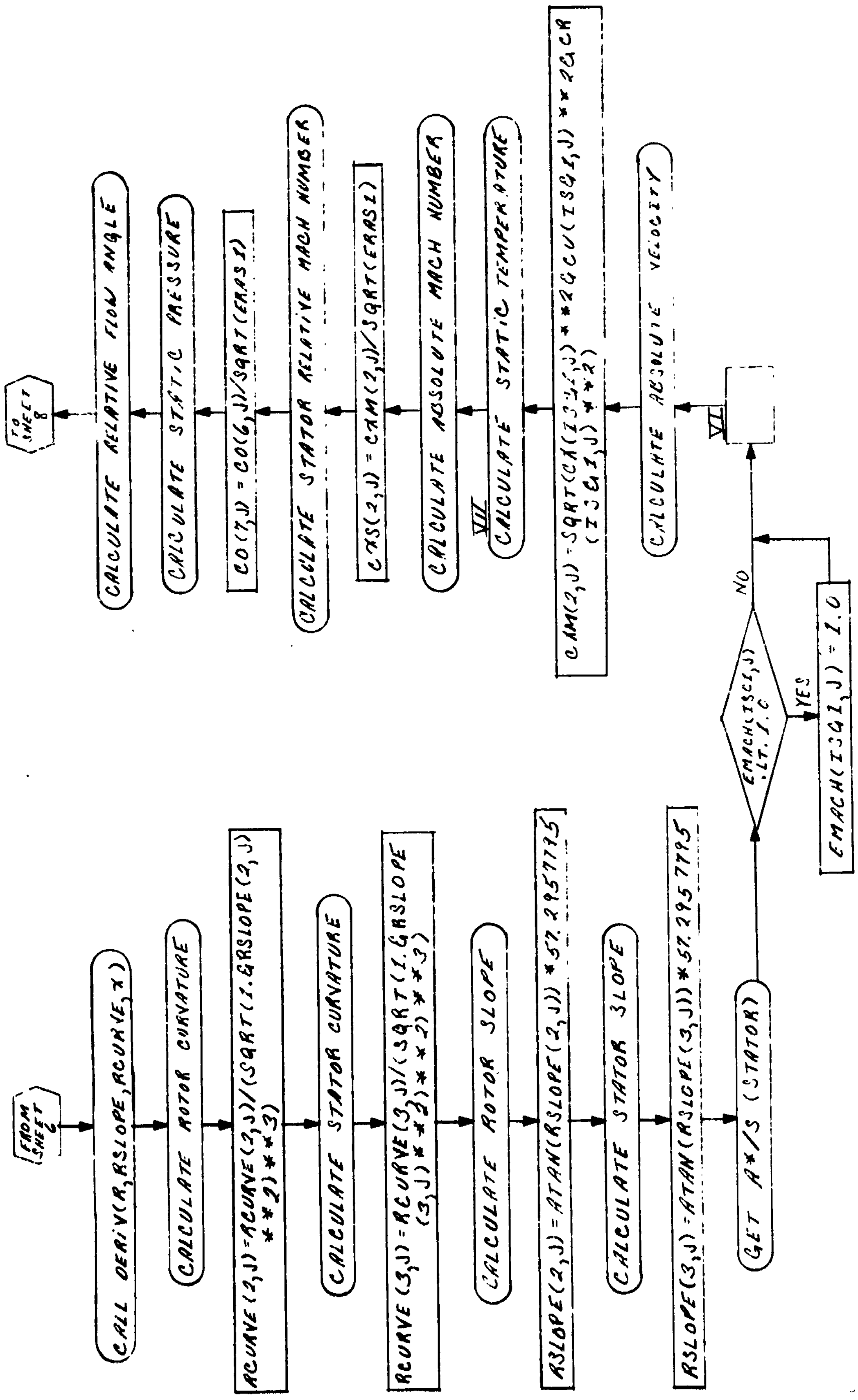
OUTPUT
SHEET 5 OF 13



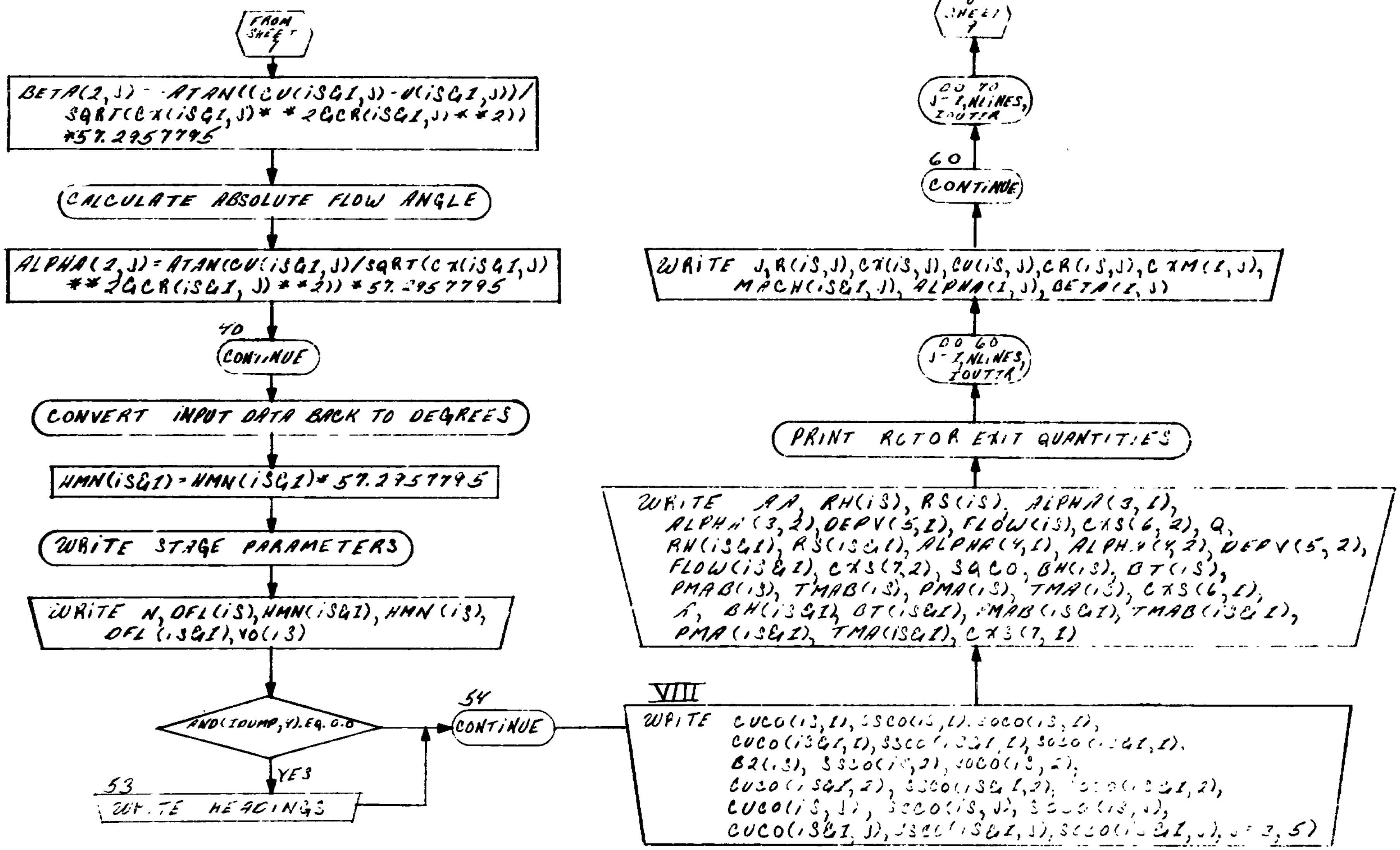
OUTPUT
SHEET 6 OF 13



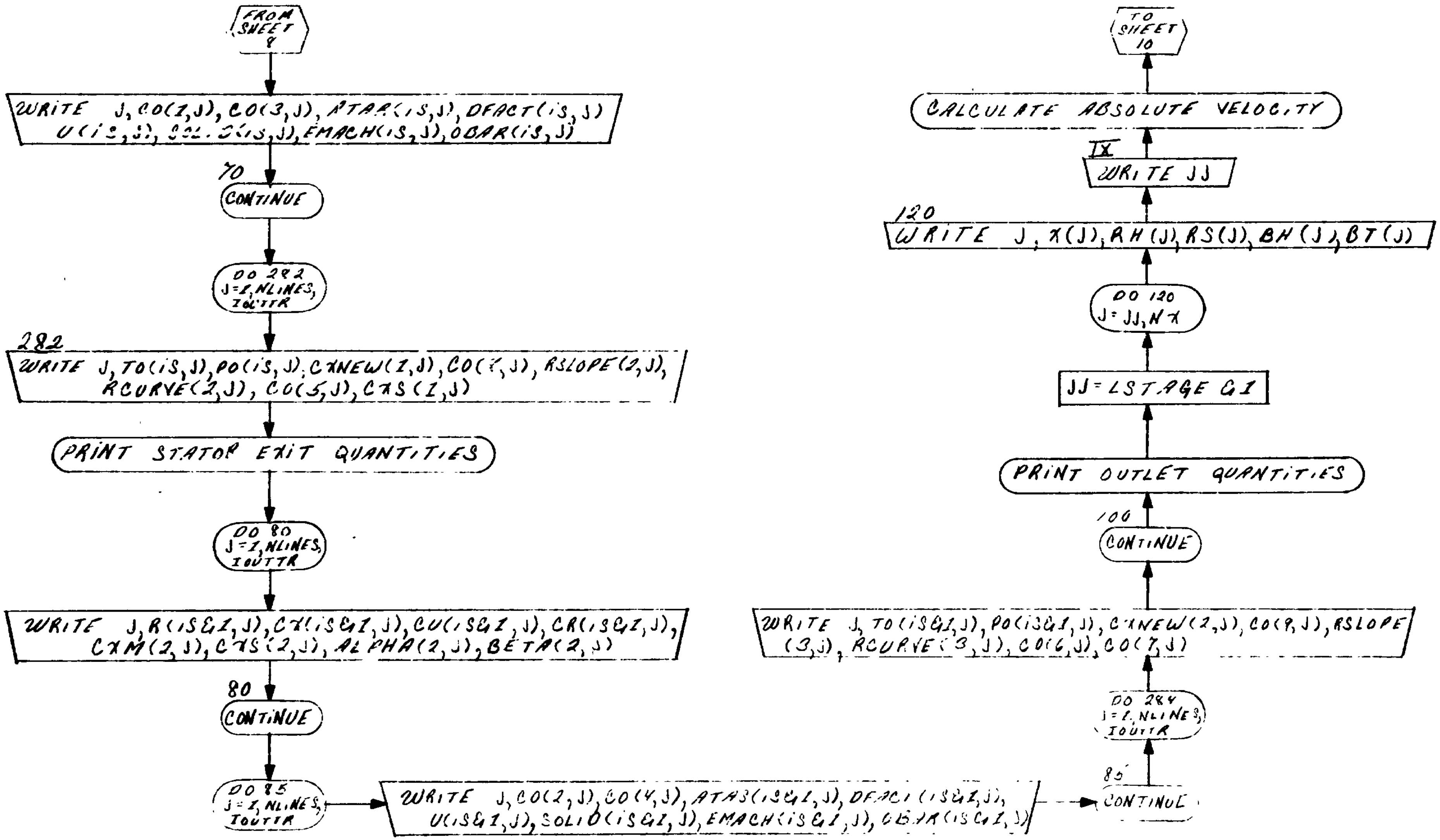
OUTPUT
SHEET 7 OF 13



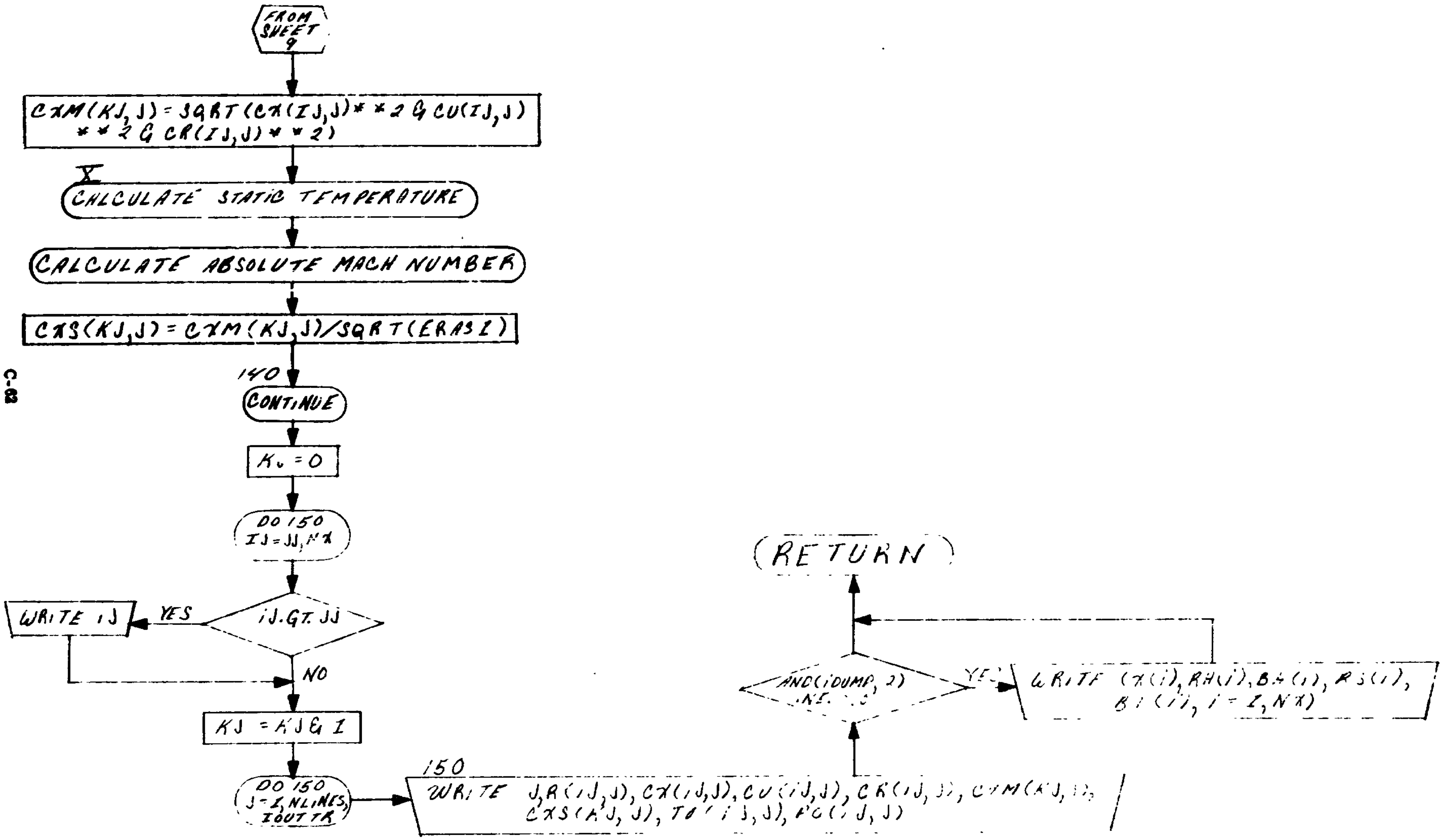
OUTPUT
SHEET 8 of 13



OUTPUT
SHEET 9 OF 13



OUTPUT
SHEET 10 OF 13



DIV. ALLISON GMC.	REPORT NO	PAGE	JOB NO	PAGE
TITLE OUTPUT SHEET 11 OF 13		PREPARED		DATE
		CHECKED		
		APPROVED		

```
I.   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

II.  TMAB(IS)=TMA(IS)/TMA(IS-1)
     TMAB(IS&1)=TMA(IS&1)/TMA(IS-1)
     PMAB(IS)=PMA(IS)/PMA(IS-1)
     AA=TMA(IS)*TO(1,1)
     BB=AA
     CC=TMA(IS&1)*TO(1,1)
     DD=CC

III. FRDEL(1,J)=THERM1(TO(IS-1,J))
     FRDEL(2,J)=THERM1(TO(IS,J))
     FRDEL(3,J)=THERM1(TO(IS&1,J))
     TERMD=TO(IS,J)

IV.  H=-CXM(1,J)**2/GJ
     T=TO(IS,J)
     CALL ENTALP
     CXNEW(I,J)=TSTAT(J)
     CALL GAM
     EKAS1=GR2*GAMMER*TSTAT(J)
     CO(8,J)=PO(IS,J)*EXP((THERM3(TSTAT
             (J))-THERM3(T))/OCP)

V.   A=GAMMA(IS-1,J)
     BETA(2,J)=BETA(2,J)/57.29578
     EMACH(IS,J)=COS(BETA(2,J))/((0.5*
        (A&1.0))**(-0.5*(A&1.0)/(A-1.0))/
        MACH(IS,J)*(1.0&0.5*(A-1.0)*
        MACH(IS,J)**2)**(0.5*(A&1.0)/
        (A-1.0))*((A&1.0)*EMACH(IS,J)**2/
```

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FORM 1577 REV. 7-67

DIV. ALLISON GMC. | REPORT NO | PAGE | JOB NO | PAGE
PREPARED | DATE
CHECKED
APPROVED

TITLE OUTPUT
SHEET 12 OF 13

```
  ((A-1.0)*EMACH(IS,J)**2G2.0))
  **(A/(A-1.0))*((?G1.0)/(2.0*A*
  EMACH(IS,J)**2G1.0-A))**(1.0/
  (A-1.0)))
BETA(2,J) = BETA(2,J)*57.29578
A=SQRT(CX(IS,J)**2GCR(IS,J)**2)

VI.   A = GAMMA(IS,J)
ALPHA(1,J)=ALPHA(1,J)/57.29578
EMACH(ISG1,J) = COS(ALPHA(1,J))/
  ((0.5*(AG1.0))**(-0.5*(AG1.0)/(A-
  1.0))/MACH(ISG1,J)*(1.0G0.5(A-1.0)
  *MACH(ISG1,J)**2)**(0.5*(AG1.0)/
  (A-1.0))  ((AG1.0)*EMACH(ISG1,J)
  **2/((A-1.0)*EMACH(ISG1,J)**2G2.0))
  **(A/(A-1.0))*((AG1.0)/(2.0*A*
  EMACH(ISG1,J)**2G1.0-A))**(1.0/
  (A-1.0)))
ALPHA(1,J)=ALPHA(1,J)*57.29578

VII.  ... XM(2,J)**
  , =TO(ISG1,J)
CALL ENTALP
CALL GAM
CXNEW(2,J) = TSTAT(J)
ERAS1 = GR2*GAMMER*TSTAT(J)
CO(9,J) = PC(ISG1,J)*EXP((THERM3
  (TSTAT(J))-THERM3(T))/DCP)

VIII. SQCO = CX(IS,JM)/CX(IS-1,JM)
A = CX(ISG1,JM)/CX(IS,JM)
Q = (RS(IS) - RH(IS))/DEPV(5,2)
AA = (RS(IS-1)-RH(IS-1))/DEPV(5,1)
```


DISTRIBUTION:

DIV. ALLISON GMC.	REPORT NO.	PAGE	JOB NO.	PAGE
TITLE OUTPUT SHEET 13 OF 13		PREPARED		DATE
		CHECKED		
		APPROVED		

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

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

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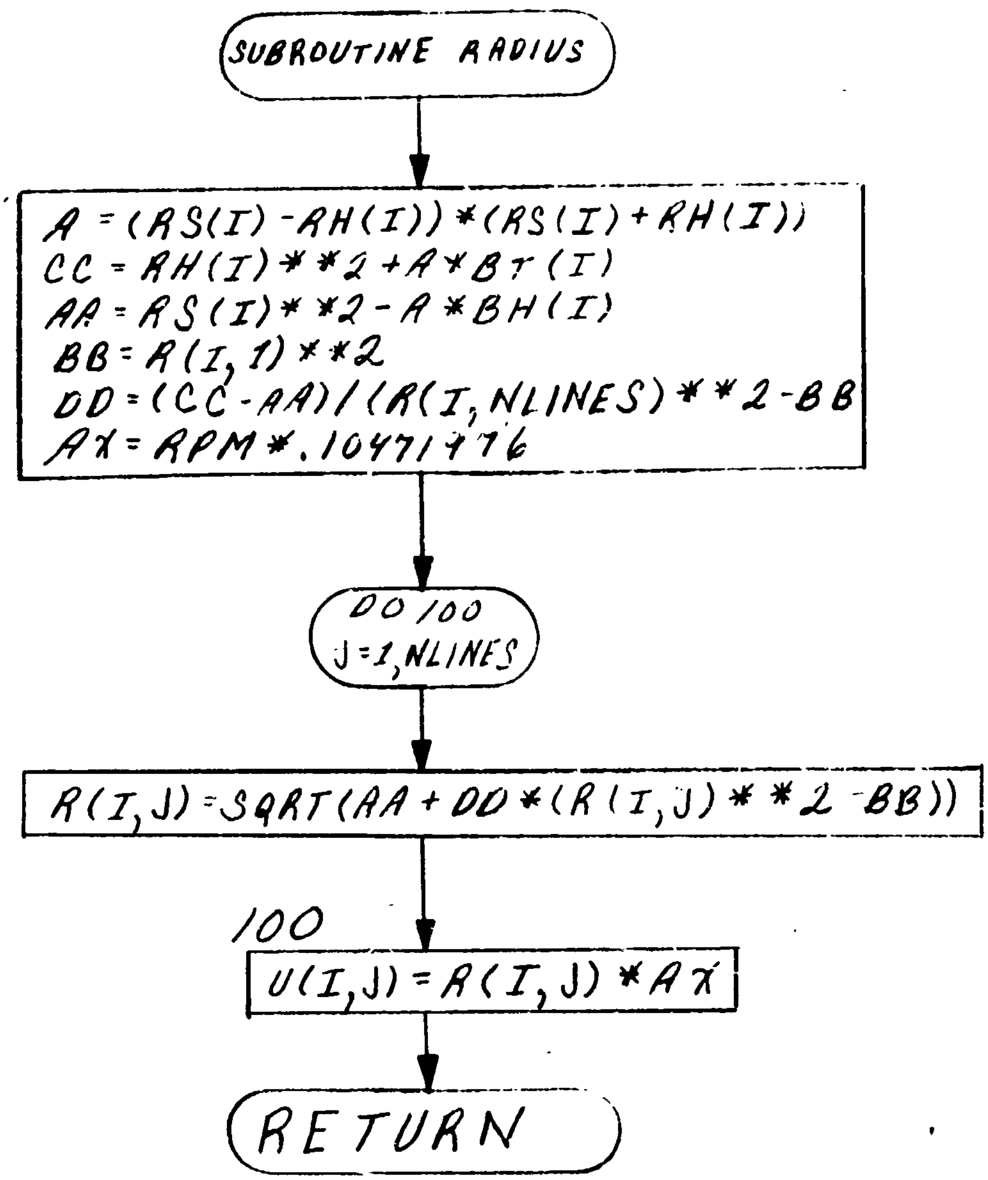
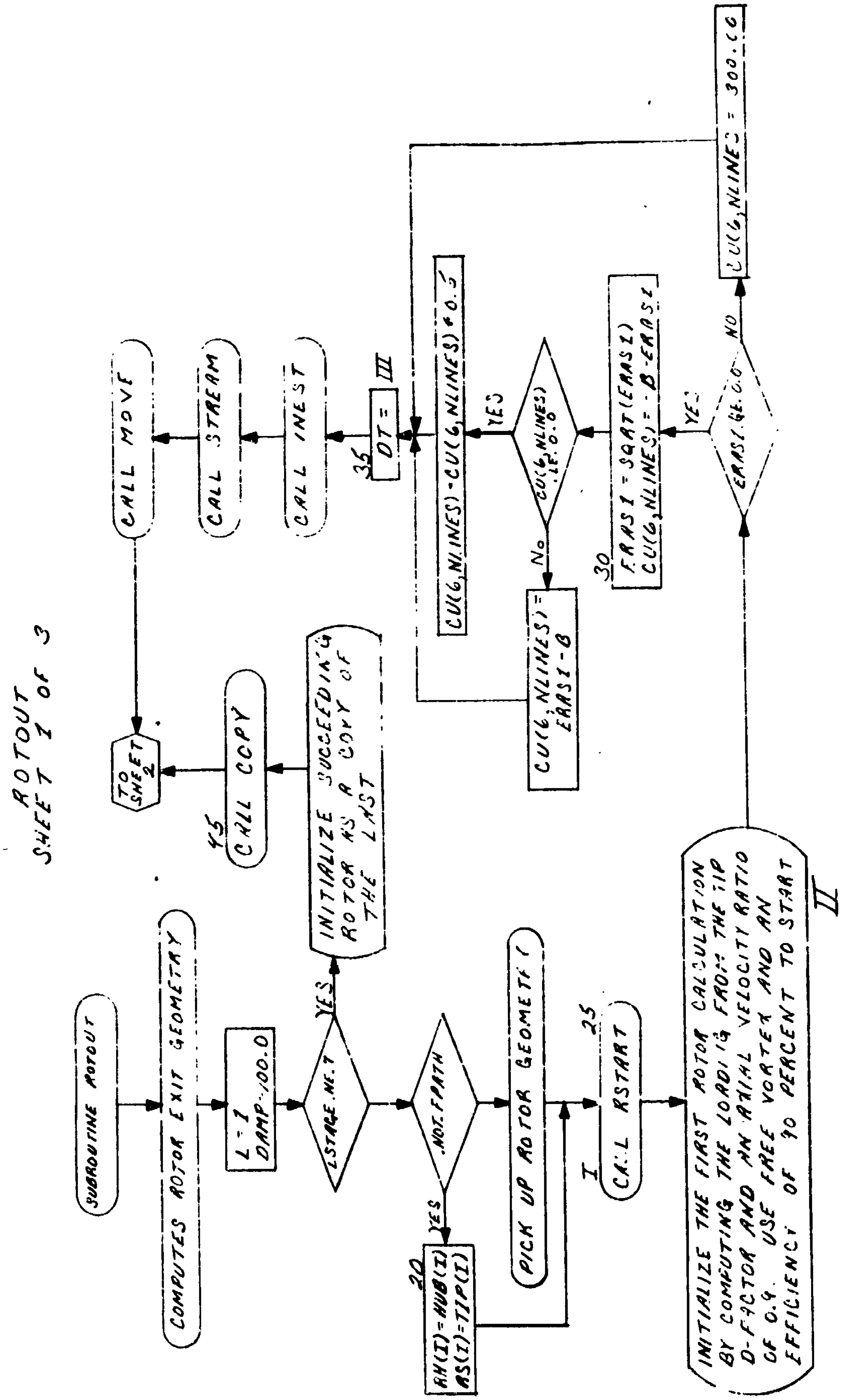
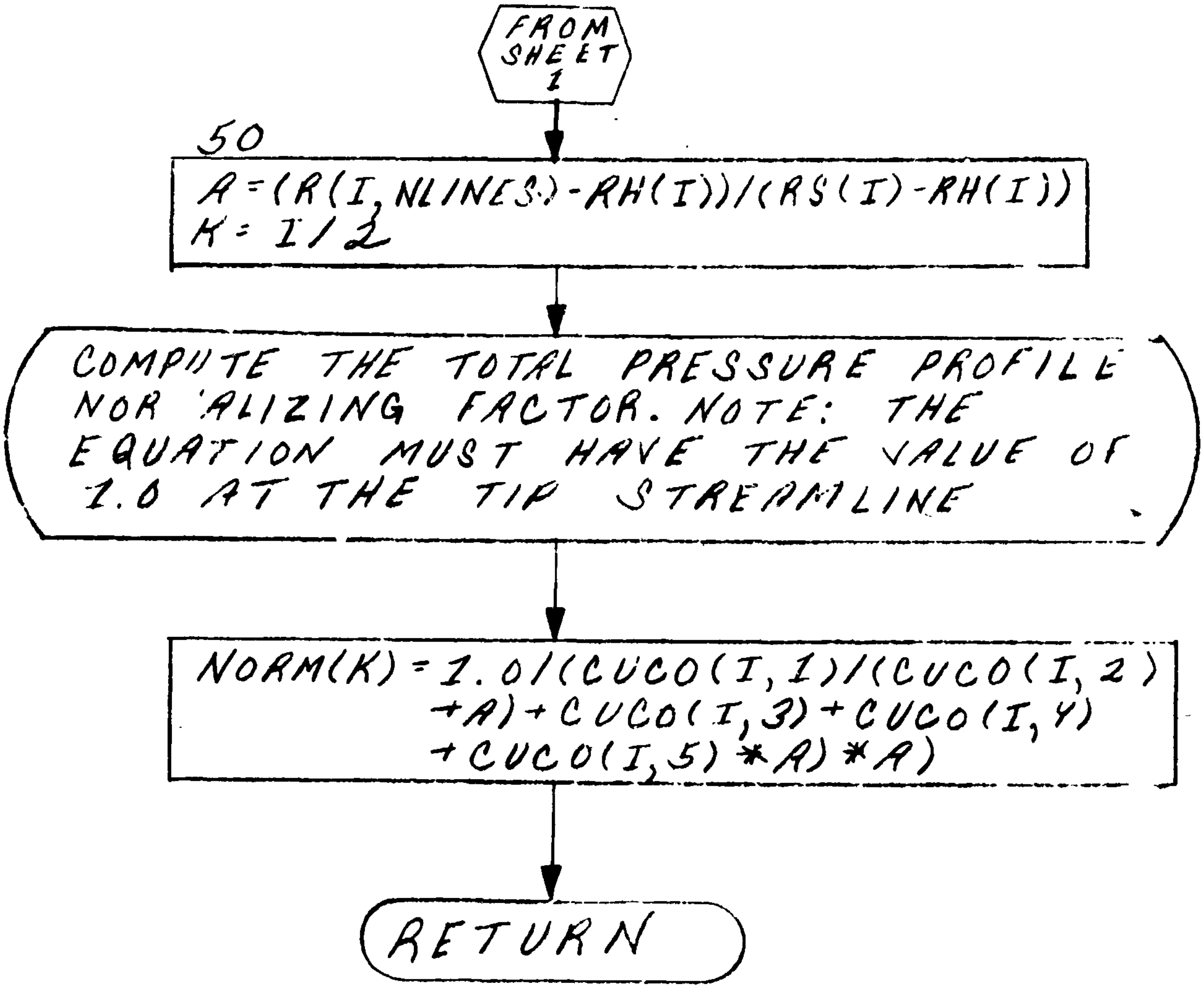
FORM 1877 REV. 7-67

RADIUS


SUBROUTINE RADIUS
A = (RS(I) - RH(I)) * (RS(I) + RH(I))
CC = RH(I) * * 2 + A * BT(I)
AA = RS(I) * * 2 - A * BH(I)
BB = R(I, 1) * * 2
DD = (CC - AA) / (R(I, NLINES) * * 2 - BB
AX = RPM * .10471976
DO 100
J = 1, NLINES
R(I, J) = SQRT(AA + DD * (R(I, J) * * 2 - BB))
100
U(I, J) = R(I, J) * AX
RETURN


ROTOUT
SHEET 1 OF 3
SUBROUTINE ROTOUT
COMPUTES ROTOR EXIT GEOMETRY
L = 1
DAMP=100.0
LSTAGE.NE.1
YES
INITIALIZE SUCCEEDING ROTOR AS A COPY OF THE LAST
45
CALL COPY
TO SHEET 2
.NOT.FPATH
YES
20
RH(I)=HUB(I)
RS(I)=TIP(I)
PICK UP ROTOR GEOMETRY
I
25
CALL RSTART
INITIALIZE THE FIRST ROTOR CALCULATION BY COMPUTING THE LOADING FROM THE TIP D-FACTOR AND AN AXIAL VELOCITY RATIO OF 0.9. USE FREE VORTEX AND AN EFFICIENCY OF 90 PERCENT TO START
II
ERRS1.GE.0.0
YES
NO
CU(6,NLINES) = 300.00
30
ERRS1 = SQRT(ERRS1)
CU(6,NLINES) = -B-ERRS1
CU(6,NLINES).LE.0.0
YES
No
CU(6,NLINES) = ERRS1-B
CU(6,NLINES)-CU(6,NLINES)*0.5
35
DT = III
CALL INEST
CALL STREAM
CALL MOVE

ROTOUT
SHEET 2 OF 3



DIV. ALLISON GMC.	REPORT NO	PAGE	JOB NO	PAGE
TITLE ROTOUT SHEET 3 OF 3		PREPARED		DATE
		CHECKED		
		APPROVED		

```
I.   RS(6)=RS(5)
     DT=(RS(5)-RH(5))/ASPECT(6)
     X(6)=X(5)+DT
     RH(6)=RH(5)+DT*AMIN1(0.6,0.8*ALH(6))

II.  V=0.9*CX(5,NLINES)
     S=SOCO(6,1)/(SOCO(6,2)+1.0)+SOCO(6,3)
       +SOCO(6,4)+SOCO(6,5)
     VMI=SQRT(CX(5,NLINES)**2+(CU(5,NLINES)
       -U(5,NLINES))**2)
     Q=0.5/S
     A=VMI*(1.0-DFL(6))+(V(5,NLINES)-CU
       (4,NLINES)-U(4,NLINES))*Q
     B=2.0*(U(6,NLINES)+A*Q)/(Q*Q-1.0)
     C=(V*V+U(6,NLINES)**2-A*A)/(1.0-Q*Q)
     ERAS1=B*B-4.0*C

III. DT=((U(6,NLINES)*CU(6,NLINES)-U(5,
       NLINES)*CU(5,NLINES))/GJ/CP(1,1))*2.0
     J=NLINES
     TO(6,J)=TOCO+DT
     CALL THERMP
     DT=0.9*DT
     CU(6,J)=CU(6,J)*R(6,J)
     DO 40 L=1,NLINES
     TO(6,L)=TO(6,J)
     CP(6,L)=CP(6,J)
     GAMMA(6,L)=GAMMA(6,J)
     PO(6,L)=POCO*(DT/TOCO+1.0)**
       (GAMMA(6,1)/(GAMMA(6,1)-1.0))
  40 CU(6,L)=CU(6,J)/R(6,L)
     L=1
```

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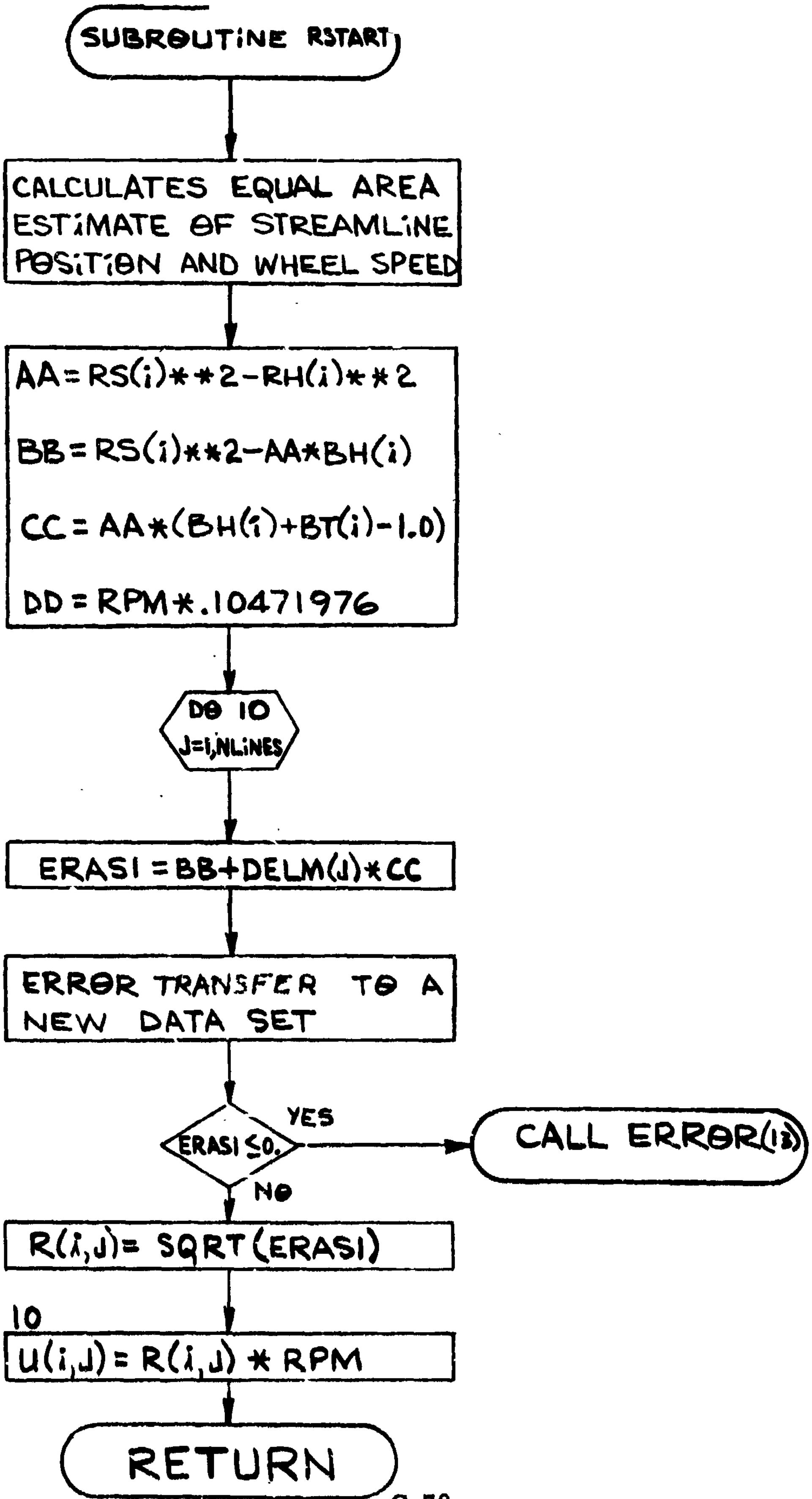
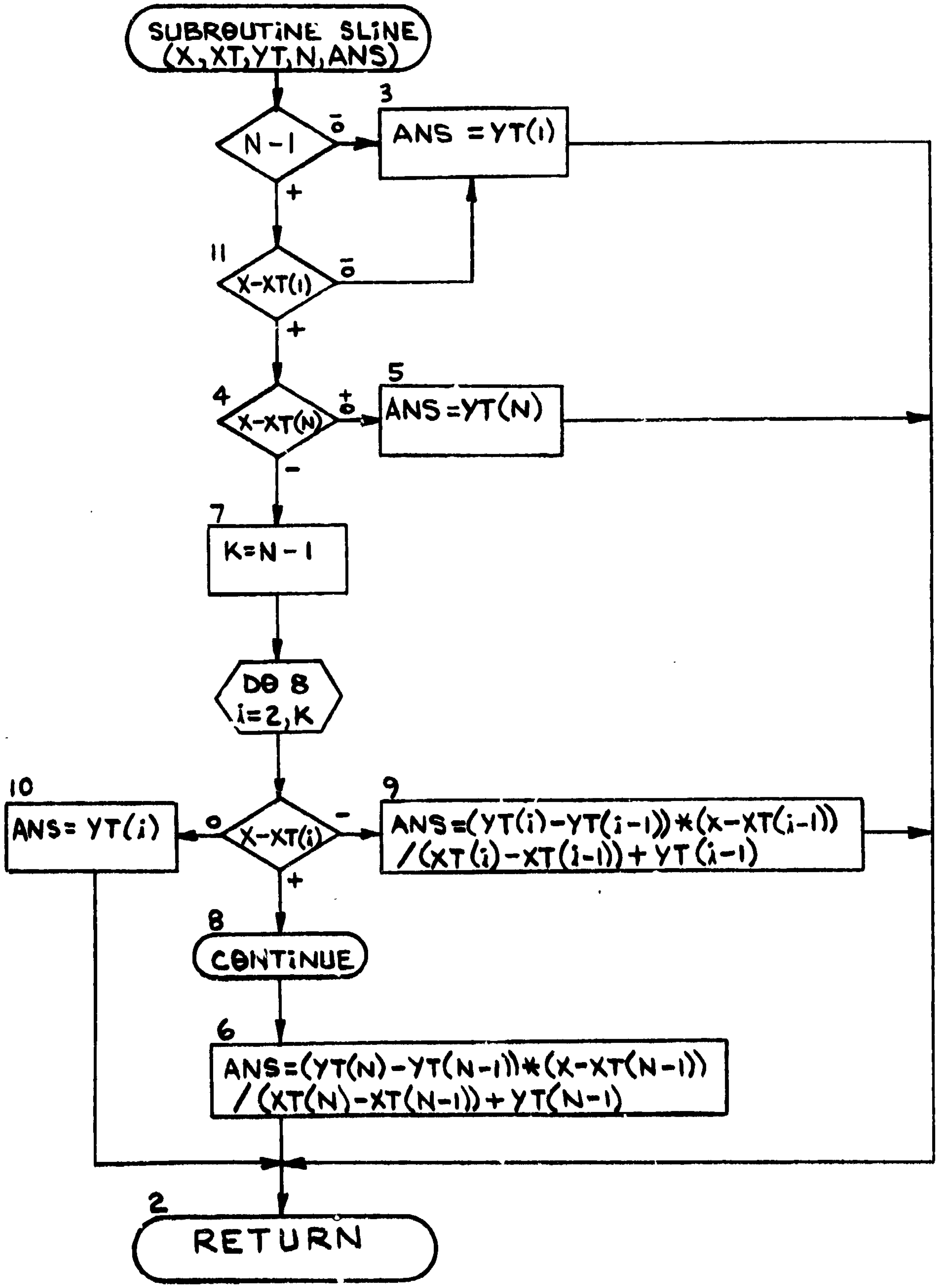
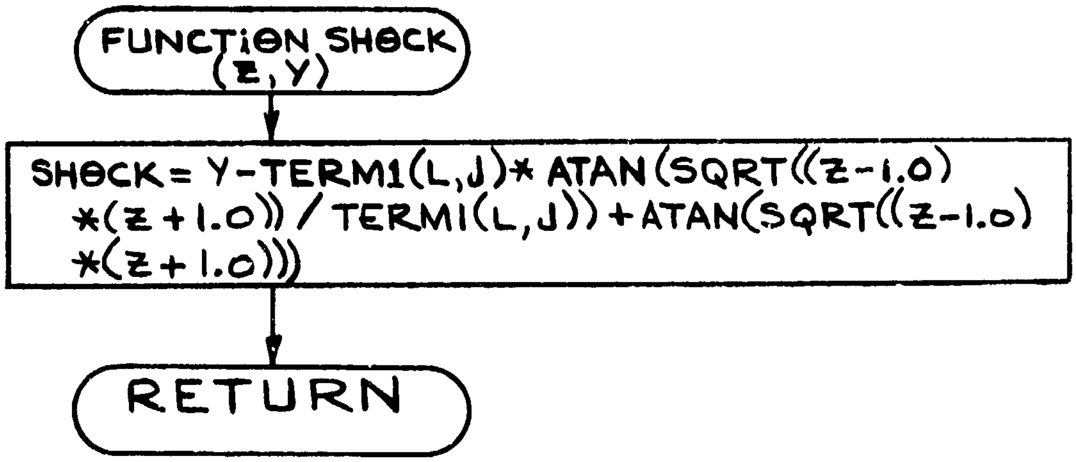
RSTART S.R.


SUBROUTINE RSTART
CALCULATES EQUAL AREA ESTIMATE OF STREAMLINE POSITION AND WHEEL SPEED
AA=RS(i)**2-RH(i)**2
BB=RS(i)**2-AA*BH(i)
CC=AA*(BH(i)+BT(i)-1.0)
DD=RPM*.10471976
DO 10 J=1,NLINES
ERASI=BB+DELM(J)*CC
ERROR TRANSFER TO A NEW DATA SET
ERASI≤0.
YES
CALL ERROR(13)
NO
R(i,J)= SQRT(ERASI)
10
U(i,J)=R(i,J)*RPM
RETURN

SLINE S.R.

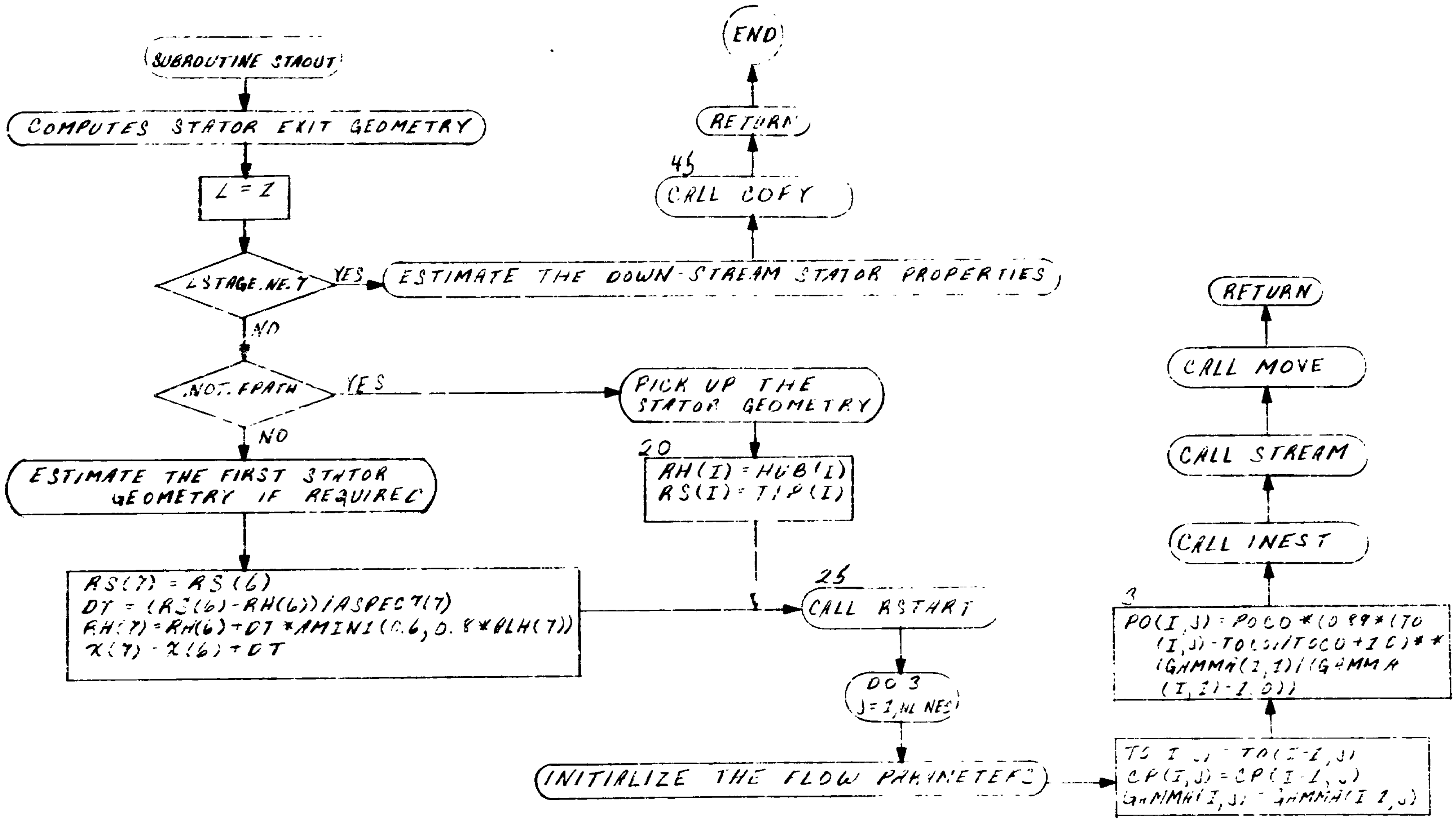

SUBROUTINE SLINE (X,XT,YT,N,ANS)
N-1
3
ANS =YT(1)
11
X-XT(1)
4
X-XT(N)
5
ANS =YT(N)
7
K=N-1
DO 8 i=2,K
10
ANS= YT(i)
X-XT(i)
9
ANS=(YT(i)-YT(i-1))*(X-XT(i-1)) /(XT(i)-XT(i-1))+YT(i-1)
8
CONTINUE
6
ANS=(YT(N)-YT(N-1))*(X-XT(N-1)) /(XT(N)-XT(N-1))+YT(N-1)
2
RETURN

SHOCK FUNCTION

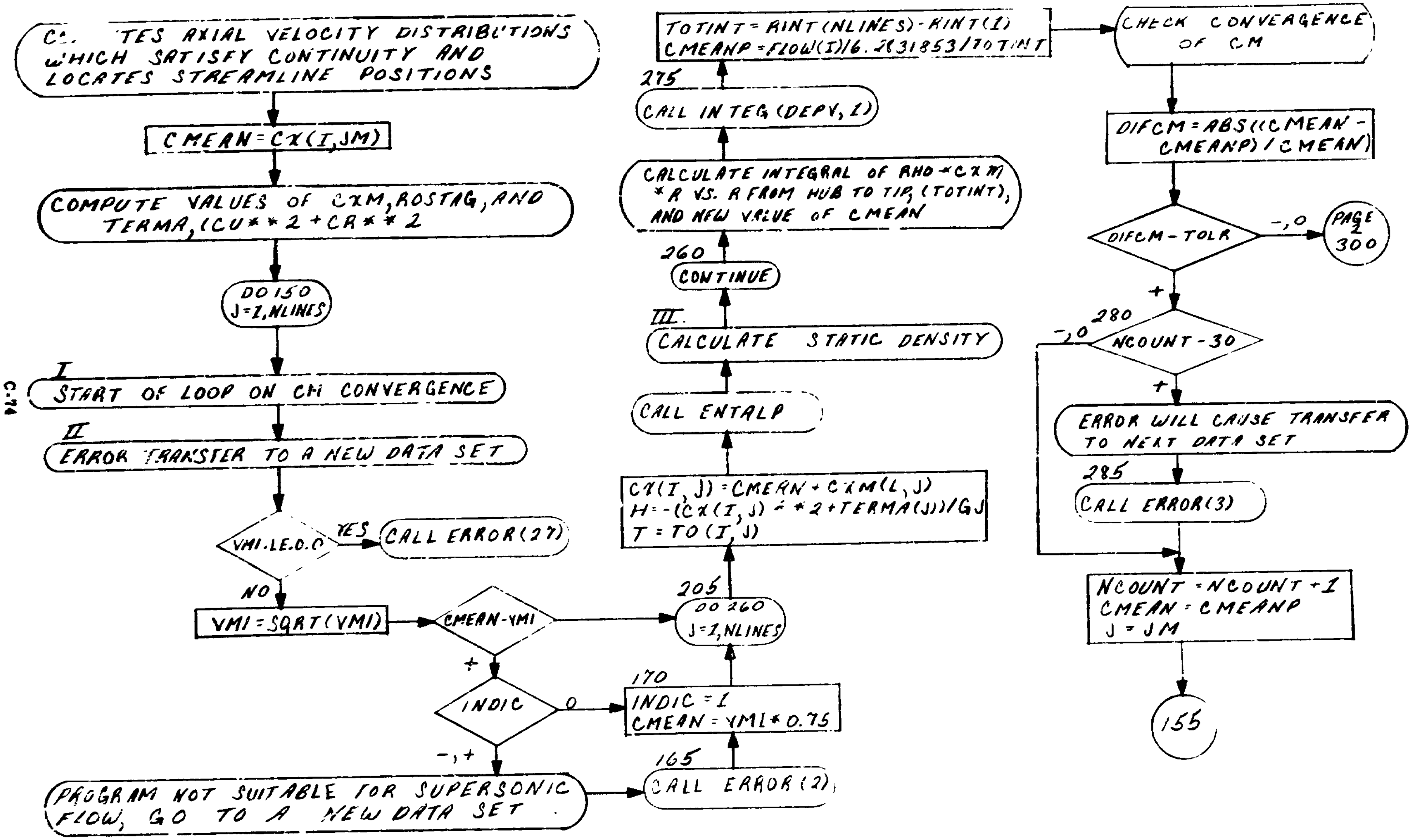


CALCULATES SUPERSONIC EXPANSION ANGLE MINUS PRANDTL-MEYER ANGLE

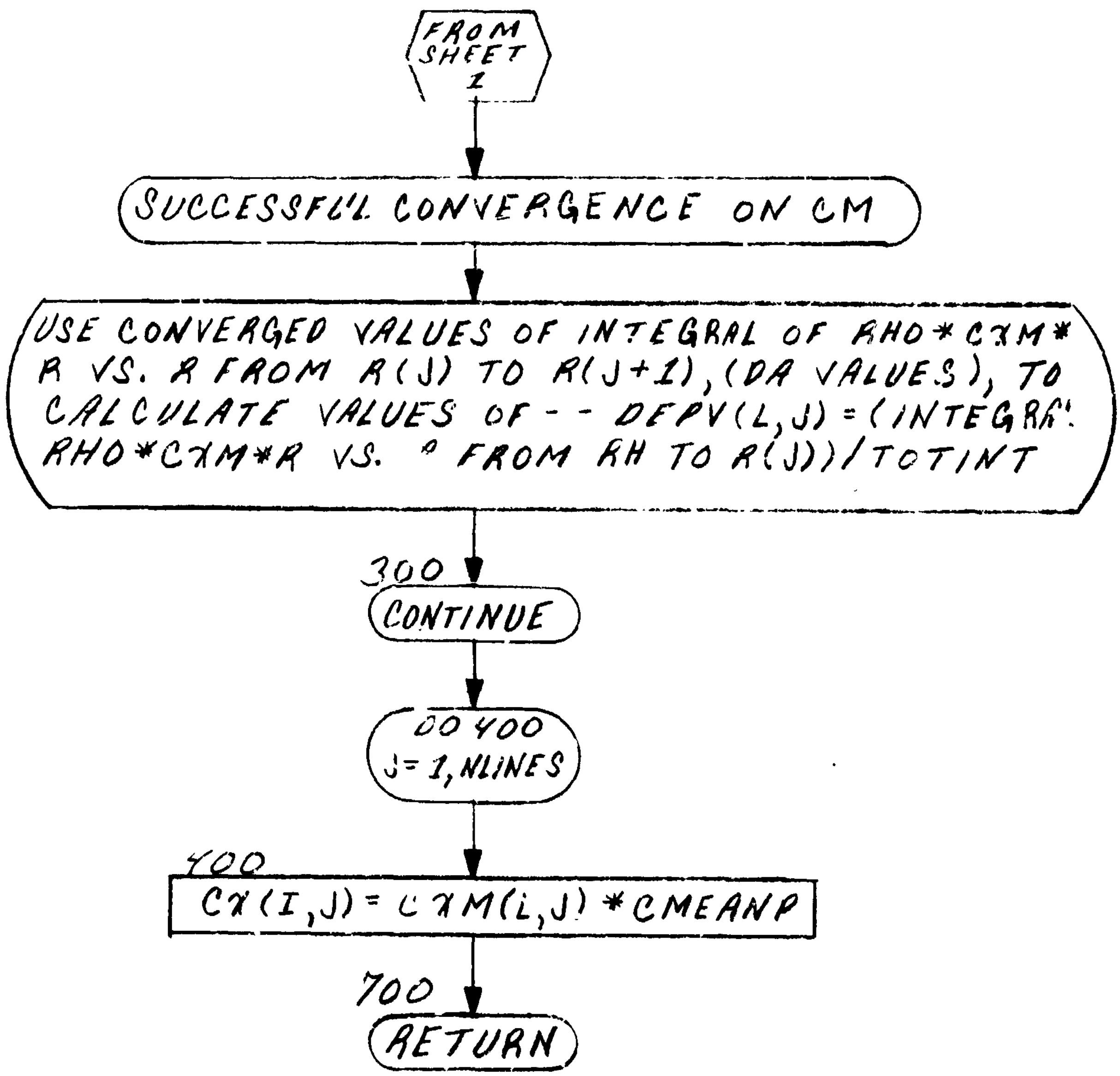
STAOUT


SUBROUTINE STAOUT
COMPUTES STATOR EXIT GEOMETRY
L = Z
LSTAGE.NE.7
YES
NO
ESTIMATE THE DOWN-STREAM STATOR PROPERTIES
45
CALL COFY
RETURN
END
.NOT.FPATH
YES
NO
PICK UP THE STATOR GEOMETRY
20
RH(I) = HUB(I)
RS(I) = TIP(I)
ESTIMATE THE FIRST STATOR GEOMETRY IF REQUIRED
RS(7) = RS(6)
DT = (RS(6)-RH(6))/ASPECT(7)
RH(7) = RH(6)+DT*AMIN1(0.6,0.8*BLH(7))
X(7) = X(6)+DT
25
CALL RSTART
DO 3 J=1,NLNES
INITIALIZE THE FLOW PARAMETERS
CP(I,J) = CP(I-1,J)
3
CALL INEST
CALL STREAM
CALL MOVE
RETURN

STREAM
SHEET 1 OF 3



DIV. ALLISON GMC.	REPORT NO	PAGE	JOB NO.	PAGE
TITLE STREAM SHEET 2 OF 3		PREPARED		DATE
		CHECKED		
		APPROVED		



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DIV. ALLISON GMC.	REPORT NO.	PAGE	JOB NO.	PAGE
TITLE STREAM SHEET 3 OF 3		PREPARED		DATE
		CHECKED		
		APPROVED		

```
I.   CXM(L,J)=CX(I,J)/CMEAN
150  TERMA(J)=CU(I,J)**2+CR(I,J)**2
     NCOUNT=1

II.  INDIC=0
     J=JM
155  H=-(CMEAN**2+TERMA(J))/GJ
     T=TO(I,J)
     CALL ENTALP
     CALL GAM
     VMI=GR2*GAMMER*TSTAT(J)

III. B=PO(I,J)*EXP((THERM3(TSTAT(J))
        -THERM3(TO(I,J)))/OCP)
     RHO(I,J)=B/TSTAT(J)/GASK
     DEPV(L,J)=RHO(I,J)*CXM(L,J)
```

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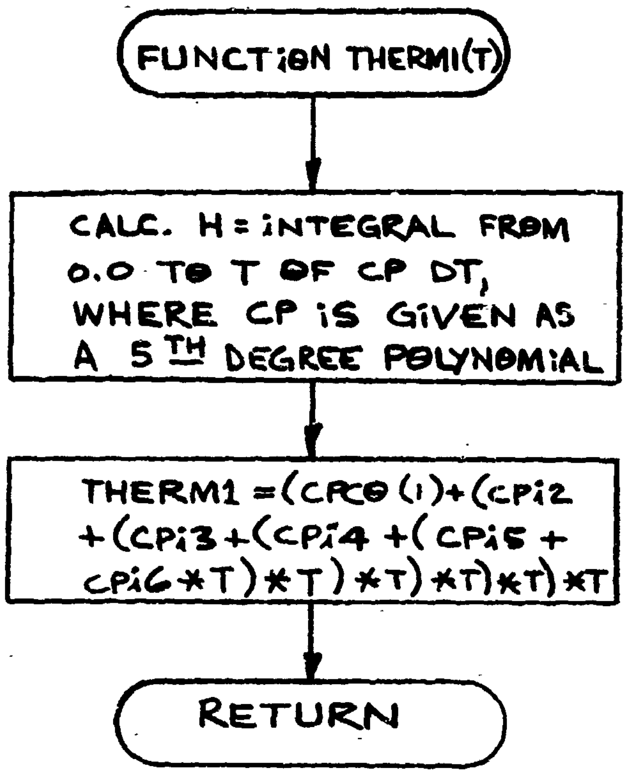
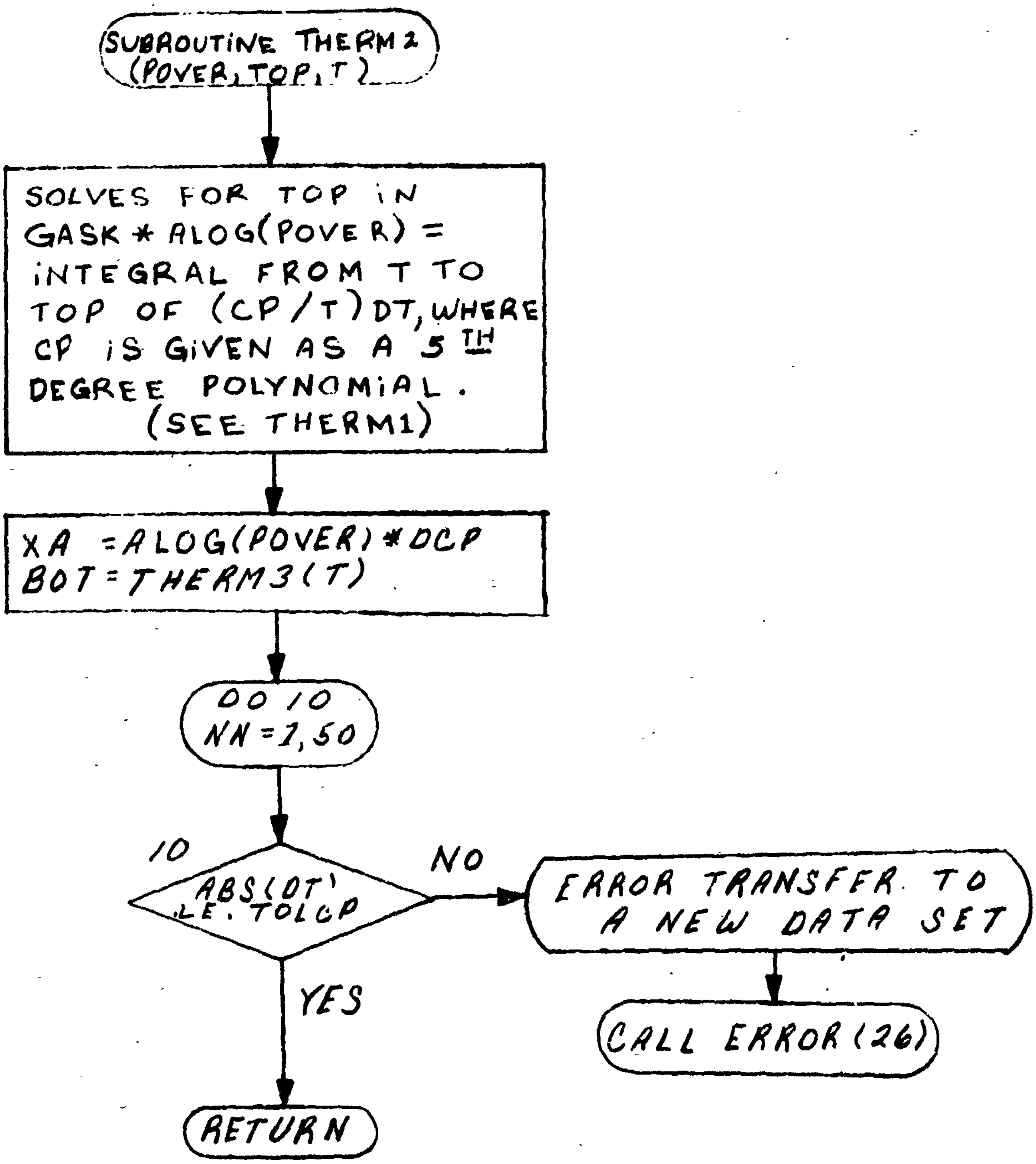
FORM 1577 REV. 7-57

THERM1 FUNCTION

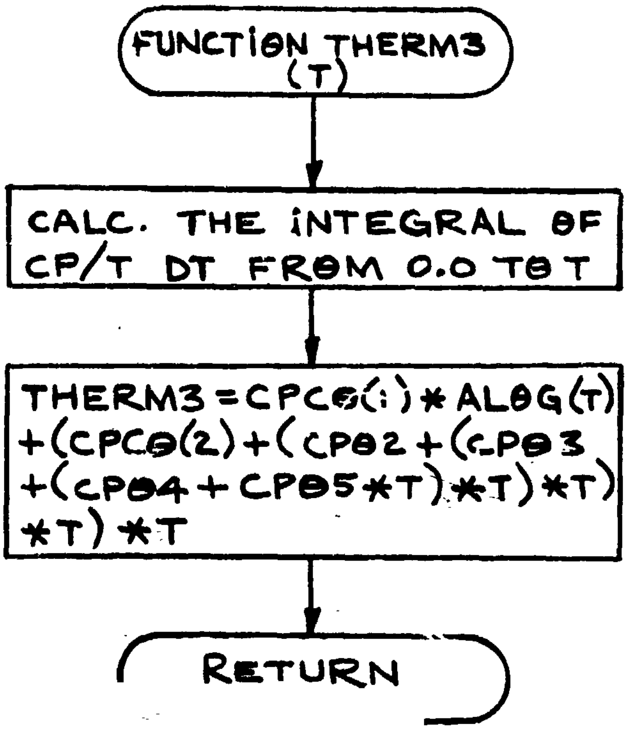


THERM2

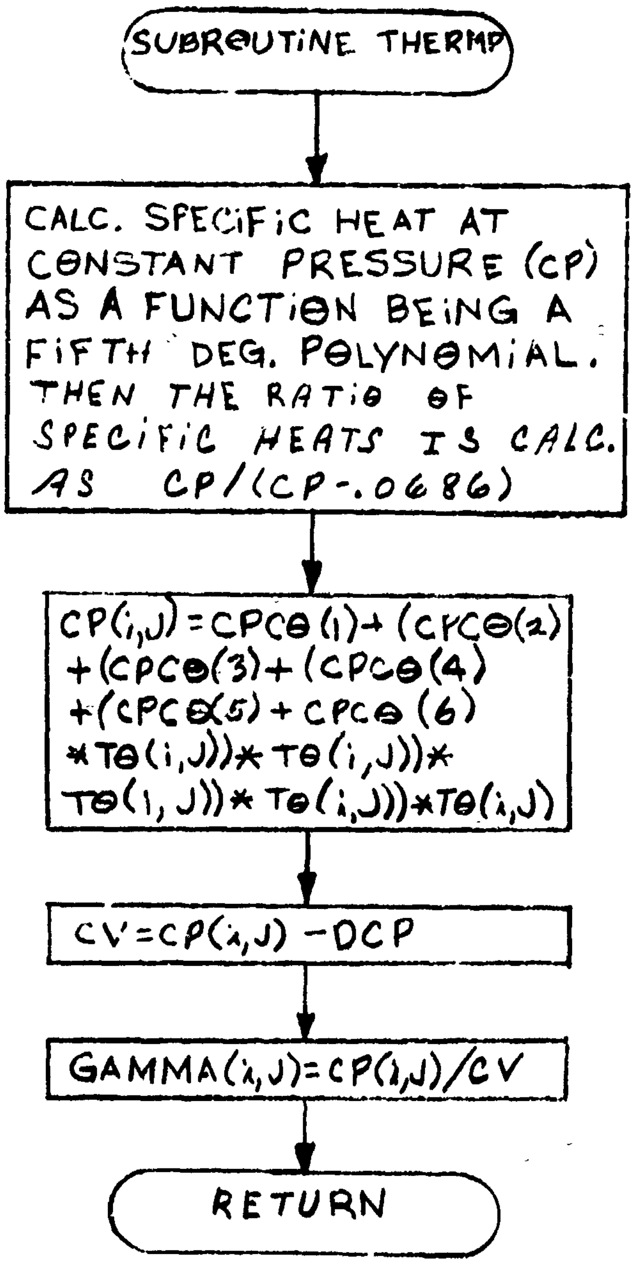


SUBROUTINE THERM2 (POVER, TOP, T)
SOLVES FOR TOP IN GASK * ALOG(POVER) = INTEGRAL FROM T TO TOP OF (CP/T)DT, WHERE CP IS GIVEN AS A 5 TH DEGREE POLYNOMIAL. (SEE THERM1)
XA =ALOG(POVER)*DCP
BOT=THERM3(T)
DO 10 NN=1,50
10
ABS(DT) .LE. TOLCP
NO
ERROR TRANSFER TO A NEW DATA SET
CALL ERROR(26)
YES
RETURN

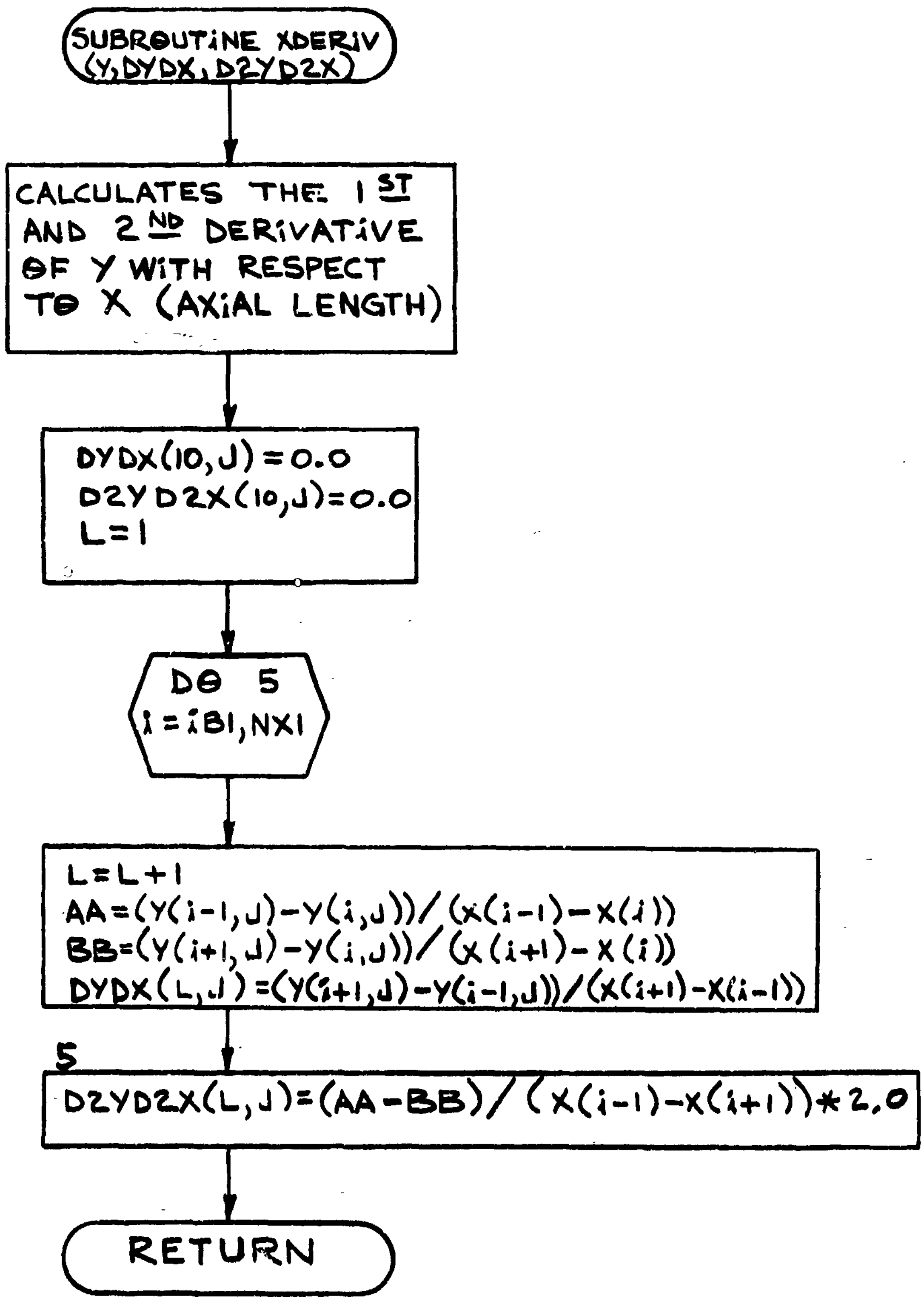
THERM3 FUNCTION



THERMP


SUBROUTINE THERMP
CALC. SPECIFIC HEAT AT CONSTANT PRESSURE (CP) AS A FUNCTION BEING A FIFTH DEG. POLYNOMIAL. THEN THE RATIO OF SPECIFIC HEATS IS CALC. AS CP/(CP-.0686)
CP(I,J)=CPCO(1)+(CPCO(2)+(CPCO(3)+(CPCO(4)+(CPCO(5)+CPCO(6)*TO(I,J))*TO(I,J))*TO(I,J))*TO(I,J))*TO(I,J)
CV=CP(I,J)-DCP
GAMMA(I,J)=CP(I,J)/CV
RETURN

XDERIV S.R.


SUBROUTINE XDERIV (Y,DYDX,D2YD2X)
CALCULATES THE 1ST AND 2ND DERIVATIVE OF Y WITH RESPECT TO X (AXIAL LENGTH)
DYDX(10,J)=0.0
D2YD2X(10,J)=0.0
L=1
DO 5
I=IB1,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
RETURN

APPENDIX D

INPUT FORMAT AND SAMPLE DATA SETS

APPENDIX D

Part A. Input Format—Data Preparation

Q45 DATA PREPARATION

The Q45 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, tip tangential absolute velocity, 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.

Two primary options have been incorporated in this design program. These are:

- Modification I—Annulus wall geometry defined to compute aerodynamics and axial velocities.
- Modification II—Mean streamline axial velocity ratio defined to compute aerodynamic and annulus wall geometry.

The procedure necessary to use these options will become evident in the following description of input data preparation. Reference can be 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 non-integer 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 which is printed out at the beginning of the output data.

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

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

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

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

Temperature	0° to 1700°R	500° to 3400°R	1500° to 5000°R
a_0	0.23746571	0.257348261	0.18198209
a_1	$0.219619999 \times 10^{-4}$	$-0.82118436 \times 10^{-4}$	$0.87076455 \times 10^{-4}$
a_2	$-0.87791471 \times 10^{-7}$	$0.11967112 \times 10^{-6}$	$-0.28093746 \times 10^{-7}$
a_3	$0.13991136 \times 10^{-9}$	$-0.57795091 \times 10^{-10}$	$0.50606304 \times 10^{-11}$
a_4	$-0.78056154 \times 10^{-13}$	$0.12572563 \times 10^{-13}$	$-0.40556182 \times 10^{-15}$
a_5	$0.15042604 \times 10^{-16}$	$-0.10414624 \times 10^{-17}$	$0.18191946 \times 10^{-19}$

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 ($\bar{\omega}_p \cos \beta_2' / 2\sigma$) versus diffusion factor at each of 10, 50 and 90% annulus height stations of the geometric annulus. (For the 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. As will be shown later, any one of these loss data sets in the buffer zone can be specified for any rotor or stator blade row as desired. 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. 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 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

Option to compute annulus walls through input of mean streamline blade row axial velocity ratio or to read in annulus wall geometry. Read in "TRUE" for annulus walls calculation or "FALSE" for annulus walls geometry read-in.

Columns 21-25

Any one or several of the following options may be selected by inputting a trigger value equal to the sum of the integers corresponding to the desired individual options. The options are:

Integer 1: Specify suction surface expansion from leading edge to normal shock intersection through fraction of total camber.

Integer 2: Card punch flow path coordinates.

Integer 4: Specify suction surface expansion from leading edge to normal shock intersection through flow angle at shock.

If options 1 and 2 are desired, input integer 3. Possible trigger values are 1, 2, 3, 4 and 6.

Columns 26-30

Instructions can be given to ensure that each stage has reached a limit on either rotor tip diffusion factor, maximum rotor tip tangential velocity, 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 stator 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 latter alternative is desired, then an integer "1" is read in for this instruction.

Summarizing, we have

Number 0: Drive calculation to one of its aerodynamic limits in each stage.

Integer 1: In converged design, all parameters will be less than or equal to their input limiting values.

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 °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 (°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.

CARD 7—CONVERGENCE TOLERANCES AND EXIT AREAS

Columns 1-10

Loading relative error tolerance defines the degree of convergence to be obtained during drive option on the controlling limit value for each stage. A recommended loading 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. Blank.

Columns 31-40

Degree of convergence on mean streamline axial velocity ratio across each blade row. A recommended tolerance is 0.01. Should be read in only if "TRUE" is specified on Card 5.

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. ANNULUS WALLS SPECIFIED.

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 on 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 fraction of 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, ANNULUS WALLS SPECIFIED.

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 non-computed stage data. The exit stations' tip radius is always equal to the last stator exit 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—FLOW PATH DATA, ANNULUS WALLS COMPUTED.

For the five inlet stations, the Card Type 8 is used. Two Card Type 10 cards are used for each stage specified on Card 5 plus 3 exit stations (Card Type 11). Thus, the maximum number of Card Type 10 cards is 24.

Columns 1-10

Axial velocity ratio across the blade or vane row along the mean streamline.

Columns 11-20

Maximum hub ramp angle for the blade or vane row (degrees). This angle is based on a straight line relationship between stations. It is recommended that a linear variation between desired rotor one hub and last stator hub versus blade row number be used as an estimate for the first flow path calculation.

Columns 21-30. Blockage factor at hub.

Columns 31-40

Maximum case ramp angle (i.e., negative value) for the blade or vane row (degrees). Hub ramp angle statements apply here also except tip ramp angle is $\leq 0°$ and both hub and tip ramp angle limits cannot be zero for the same axial station.

Columns 41-50. Blockage factor at tip.

Columns 51-60

Blade or vane aspect ratio based on axial inlet station annulus height divided by axial station distance (i.e., projected chord).

CARD TYPE 11—EXIT STATION DATA. ANNULUS WALLS COMPUTED.

Three exit station cards are required for the exit annulus which specifies the blockage factor at hub and tip. The axial station locations are successively incremented from the last station a distance equal to the last station row axial spacing. The exit station tip radius is always equal to the last stator out tip radius.

Columns 1-10. Blank.

Columns 11-20. Blank.

Columns 21-30. Blockage factor at hub.

Columns 31-40. Blank.

Columns 41-50. Blockage factor at tip.

CARD TYPE 12—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 12. If 9 or 11 streamlines are specified, the additional streamline values are entered on a second Card Type 12. 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 13—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 specified at axial station 5. Two cards are used in fields of ten if more than seven streamlines are specified as defined for Card Type 12. A value of zero is read in for each streamline if no vanes or zero loss is desired.

CARD TYPE 14—INLET GUIDE VANE EXIT WHIRL 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 15—FIRST ROTOR ADIABATIC EFFICIENCY ESTIMATE

Estimate of rotor adiabatic efficiency for start of iteration. One value per streamline from hub to tip in fields of 10 columns. Two cards are used if more than seven streamlines are specified as defined for Card Type 12. Succeeding rotors assume previous rotor efficiency calculated as first estimate for this rotor.

CARD TYPE 16—FIRST STAGE ADIABATIC EFFICIENCY ESTIMATE

Estimate of stage adiabatic efficiencies for start of iteration on stator losses. One value per streamline specified from hub to tip as described for Card Type 15.

CARD TYPE 17—LOADING LIMIT DATA FOR EACH STAGE

Card Types 17 through 24 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 limits.

Columns 41-50

Maximum rotor exit tip tangential velocity permissible (ft/sec).

CARD TYPE 18—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 equally among streamtubes.

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 19—ROTOR EXIT TOTAL PRESSURE PROFILE

The total pressure profile is defined by the following expression.

$$\frac{P_t}{P_{t_T}} = \frac{A}{B + p} + C + Dp + Ep^2$$

where

$$p = \frac{R - R_H}{R_T - R_H}$$

Note that during design computations, this polynomial is normalized before each use. That is, the ratio P_t/P_{t_T} is set to 1.0 for $p = (R_{T_e} - R_{H_g})/(R_{T_g} - R_{H_g})$.

The program user should avoid using B = 0. In the case of zero blockage, p_{H_e} = 0 and for B = 0, the term A/(B + p) results in a division by zero at the hub.

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 20—ROTOR SHOCK LOSS PARAMETER

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. One of two methods may be selected (Card 5, Columns 21-25). These are (1) ratio of supersonic turning to total turning, ϕ_{ss}/ϕ; and (2) suction surface flow angle, β_{ss}, (degrees) at shock intersection. These data are to be established along the streamline airfoil section. The method of input is identical to Card Type 19 where P_t/P_{t_T} is replaced by ϕ_{ss}/ϕ or β_{ss}. The program user should beware of using β_{ss} on the first attempt at designing a given compressor. Very large shock losses can result, since it is difficult to guess appropriate values for β_{ss} in advance.

CARD TYPE 21—ROTOR SOLIDITY

Solidity, σ, for the streamline airfoil section as a function of p, the fraction of blade height. The method of input is identical to Card Type 19 where P_t is replaced by σ.

CARD TYPE 22—STATOR 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. The fields for constants A through E are identical to Card Type 19.

CARD TYPE 23—STATOR SHOCK LOSS PARAMETER

Identical procedure to that for the rotor on Card Type 20.

CARD TYPE 24—STATOR SOLIDITY

Identical procedure to that for the rotor on Card Type 21.

APPENDIX D

Part B. Sample Design Problem Data Set

ALLISON 7094 COMPUTER DATA SHEET

SECURITY MARKINGS – ☐ UNCLASSIFIED ☐ CONFIDENTIAL ☐ SECRET ☐ RESTRICTED DATA NOTE ☐ ESPIONAGE NOTE ☐ AUTOMATIC DOWNGRADING STAMP

FORM 2456 (REV. 3/60)

PROBLEM TITLE Q45 — Axial Flow Compressor Design (Program III)

JOB NUMBER ______ CHARGE NO ______

RETURN TO ______ DEPT. ______

PAGE __ OF __

IDENTIFICATION NUMBER

Card Type	Cols 1–10	Cols 11–20	Cols 21–30	Cols 31–40	Cols 41–50	Cols 51–60	Cols 61–70	Cols 71–80
1	Title	Card						
2	a_0			a_1		a_2		
3	a_3			a_4		a_5		
4	← Buffer	Zone	→					
5	$N \le 12$ n	← Option	Triggers →	ω	M	T_{T00}	P_{T00}	
6	$(R_t)_{av}$	$V_{\theta s}$	ωt	T_{Tt}	U_{T1}			
7	L_t	η_{adt}		$(V_{\theta o}/V_{\theta i})_t$	A_{i-2}/A_{i-3}	A_{i-1}/A_{i-3}	A_i/A_{i-3}	
8	Z	R_H	δ^*_H	R_T	δ^*_T			
9	Z		δ^*_H		δ^*_T			
10	$V_{\theta o}/V_{\theta i}$	$\alpha_{H\,min}$	δ^*_H	$\alpha_{T\,min}$	δ^*_T	AR		
11			δ^*_H		δ^*_T			
12	C.O	$w_{n=2}/w$	$w_{n=3}/w$	$w_{n=4}/w$	$w_{n=5}/w$	$w_{n=6}/w$	$w_{n=7}/w$	
13	$\bar{\omega}_{n=1}$	$\bar{\omega}_{n=2}$	$\bar{\omega}_{n=3}$	$\bar{\omega}_{n=4}$	$\bar{\omega}_{n=5}$	$\bar{\omega}_{n=6}$	$\bar{\omega}_{n=7}$	
14	A	B	C	D	E			
15	$\eta_{ad\,n=1}$	$\eta_{ad\,n=2}$	$\eta_{ad\,n=3}$	$\eta_{ad\,n=4}$	$\eta_{ad\,n=5}$	$\eta_{ad\,n=6}$	$\eta_{ad\,n=7}$	
16	$\eta_{ad\,n=1}$	$\eta_{ad\,n=2}$	$\eta_{ad\,n=3}$	$\eta_{ad\,n=4}$	$\eta_{ad\,n=5}$	$\eta_{ad\,n=6}$	$\eta_{ad\,n=7}$	
17	D_{ST}	M_{2H}	β'_{2H}	D_{2H}	$V_{\theta 2T}$			
18	$\bar{\omega}^*_{PR}$ Set $\bar{\omega}^*_s$ Set	Δ_{wR}	$\Delta_{w/s}$					
19	A	B	C	D	E			
20	A	B	C	D	E			
21	A	B	C	D	E			
22	A	B	C	D	E			
23	A	B	C	D	E			
24	A	B	C	D	E			

ALLISON 7094 COMPUTER DATA SHEET

SECURITY MARKINGS ☐ ☐ ☐ ☐ SECRET ☐ RESTRICTED DATA NOTE ☐ ESPIONAGE NOTE ☐ AUTOMATIC DOWNGRADING STAMP

FORM 2485 (REV 3/64)

PROBLEM TITLE EXAMPLE - Q45 ANNULUS WALL GEOMETRY SPECIFIED (PROGRAM III)

JOB NUMBER ______ CHARGE NO ______ PAGE 1 OF 6

RETURN TO ______ DEPT. ______

IDENTIFICATION NUMBER

Card	Cols 1–10	Cols 11–20	Cols 21–30	Cols 31–40	Cols 41–50	Cols 51–60	Cols 61–72
1		EXAMPLE - Q45 ANNULUS WALL GEOMETRY SPECIFIED(PROGRAM III)					
2	.23747	E 0.21962		E-04-.87791		E-07	
3	.13991	E-09-.78056		E-13-.15043		E-16	
4	1 2						
5	10 11	1FALSE	4	.0401	28.97	518.69	14.7
6	9.	.01	.0005	.05	1200.		
7	.01	.01			.94	.93	.92
8	0.	7.	1.	25.	1.		
9	3.	7.415	1.	25.	1.		
10	6.	8.58	1.	25.	1.		
11	9.	10.35	1.	25.	1.		
12	12.	12.5	.995	25.	.995		
13	15.125	14.9	.992	25.	.992		
14	17.65	16.4	.99	25.	.99		
15	20.107	17.75	.987	25.	.987		
16	22.178	18.7	.985	25.	.985		
17	24.658	19.688	.983	25.	.983		
18	26.783	20.522	.98	25.	.98		
19	28.575	21.15	.98	25.	.98		
20	30.173	21.625	.98	25.	.98		
21	31.525	21.991	.98	25.	.98		
22	33.1	22.4	.98	25.	.98		
23	34.48	22.733	.98	25.	.98		
24	35.4	22.948	.98	25.	.98		

ALLISON 7094 COMPUTER DATA SHEET

SECURITY MARKINGS

FORM 2455 (REV. 7/61)

PROBLEM TITLE EXAMPLE — Q45 Annulus Wall Geometry Specified (Program III)

JOB NUMBER

CHARGE NO.

RETURN TO

DEPT.

IDENTIFICATION NUMBER

Card	Cols 1–10	Cols 11–20	Cols 21–30	Cols 31–40	Cols 41–50	Cols 51–60	Cols 61–70
1	36.8	23.24	.98	25.	.98		
2	37.7	23.3	.98	25.	.98		
3	39.	23.3	.98	25.	.98		
4	40.	23.3	.98	25.	.98		
5	41.	23.3	.98	25.	.98		
6	42.	23.3	.98	25.	.98		
7	43.	23.3	.98	25.	.98		
8	44.	23.3	.98	25.	.98		
9	45.		.98		.98		
10	46.		.98		.98		
11	47.		.98		.98		
12	0.	.1	.2	.3	.4	.5	.6
13	.7	.8	.9	1.			
14	0.	0.	0.	0.	0.	0.	0.
15	0.	0.	0.	0.			
16	0.	0.	0.	0.	0.		
17	.97	.98	.97	.965	.95	.925	.89
18	.85	.81	.745	.68			
19	.96	.97	.96	.955	.94	.915	.88
20	.84	.8	.735	.67			
21	.35	.73	20.	.47	1000.		
22	1	20.	0.				
23	0.	0.	1.	0.	0.		
24	24.965	1.	11.41	37.894	-7.346		

ALLISON 7094 COMPUTER DATA SHEET

SECURITY MARKINGS

FORM 2455 (REV 3/64)

PROBLEM TITLE EXAMPLE—Q45 Annulus Wall Geometry Specified (Program III)

JOB NUMBER CHARGE NO

RETURN TO DEPT.

IDENTIFICATION NUMBER

	1–10	11–20	21–30	31–40	41–50
1	5.34	1.	-3.035	2.341	-.681
2	0.	0.	0.	0.	0.
3	15.134	1.	10.55	-5.393	2.977
4	2.505	1.	-.639	.536	-.149
5	.40	.73	20.	.47	1000.
6	1	20.	0.		
7	0.	0.	1.	0.	0.
8	.906	1.	38.37	16.647	-1.797
9	1.446	1.	.555	.004	.017
10	0.	0.	0.	0.	0.
11	32.268	1.	-7.855	17.788	-8.422
12	3.324	1.	-1.617	1.986	-.914
13	.45	.73	20.	.47	1000.
14	1	20.	0.		
15	0.	0.	1.	0.	0.
16	-2.357	1.	44.108	8.773	-.041
17	-.184	1.	1.952	-.812	.251
18	0.	0.	0.	0.	0.
19	-1.821	1.	25.875	-8.868	2.952
20	-.268	1.	1.846	-.744	.226
21	.45	.73	20.	.47	1000.
22	1	20.	0.		
23	0.	0.	1.	0.	0.
24	2.67	1.	40.57	11.722	-3.008

ALLISON 7094 COMPUTER DATA SHEET

SECURITY MARKINGS

PROBLEM TITLE EXAMPLE – Q45 Annulus Wall Geometry Specified (Program III)

JOB NUMBER CHARGE NO

RETURN TO DEPT.

IDENTIFICATION NUMBER

FORM 2449 (REV 5/64)

Line	Cols 1–10	Cols 11–20	Cols 21–30	Cols 31–40	Cols 41–50
1	-.166	1.	1.787	-.594	.19
2	0.	0.	0.	0.	0.
3	2.989	1.	19.497	-2.854	1.055
4	-.149	1.	1.629	-.463	.124
5	.45	.73	20.	.47	1000.
6	1	20.	0.		
7	0.	0.	1.	0.	0.
8	.824	1.	44.248	8.006	-1.364
9	.045	1.	1.463	-.24	.054
10	0.	0.	0.	0.	0.
11	-4.609	1.	26.502	-8.353	3.812
12	-.176	1.	1.619	-.402	.114
13	.45	.73	20.	.47	1000.
14	1	20.	0.		
15	0.	0.	1.	0.	0.
16	4.036	1.	40.724	9.451	-2.853
17	.167	1.	1.288	-.053	-.018
18	0.	0.	0.	0.	0.
19	.312	1.	20.599	-3.152	1.554
20	-.125	1.	1.521	-.298	.082
21	.45	.73	20.	.47	1000.
22	1	20.	0.		
23	0.	0.	1.	0.	0.
24	.916	1.	42.868	7.906	-2.895

ALLISON 7094 COMPUTER DATA SHEET

SECURITY MARKINGS - ☐ SECRET ☐ ESPIONAGE NOTE ☐ AUTOMATIC DOWNGRADING STAMP

FORM 2489 (REV. 3/64)

PROBLEM TITLE EXAMPLE—Q45 Annulus Wall Geometry Specified (Program III)

JOB NUMBER ______ CHARGE NO ______

RETURN TO ______ DEPT. ______

IDENTIFICATION NUMBER

Card	Cols 1–10	Cols 11–20	Cols 21–30	Cols 31–40	Cols 41–50
1	.057	1.	1.359	-.101	.013
2	0.	0.	0.	0.	0.
3	-5.493	1.	26.374	-6.42	3.198
4	-.034	1.	1.462	-.141	.024
5	.45	.73	20.	.47	1000.
6	1	20.	0.		
7	0.	0.	1.	0.	0.
8	0.	0.	49.9	57.8	0.
9	0.	0.	1.368	-.099	.06
10	0.	0.	0.	0.	0.
11	0.	0.	33.	1.7	0.
12	0.	0.	1.368	-.099	.06
13	.45	.73	20.	.47	1000.
14	1	20.	0.		
15	0.	0.	1.	0.	0.
16	0.	0.	49.9	57.8	0.
17	0.	0.	1.368	-.099	.06
18	0.	0.	0.	0.	0.
19	0.	0.	33.	1.7	0.
20	0.	0.	1.368	-.099	.06
21	.45	.73	20.	.47	1000.
22	1	20.	0.		
23	0.	0.	1.	0.	0.
24	0.	0.	49.9	57.8	0.

ALLISON 7094 COMPUTER DATA SHEET

SECURITY MARKINGS

PROBLEM TITLE EXAMPLE—Q45 Annulus Wall Geometry Specified (Program III)

JOB NUMBER CHARGE NO

RETURN TO DEPT.

FORM 2485 (REV 3/64)

	1–10	11–20	21–30	31–40	41–50	IDENTIFICATION NUMBER (73–80)
1	0.	0.	1.368	-.099	.06	
2	0.	0.	0.	0.	0.	
3	0.	0.	33.	1.7	0.	
4	0.	0.	1.368	-.099	.06	

ALLISON 7094 COMPUTER DATA SHEET

SECURITY MARKINGS – ☐ UNCLASSIFIED ☐ CONFIDENTIAL ☐ SECRET ☐ RESTRICTED DATA NOTE ☐ ESPIONAGE NOTE ☐ AUTOMATIC DOWNGRADING STAMP

FORM 2455 (REV. 5/64)

PROBLEM TITLE EXAMPLE - Q45 AXIAL VELOCITY RATIO SPECIFIED (PROGRAM III)

JOB NUMBER ______ CHARGE NO. ______

RETURN TO ______ DEPT. ______

PAGE 1 OF 6

IDENTIFICATION NUMBER

```
1            EXAMPLE - Q45 AXIAL VELOCITY RATIO SPECIFIED(PROGRAM III)
2  .23747          E  0.21962                  E-04-.87791               E-07
3  .13991          E-09-.78056                 E-13.15043                E-16
4     1  2
5     10    11     1TRUE      4    0401.        28.971       518.69      14.7
6  9.0       .01           .0005       .05       1200.
7  .01       .01                       .01       .94         .93          .92
8  0.        7.           1.           25.       1.
9  3.        7.415        1.           25.       1.
10 6.        8.58         1.           25.       1.
11 9.        10.35        1.           25.       1.
12 12.       12.5         .995         25.       .995
13 .95       40.          .992         0.        .992        4.0
14 1.05      37.2         .990         0.        .990        4.0
15 .95       34.5         .987         0.        .987        3.5
16 1.05      31.7         .985         0.        .985        3.5
17 .95       28.9         .983         0.        .983        2.5
18 1.05      26.2         .98          0.        .98         2.5
19 .95       23.4         .98          0.        .98         2.5
20 1.05      20.6         .98          0.        .98         2.5
21 .95       17.9         .98          0.        .98         2.5
22 1.05      15.1         .98          0.        .98         2.5
23 .95       12.3         .98          0.        .98         2.5
24 1.05      9.5          .98          0.        .98         2.5
```

ALLISON 7094 COMPUTER DATA SHEET

SECURITY MARKINGS

FORM 2499 (REV 5/64)

PROBLEM TITLE EXAMPLE—Q45 Axial Velocity Ratio Specified (Program III)

JOB NUMBER

CHARGE NO

RETURN TO

DEPT.

IDENTIFICATION NUMBER

	1–10	11–20	21–30	31–40	41–50	51–60	61–70	71–72	73–80
1	.95	6.8	.98	0.	.98	2.5			
2	1.05	4.0	.98	0.	.98	2.5			
3	.95	4.0	.98	0.	.98	2.5			
4	1.05	4.0	.98	0.	.98	2.5			
5	.95	4.0	.98	0.	.98	2.5			
6	1.05	4.0	.98	0.	.98	2.5			
7	.95	4.0	.98	0.	.98	2.5			
8	1.05	4.0	.98	0.	.98	2.5			
9			.98		.98				
10			.98		.98				
11			.98		.98				
12	0.	.1	.2	.3	.4	.5	.6		
13	.7	.8	.9	1.0					
14	0.	0.	0.	0.	0.	0.	0.		
15	0.	0.	0.	0.					
16	0.	0.	0.	0.	0.				
17	.97	.98	.97	.965	.95	.925	.89		
18	.85	.81	.745	.68					
19	.96	.97	.96	.955	.94	.915	.88		
20	.84	.8	.735	.67					
21	.35	.73	20.	.47	1000.				
22	1	20.	0.						
23	0.	0.	1.	0.	0.				
24	0.	0.	37.4	16.6	0.				

FORM 2455 (REV 3/54)

ALLISON 7094 COMPUTER DATA SHEET

SECURITY MARKINGS

PROBLEM TITLE EXAMPLE—Q45 Axial Velocity Ratio Specified (Program III)

JOB NUMBER CHARGE NO

RETURN TO DEPT.

IDENTIFICATION NUMBER

	1–10	11–20	21–30	31–40	41–50
1	4.83	1.	-2.528	1.917	-.504
2	0.	0.	0.	0.	0.
3	0.	0.	36.5	-6.5	0.
4	0.	0.	1.857	-1.715	.858
5	.40	.73	20.	.47	1000.
6	1	20.	0.		
7	0.	0.	1.	0.	0.
8	0.	0.	38.7	12.7	0.
9	2.473	1.	-.473	.916	-.38
10	0.	0.	0.	0.	0.
11	0.	0.	38.	-2.	0.
12	0.	0.	1.716	-1.076	.48
13	.45	.73	20.	.47	1000.
14	1	20.	0.		
15	0.	0.	1.	0.	0.
16	0.	0.	42.	8.8	0.
17	.379	1.	1.389	-.369	.09
18	0.	0.	0.	0.	0.
19	0.	0.	40.	-1.	0.
20	0.	0.	1.563	-.591	.218
21	.45	.73	20.	.47	1000.
22	1	20.	0.		
23	0.	0.	1.	0.	0.
24	0.	0.	41.	10.8	0.

ALLISON 7094 COMPUTER DATA SHEET

SECURITY MARKINGS

FORM 2455 (REV. 5/64)

PROBLEM TITLE EXAMPLE – Q45 Axial Velocity Ratio Specified (Program III)

JOB NUMBER ______ CHARGE NO ______

RETURN TO ______ DEPT. ______

PAGE 4 OF 6

IDENTIFICATION NUMBER

Line	Cols 1–10		Cols 11–20	Cols 21–30	Cols 31–40	Cols 41–50
1	.526		1.	1.124	-.127	.04
2	0.		0.	0.	0.	0.
3	0.		0.	39.5	-1.	0.
4	0.		0.	1.498	-.384	.096
5	.45		.73	20.	.47	1000.
6	c1	20.		0.		
7	0.		0.	1.	0.	0.
8	0.		0.	43.4	9.1	0.
9	.063		1.	1.445	-.222	.045
10	0.		0.	0.	0.	0.
11	0.		0.	38.3	0.	0.
12	0.		0.	1.439	-.269	.07
13	.45		.73	20.	.47	1000.
14	1	20.		0.		
15	0.		0.	1.	0.	0.
16	0.		0.	46.5	8.1	0.
17	.105		1.	1.35	-.102	0.
18	0.		0.	0.	0.	0.
19	0.		0.	37.1	0.	0.
20	0.		0.	1.392	-.2	.048
21	.45		.73	20.	.47	1000.
22	1	20.		0.		
23	0.		0.	1.	0.	0.
24	0.		0.	49.9	57.8	0.

ALLISON 7094 COMPUTER DATA SHEET

FORM 2485 (REV 5/64)

SECURITY MARKINGS

PROBLEM TITLE EXAMPLE—Q45 Axial Velocity Ratio Specified (Program III)

JOB NUMBER ______ CHARGE NO ______

RETURN TO ______ DEPT. ______

IDENTIFICATION NUMBER

Card	Cols 1–10	Cols 11–20	Cols 21–30	Cols 31–40	Cols 41–50
1	.126	1.	1.29	-.043	-.01
2	0.	0.	0.	0.	0.
3	0.	0.	33.	1.7	0.
4	0.	0.	1.368	-.099	.06
5	.45	.73	20.	.47	1000.
6	1	20.	0.		
7	0.	0.	1.	0.	0.
8	0.	0.	49.9	57.8	0.
9	.126	1.	1.29	-.043	-.01
10	0.	0.	0.	0.	0.
11	0.	0.	33.	1.7	0.
12	0.	0.	1.368	-.099	.06
13	.45	.73	20.	.47	1000.
14	1	20.	0.		
15	0.	0.	1.	0.	0.
16	0.	0.	49.9	57.8	0.
17	.126	1.	1.29	-.043	-.01
18	0.	0.	0.	0.	0.
19	0.	0.	33.	1.7	0.
20	0.	0.	1.368	-.099	.06
21	.45	.73	20.	.47	1000.
22	1	20.	0.		
23	0.	0.	1.	0.	0.
24	0.	0.	49.9	57.8	0.

ALLISON 7094 COMPUTER DATA SHEET

SECURITY MARKINGS

PROBLEM TITLE EXAMPLE—Q45 Axial Velocity Ratio Specified (Program III)

JOB NUMBER CHARGE NO

RETURN TO DEPT.

PAGE 6 OF 6

IDENTIFICATION NUMBER

1	.126	1.	1.29	-.043	-.01
2	0.	0.	0.	0.	0.
3	0.	0.	33.	1.7	0.
4	0.	0.	1.368	-.099	.06

APPENDIX E

OUTPUT FORMAT—SAMPLE DESIGN PROBLEMS

EXAMPLE - ANNULUS WALL GEOMETRY SPECIFIED (PROGRAM III) 10/31/67

****---*** ADVANCED MULTISTAGE AXIAL-FLOW COMPRESSOR ***---****

-- ANALYSIS AT DESIGN CONDITIONS **--**

----I N P U T D A T A----

THE MACHINE IS TO HAVE NO MORE THAN 10 STAGES

CALCULATIONS ARE TO BE PERFORMED AT 11 STREAMLINES

THE INLET MASS FLOW RATE IS 401.00 LB/SEC

MOLECULAR WEIGHT OF THE FLUID IS 28.97

AXIAL VELOCITY TOLERANCE IS 0.0100

THE EFFICIENCY TOLERANCE IS 0.0100

A TOTAL PRESSURE RATIO OF 9.000 IS DESIRED

THE INLET TOTAL PRESSURE IS 14.70 LBS/SQ IN.

THE INLET TOTAL TEMPERATURE IS 518.69 DEG. R

THE TIP SPEED IS 1200.0 FT./SEC.

THE LOADING LIMIT TOLERANCE IS 0.0100

THE CONTINUITY TOLERANCE IS 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

THE INLET GUIDE VANE EXIT TANGENTIAL VELOCITY IS SPECIFIED BY
A = -0.000000E-38 B = -0.000000E-38C = -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 + -0.78056E-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 0.9400. 0.9300. 0.9200 .

----FLOW PATH DESCRIPTION----

STATION NO.	AXIAL COORDINATE (IN.)	HUB RADIUS (IN.)	HUB BLOCKAGE FACTOR	TIP RADIUS (IN.)	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	19.686	0.983	25.000	0.983
11	26.783	20.522	0.980	25.000	0.980
12	28.575	21.150	0.980	25.000	0.980
13	30.173	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	22.733	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	23.300	0.980	25.000	0.980
23	42.000	23.300	0.980	25.000	0.980
24	43.000	23.300	0.980	25.000	0.980
25	44.000	23.300	0.980	25.000	0.980
26	45.000	23.300	0.980	25.000	0.980
27	46.000	23.300	0.980	25.000	0.980
28	47.000	23.300	0.980	25.000	0.990

.... LOSS DATA SET NUMBER 1 ....

D-FACTOR	AT 10 PERCENT	AT 50 PERCENT	AT 90 PERCENT (OF BLADE HEIGHT FROM THE GEOMETRIC HUB.)
0.000	0.0070	0.0060	0.0080
0.100	0.0073	0.0060	0.0083
0.150	0.0076	0.0068	0.0090
0.200	0.0080	0.0072	0.0096
0.250	0.0083	0.0077	0.0103
0.300	0.0090	0.0080	0.0114
0.350	0.0097	0.0089	0.0127
0.400	0.0108	0.0097	0.0141
0.450	0.0121	0.0108	0.0159
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	0.0176	0.0285
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	0.0628
0.900	0.0464	0.0397	0.0764
0.950	0.0534	0.0464	0.0924
1.000	0.0604	0.0531	0.1084

.... LOSS DATA SET NUMBER 2 ....

C-FACTOR	AT 10 PERCENT	AT 50 PERCENT	AT 90 PERCENT	(OF BLADE HEIGHT FROM THE GEOMETRIC HUB.)
0.000	0.0060	0.0060	0.0060	
0.100	0.0060	0.0060	0.0060	
0.150	0.0068	0.0068	0.0068	
0.200	0.0072	0.0072	0.0072	
0.250	0.0077	0.0077	0.0077	
0.300	0.0080	0.0080	0.0080	
0.350	0.0089	0.0089	0.0089	
0.400	0.0097	0.0097	0.0097	
0.450	0.0108	0.0108	0.0108	
0.500	0.0119	0.0119	0.0119	
0.550	0.0134	0.0134	0.0134	
0.600	0.0152	0.0152	0.0152	
0.650	0.0176	0.0176	0.0176	
0.700	0.0204	0.0204	0.0204	
0.750	0.0236	0.0236	0.0236	
0.800	0.0277	0.0277	0.0277	
0.850	0.0330	0.0330	0.0330	
0.900	0.0397	0.0397	0.0397	
0.950	0.0464	0.0464	0.0464	
1.000	0.0531	0.0531	0.0531	

----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 1/IN.	FLOW ANGLE (DEGREES)
1	7.0000	0.413	453.78	453.78	0.0000	0.00	0.00000	0.0
2	10.3247	0.413	453.78	453.78	0.0000	0.00	0.00000	0.0
3	12.8141	0.413	453.78	453.78	0.0000	0.00	0.00000	0.0
4	14.8930	0.413	453.78	453.78	0.0000	0.00	0.00000	0.0
5	16.7153	0.413	453.78	453.78	0.0000	0.00	0.00000	0.0
6	18.3576	0.413	453.78	453.78	0.0000	0.00	0.00000	0.0
7	19.8645	0.413	453.78	453.78	0.0000	0.00	0.00000	0.0
8	21.2650	0.413	453.78	453.78	0.0000	0.00	0.00000	0.0
9	22.5788	0.413	453.78	453.78	0.0000	0.00	0.00000	0.0
10	23.8202	0.413	453.78	453.78	0.0000	0.00	0.00000	0.0
11	25.0000	0.413	453.78	453.78	0.0000	0.00	0.00000	0.0

S.L. NO.	STREAMLINE RADIUS (IN.)	TOTAL PRES. (LB/SQ IN.)	TOTAL TEMP. (DEGREES)
1	7.0000	14.70	518.69
2	10.3247	14.70	518.69
3	12.8141	14.70	518.69
4	14.8930	14.70	518.69
5	16.7153	14.70	518.69
6	18.3576	14.70	518.69
7	19.8645	14.70	518.69
8	21.2650	14.70	518.69
9	22.5788	14.70	518.69
10	23.8202	14.70	518.69
11	25.0000	14.70	518.69

----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 1/IN.	FLOW ANGLE (DEGREES)
1	7.4150	0.266	294.77	285.06	75.0643	14.75	0.07536	0.0
2	11.3835	0.351	386.82	374.62	96.4113	14.43	-0.05792	0.0
3	13.9211	0.394	433.84	423.30	95.0498	12.65	-0.08959	0.0
4	15.9082	0.422	463.60	455.54	86.0968	10.69	-0.09464	0.0
5	17.5912	0.442	483.83	478.13	74.0473	8.79	-0.08835	0.0
6	19.0783	0.455	497.93	494.20	60.8422	7.01	-0.07647	0.0
7	20.4277	0.464	507.74	505.51	47.4630	5.35	-0.06184	0.0
8	21.6747	0.471	514.37	513.22	34.4459	3.83	-0.04607	0.0
9	22.8424	0.475	518.57	518.10	22.0939	2.44	-0.03013	0.0
10	23.9469	0.477	520.83	520.72	10.5796	1.16	-0.01464	0.0
11	25.0000	0.478	521.52	521.52	-0.0000	-0.00	0.00000	0.0

S.L. NO.	STREAMLINE RADIUS (IN.)	TOTAL PRES. (LB/SQ IN.)	TOTAL TEMP. (DEGREES)
1	7.4150	14.70	518.69
2	11.3835	14.70	518.69
3	13.9211	14.70	518.69
4	15.9082	14.70	518.69
5	17.5912	14.70	518.69
6	19.0783	14.70	518.69
7	20.4277	14.70	518.69
8	21.6747	14.70	518.69
9	22.8424	14.70	518.69

10	23.9469	14.70	518.69
11	25.0000	14.70	518.69

----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 1/IN.	FLOW ANGLE (DEGREES)
1	8.5800	0.340	374.82	336.70	164.7023	26.07	0.04873	0.0
2	11.8685	0.397	436.09	416.91	127.8913	17.17	0.08571	0.0
3	14.1603	0.426	467.43	456.08	102.3773	12.82	0.09140	0.0
4	16.0257	0.444	486.50	479.55	81.9409	9.89	0.08613	0.0
5	17.6432	0.456	498.85	494.61	64.8573	7.66	0.07605	0.0
6	19.0951	0.464	507.01	504.52	50.2675	5.87	0.06376	0.0
7	20.4269	0.469	512.37	510.98	37.6214	4.36	0.05060	0.0
8	21.6670	0.472	515.71	515.03	26.5287	3.07	0.03728	0.0
9	22.8341	0.474	517.55	517.28	16.6998	1.93	0.02426	0.0
10	23.9418	0.474	518.20	518.14	7.9142	0.92	0.01178	0.0
11	25.0000	0.474	517.86	517.86	0.0000	0.00	0.00000	0.0

S.L. NO.	STREAMLINE RADIUS (IN.)	TOTAL PRES. (LB/SQ IN.)	TOTAL TEMP. (DEGREES)
1	8.5800	14.70	518.69
2	11.8665	14.70	518.69
3	14.1603	14.70	518.69
4	16.0257	14.70	518.69
5	17.6432	14.70	518.69
6	19.0951	14.70	518.69
7	20.4269	14.70	518.69
8	21.6670	14.70	518.69
9	22.8341	14.70	518.69
10	23.9418	14.70	518.69
11	25.0000	14.70	518.69

E-6

----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 1/IN.	FLOW ANGLE (DEGREES)
1	10.3500	0.358	395.12	328.42	219.6809	33.78	0.03021	0.0
2	13.2379	0.423	464.64	422.10	194.2094	24.73	0.00200	0.0
3	15.2868	0.464	507.60	479.35	166.9867	19.24	-0.01481	0.0
4	16.9540	0.492	536.58	517.93	140.2486	15.20	-0.02258	0.0
5	18.3983	0.512	556.87	544.89	114.3859	11.96	-0.02485	0.0
6	19.6948	0.525	571.19	563.87	91.1478	9.24	-0.02388	0.0
7	20.8854	0.535	581.10	576.98	69.0471	6.87	-0.02106	0.0
8	21.9962	0.541	587.60	585.60	48.5168	4.78	-0.01728	0.0
9	23.0446	0.545	591.40	590.67	29.4629	2.88	-0.01314	0.0
10	24.0428	0.547	593.00	592.89	11.7815	1.15	-0.00903	0.0
11	25.0000	0.546	592.79	592.77	-4.6354	-0.45	-0.00521	0.0

S.L. NO.	STREAMLINE RADIUS (IN.)	TOTAL PRES. (LB/SQ IN.)	TOTAL TEMP. (DEGREES)
1	10.3500	14.70	518.69
2	13.2379	14.70	518.69
3	15.2868	14.70	518.69
4	16.9540	14.70	518.69
5	18.3983	14.70	518.69
6	19.6948	14.70	518.69
7	20.6854	14.70	518.69
8	21[illegible]	1[illegible]	[illegible]18.[illegible]

9	23.0446	14.70	518.69
10	24.0428	14.70	518.69
11	25.0000	14.70	518.69

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

S.L. NO.	STREAMLINE RADIUS (IN.)	ABS. MACH NUMBER	ABS. VEL. (FT/SEC)	AXIAL VEL. (FT/SEC)	RADIAL VEL. (FT/SEC)	STREAMLINE SLOPE (DEG)	STREAMLINE CURVATURE 1/IN.	FLOW ANGLE (DEGREES)
1	12.5934	0.530	575.76	458.54	348.1945	37.21	0.00374	-0.0
2	14.6314	0.559	605.28	537.07	279.1387	27.51	0.02510	-0.0
3	16.2548	0.576	623.20	581.44	224.2975	21.18	0.03361	-0.0
4	17.6562	0.588	635.06	609.20	179.3805	16.52	0.03524	-0.0
5	18.9146	0.596	643.30	627.53	141.5863	12.83	0.03306	-0.0
6	20.0711	0.602	649.20	639.98	108.9715	9.78	0.02873	-0.0
7	21.1503	0.606	653.42	648.47	80.3361	7.16	0.02335	-0.0
8	22.1683	0.609	656.40	654.09	54.9238	4.88	0.01770	-0.0
9	23.1363	0.611	658.39	657.60	32.2010	2.86	0.01231	-0.0
10	24.0625	0.612	659.61	659.50	11.8028	1.05	0.00753	-0.0
11	24.9531	0.613	660.19	660.16	-6.5231	-0.57	0.00368	-0.0

S.L. NO.	STREAMLINE RADIUS (IN.)	TOTAL PRES. (LB/SQ IN.)	TOTAL TEMP. (DEGREES)	REL. VEL. (FT/SEC)	WHIRL VEL. (FT/SEC)	RELATIVE MACH NO.	REL. FLOW ANG.(DEG)	WHEEL SPEED (FT/SEC)
1	12.5934	14.70	518.69	834.80	-0.00	0.768	46.394	604.483
2	14.6314	14.70	518.69	927.14	-0.00	0.856	49.244	702.306
3	16.2548	14.70	518.69	998.57	-0.00	0.923	51.384	780.233
4	17.6562	14.70	518.69	1059.04	-0.00	0.981	53.154	847.499
5	18.9146	14.70	518.69	1112.71	-0.00	1.031	54.680	907.901
6	20.0711	14.70	518.69	1151.73	-0.00	1.077	56.026	963.414
7	21.1503	14.70	518.69	1207.32	-0.00	1.120	57.233	1015.215
8	22.1683	14.70	518.69	1250.25	-0.00	1.160	58.331	1064.078
9	23.1363	14.70	518.69	1291.04	-0.00	1.198	59.338	1110.541
10	24.0625	14.70	518.69	1330.08	-0.00	1.235	60.270	1154.998
11	24.9531	14.70	518.69	1367.64	-0.00	1.270	61.137	1197.748

ITERATION ON LOADING WAS TAKING PLACE

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

*** STAGE INPUT PARAMETERS ***

ROTOR 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
MAXIMUM TIP TANGENTIAL VELOCITY	1000.0

---ROTOR---

	PRESSURE PROFILE	FLOW ANGLE AT THE SHOCK	SOLIDITY
A	-0.000000E-38	0.249650E 02	0.534000E 01
B	-0.000000E-38	0.100000E 01	0.100000E 01
C	0.100000E 01	0.114100E 02	-0.303500E 01
D	-0.000000E-38	0.378940E 02	0.234100E 01
E	-0.000000E-38	-0.734600E 01	-0.681000E 00

---STATOR---

	WHIRL VELOCITY	FLOW ANGLE AT THE SHOCK	SOLIDITY
A	-0.000000E-38	0.151340E 02	0.250500E 01
B	-0.000000E-38	0.100000E 01	0.100000E 01
C	0.000000E-38	0.105500E 02	-0.639000E 00
D	-0.000000E-38	-0.539300E 01	0.536000E 00
E	-0.000000E-38	0.297700E 01	-0.149000E 00

*** 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--	4.000	14.9000	25.0000	37.524	0.000	3.1250	401.0000	0.8980
-STATOR-	4.000	16.4000	25.0000	30.713	0.000	2.5250	401.0000	0.8856

	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--	0.916	0.9925	0.9925	1.4331	1.1206	1.4331	1.1206	0.8980
-STATOR-	1.095	0.9900	0.9900	1.4263	1.1206	1.4263	1.1206	0.8856

	LOSS DATA SET USED
-ROTOR--	1
-STATOR-	2

------ ROTOR EXIT **------**

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	15.0011	499.467	485.36	346.07	777.693	0.6912	38.616	21.118
2	16.4272	534.513	445.84	261.15	750.679	0.6648	36.435	29.570
3	17.6600	555.734	418.69	230.82	733.086	0.6475	34.829	35.485
4	18.7705	569.154	400.12	188.70	720.860	0.6353	33.715	39.872
5	19.7938	579.035	384.61	152.53	711.666	0.6261	32.713	43.362
6	20.7504	585.954	372.16	120.42	704.520	0.6188	31.887	46.203
7	21.6550	589.984	363.21	91.36	698.820	0.6128	31.315	48.560
8	22.5188	591.342	357.22	64.81	694.067	0.6075	30.976	50.570
9	23.3501	591.041	353.51	40.46	689.380	0.6026	30.825	52.328
10	24.1551	588.660	351.78	18.07	686.000	0.5980	30.850	53.901
11	24.9395	584.274	352.27	-2.52	682.260	0.5932	31.087	55.332

S.L. NO.	TOTAL TEMP. RATIO	TOTAL PRES. RATIO	ADIABATIC EFFICIENCY	DIFFUSION FACTOR	WHEEL SPEED (FT/SEC)	SOLIDITY	A*/S	LOSS COEFF.
1	1.1122	1.4331	0.9655	0.3169	720.05	2.280	0.6551	0.0406
2	1.1129	1.4331	0.9599	0.3519	788.51	1.922	0.6407	0.0398
3	1.1139	1.4331	0.9508	0.3615	847.68	1.728	0.6223	0.0437
4	1.1157	1.4331	0.9360	0.3639	900.98	1.607	0.6034	0.0525
5	1.1173	1.4331	0.9234	0.3605	950.10	1.525	0.5837	0.0589
6	1.1190	1.4331	0.9103	0.3556	996.02	1.465	0.5639	0.0656
7	1.1212	1.4331	0.8938	0.3516	1039.44	1.420	0.5448	0.0746
8	1.1239	1.4331	0.8739	0.3490	1080.90	1.383	0.5266	0.0859
9	1.1272	1.4331	0.8517	0.3475	1120.30	1.351	0.5091	0.0988
10	1.1309	1.4331	0.8273	0.3472	1159.45	1.323	0.4923	0.1131
11	1.1354	1.4331	0.8002	0.3485	1197.09	1.297	0.4765	0.1295

S.L. NO.	TOTAL TEMP. (DEGREES)	TOTAL PRES. (LB/SQ IN.)	STATIC TEMP. (DEGREES)	STATIC PRES. (LB/SQ IN.)	SLOPE (DEGREES)	CURVATURE 1/IN.	REL. VEL. (FT/SEC)	REL. MACH NUMBER
1	576.89	21.06	526.54	15.30	34.72	-0.03412	651.3943	0.5790
2	577.23	21.06	530.32	15.66	27.75	-0.02663	694.3831	0.6150
3	577.79	21.06	533.05	15.89	22.57	-0.02117	739.0227	0.6529
4	578.72	21.06	535.46	16.05	18.37	-0.01656	781.2868	0.6887
5	579.54	21.06	537.38	16.17	14.79	-0.01237	823.6072	0.7247
6	580.41	21.06	539.10	16.26	11.65	-0.00833	864.3149	0.7593
7	581.55	21.06	540.91	16.34	8.84	-0.00463	902.0606	0.7911
8	582.98	21.06	542.89	16.41	6.28	-0.00165	936.9298	0.8202
9	584.66	21.06	545.05	16.49	3.94	0.00030	969.3848	0.8470
10	586.60	21.06	547.44	16.54	1.77	0.00096	999.5848	0.8715
11	588.90	21.06	550.17	16.60	-0.25	0.00003	1027.1838	0.8933

------ S T A T O R   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	16.5082	582.940	-0.00	334.38	672.034	0.5903	-0.000	49.699
2	17.6041	603.710	-0.00	277.16	664.291	0.5828	-0.000	51.828
3	18.6037	617.834	-0.00	230.34	659.374	0.5779	-0.000	53.558
4	19.5326	628.208	-0.00	190.24	656.381	0.5746	-0.000	55.004
5	20.4065	635.921	-0.00	154.85	654.501	0.5725	-0.000	56.250
6	21.2360	641.754	-0.00	123.07	653.487	0.5711	-0.000	57.336
7	22.0286	646.399	-0.00	94.17	653.222	0.5702	-0.000	58.293
8	22.790	650.026	-0.00	67.55	653.566	0.5698	-0.000	59.144
9	23.5250	652.980	-0.00	42.81	654.382	0.5697	-0.000	59.907
10	24.2369	655.292	-0.00	19.63	655.586	0.5698	-0.000	60.598
11	24.9287	657.155	-0.00	-2.25	657.159	0.5701	-0.000	61.224

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	0.9918	0.9424	0.3051	792.39	1.844	0.7097	0.0298
2	1.0000	0.9933	0.9412	0.2980	845.00	1.622	0.7168	0.0259
3	1.0000	0.9942	0.9347	0.2942	892.98	1.472	0.7214	0.0235
4	1.0000	0.9948	0.9219	0.2927	937.56	1.363	0.7234	0.0217
5	1.0000	0.9953	0.9107	0.2912	979.51	1.280	0.7258	0.0203
6	1.0000	0.9955	0.8986	0.2900	1019.33	1.213	0.7276	0.0193
7	1.0000	0.9959	0.8830	0.2895	1057.37	1.158	0.7280	0.0184
8	1.0000	0.9961	0.8639	0.2898	1093.92	1.1[illegible]	0.7269	0.0176
9	1.0000	0.9963	0.8424	0.2906	1129.20	1.071	0.7246	0.0170
10	1.0000	0.9965	0.8167	0.2920	1163.37	1.035	0.7210	0.0165
11	1.0000	0.9966	0.7922	0.2941	1196.58	1.003	0.7158	0.0160

S.L. NO.	TOTAL TEMP. (DEGREES)	TOTAL PRES. (LB/SQ IN.)	STATIC TEMP. (DEGREES)	STATIC PRES. (LB/SQ IN.)	SLOPE (DEGREES)	CURVATURE 1/IN.	REL. VEL. (FT/SEC)	REL. MACH NUMBER
1	576.89	20.89	539.29	16.50	29.84	-0.01236	1038.9978	0.9126
2	577.23	20.92	540.50	16.62	24.70	-0.00373	1074.8519	0.9430
3	577.79	20.94	541.60	16.70	20.52	0.00033	1110.0362	0.9729
4	578.72	20.95	542.86	16.75	16.93	0.00189	1144.4915	1.0020
5	579.54	20.96	543.88	16.78	13.78	0.00190	1178.0569	1.0304
6	580.41	20.97	544.87	16.81	10.95	0.00082	1210.8150	1.0581
7	581.55	20.97	546.04	16.82	8.37	-0.00068	1242.8727	1.0849
8	582.98	20.98	547.43	16.83	5.99	-0.00193	1274.2905	1.1110
9	584.66	20.98	549.03	16.84	3.79	-0.00240	1305.1070	1.1362
10	586.60	20.99	550.84	16.84	1.74	-0.00167	1335.3727	1.1606
11	588.90	20.99	552.97	16.84	-0.20	0.00069	1365.1575	1.1843

--- 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
MAXIMUM TIP TANGENTIAL VELOCITY	1000.0

---ROTOR---

	PRESSURE PROFILE	FLOW ANGLE AT THE SHOCK	SOLIDITY
A	-0.000000E-38	0.560000E 00	0.144600E 01
B	-0.000000E-38	0.100000E 01	0.100000E 01
C	0.100000E 01	0.383700E 02	0.555000E 00
D	-0.000000E-38	0.166470E 02	0.430000E-02
E	-0.000000E-38	-0.179700E 01	0.170000E-01

---STATOR---

	WHIRL VELOCITY	FLOW ANGLE AT THE SHOCK	SOLIDITY
A	-0.000000E-38	0.322680E 02	0.332400E 01
B	-0.000000E-38	0.100000E 01	0.100000E 01
C	0.000000E-38	-0.785500E 01	-0.161700E 01
D	-0.000000E-38	0.177880E 02	0.198600E 01
E	-0.000000E-38	-0.842200E 01	-0.914000E 00

*** 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--	3.500	17.7500	25.0000	28.787	0.000	2.4570	401.0000	0.9023
-STATOR-	3.501	13.7000	25.0000	24.642	0.000	2.0710	401.0000	0.8891

	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--	0.904	0.9875	0.9875	1.4635	1.1271	2.0875	1.2630	0.8886
-STATOR-	1.083	0.9850	0.9850	1.4558	1.1271	2.0764	1.2630	0.8816

	LOSS DATA SET USED
-ROTOR--	1
-STATOR-	2

----- R O T O R   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	17.8568	559.791	498.56	264.07	800.943	0.6702	38.497	29.776
2	18.7190	566.644	475.48	240.77	777.908	0.6491	37.679	34.493
3	19.5243	571.640	458.19	203.07	760.228	0.6327	37.064	38.293
4	20.2874	574.818	444.89	169.49	746.366	0.6194	36.589	41.431
5	21.0155	577.961	431.92	139.40	734.864	0.6086	35.998	44.134
6	21.7138	579.968	421.23	111.71	725.452	0.5995	35.496	46.437
7	22.3877	580.449	413.54	85.94	717.857	0.5918	35.175	48.407
8	23.0420	579.638	408.26	61.88	711.678	0.5852	35.006	50.123
9	23.6804	577.597	405.10	39.36	706.593	0.5792	34.982	51.643
10	24.3062	574.344	403.91	18.28	702.387	0.5739	35.103	53.008
11	24.9224	569.677	404.67	-1.44	698.944	0.5689	35.379	54.250

S.L. NO.	TOTAL TEMP. RATIO	TOTAL PRES. RATIO	ADIABATIC EFFICIENCY	DIFFUSION FACTOR	WHEEL SPEED (FT/SEC)	SOLIDITY	A*/S	LOSS COEFF.
1	1.1231	1.4686	0.9409	0.4103	857.22	1.982	0.6435	0.0567
2	1.1229	1.4663	0.9379	0.4124	898.51	1.828	0.6185	0.0566
3	1.1234	1.4650	0.9317	0.4124	937.17	1.713	0.5974	0.0594
4	1.1243	1.4641	0.9235	0.4114	973.79	1.624	0.5791	0.0640
5	1.1249	1.4635	0.9184	0.4069	1008.74	1.552	0.5615	0.0657
6	1.1256	1.4630	0.9119	0.4023	1042.26	1.492	0.5454	0.0686
7	1.1269	1.4626	0.9020	0.3993	1074.61	1.442	0.5307	0.0742
8	1.1286	1.4623	0.8894	0.3975	1106.02	1.400	0.5170	0.0818
9	1.1308	1.4620	0.8742	0.3970	1136.66	1.363	0.5043	0.0914
10	1.1334	1.461	0.8556	0.3976	1166.70	1.330	0.4924	0.1027
11	1.1364	1.4615	0.8368	0.3995	1196.27	1.302	0.4812	0.1158

S.L. NO.	TOTAL TEMP. (DEGREES)	TOTAL PRES. (LB/SQ IN.)	STATIC TEMP. (DEGREES)	STATIC PRES. (LB/SQ IN.)	SLOPE (DEGREES)	CURVATURE 1/IN.	REL. VEL. (FT/SEC)	REL. MACH NUMBER
1	647.88	30.68	594.62	22.70	26.95	-0.02827	722.2049	0.6043
2	648.20	30.68	597.96	23.11	23.03	-0.02160	747.0012	0.6234
3	649.12	30.68	601.14	23.43	19.57	-0.01552	772.9344	0.6433
4	650.68	30.68	604.44	23.66	16.45	-0.01024	799.3056	0.6635
5	651.90	30.68	607.08	23.89	13.59	-0.00559	828.3679	0.6861
6	653.33	30.68	609.65	24.06	10.92	-0.00138	857.0403	0.7084
7	655.35	30.68	612.59	24.21	8.44	0.00205	883.9270	0.7289
8	657.96	30.68	615.94	24.33	6.11	0.00426	909.2158	0.7477
9	661.11	30.68	619.70	24.44	3.91	0.00488	932.9230	0.7649
10	664.83	30.68	623.92	24.54	1.83	0.00358	955.0134	0.7804
11	669.25	30.68	627.75	24.64	.14	0.00004	975.3941	0.7940

****-----** S T A T O R   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	18.8101	601.556	-0.00	255.69	653.643	0.5390	-0.000	54.097
2	19.5287	606.165	-0.00	221.55	647.263	0.5333	-0.000	55.375
3	20.2133	614.062	-0.00	190.51	642.935	0.5292	-0.000	56.469
4	20.8691	619.471	-0.00	161.78	640.247	0.5262	-0.000	57.415
5	21.5002	623.999	-0.00	134.88	638.411	0.5241	-0.000	58.259
6	22.1098	627.931	-0.00	109.62	637.427	0.5226	-0.000	59.010
7	22.7004	631.562	-0.00	85.66	637.344	0.5217	-0.000	59.676
8	23.2746	634.941	-0.00	62.77	638.036	0.5212	-0.000	60.269
9	23.8344	638.079	-0.00	40.80	639.382	0.5211	-0.000	60.800
10	24.3814	641.017	-0.00	19.64	641.318	0.5212	-0.000	61.278
11	24.9173	643.844	-0.00	-0.79	643.844	0.5216	-0.000	61.706

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	0.9919	0.9200	0.3685	902.88	1.686	0.7002	0.0310
2	1.0000	0.9930	0.9137	0.3631	937.38	1.565	0.6964	0.0285
3	1.0000	0.9937	0.9154	0.3569	970.24	1.486	0.6924	0.0268
4	1.0000	0.9942	0.9086	0.3504	1001.72	1.430	0.6884	0.0255
5	1.0000	0.9946	0.9047	0.3433	1032.01	1.385	0.6866	0.0243
6	1.0000	0.9950	0.8992	0.3369	1061.27	1.346	0.6848	0.0233
7	1.0000	0.9953	0.8901	0.3323	1089.62	1.308	0.6822	0.0224
8	1.0000	0.9955	0.8785	0.3296	1117.18	1.263	0.6789	0.0216
9	1.0000	0.9958	0.8639	0.3291	1144.05	1.225	0.6748	0.0209
10	1.0000	0.9960	0.8470	0.3311	1170.31	1.178	0.6699	0.0202
11	1.0000	0.9962	0.8278	0.3362	1196.03	1.125	0.6640	0.0195

S.L. NO.	TOTAL TEMP. (DEGREES)	TOTAL PRES. (LB/SQ IN.)	STATIC TEMP. (DEGREES)	STATIC PRES. (LB/SQ IN.)	SLOPE (DEGREES)	CURVATURE 1/IN.	REL. VEL. (FT/SEC)	REL. MACH NUMBER
1	647.88	30.43	612.42	24.97	23.03	-0.02155	1114.6521	0.9192
2	648.20	30.46	613.43	25.10	20.04	-0.01759	1139.1352	0.9387
3	649.12	30.43	614.81	25.19	17.27	-0.01529	1163.9267	0.9580
4	650.68	30.50	616.66	25.26	14.68	-0.01385	1188.8458	0.9771
5	651.90	30.51	616.08	25.31	12.24	-0.01287	1213.5139	0.9962
6	653.33	30.52	619.62	25.34	9.94	-0.01222	1237.9837	1.0151
7	655.35	30.53	621.65	25.37	7.76	-0.01153	1262.3313	1.0333
8	657.96	30.54	624.19	25.38	5.67	-0.01031	1286.5403	1.0510
9	661.11	30.55	627.21	25.39	3.68	-0.00809	1310.5959	1.0681
10	664.93	30.55	630.73	25.39	1.76	-0.00445	1334.5072	1.0846
11	669.25	30.56	634.89	25.39	-0.07	0.00100	1358.3154	1.1004

-- 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
MAXIMUM TIP TANGENTIAL VELOCITY	1000.0

---ROTOR---

	PRESSURE PROFILE	FLOW ANGLE AT THE SHOCK	SOLIDITY
A	-0.000000E-38	-0.235700E 01	-0.184000E 00
B	-0.000000E-38	0.100000E 01	0.100000E 01
C	0.100000E 01	0.441000E 02	0.195200E 01
D	-0.000000E-38	0.377300E 01	-0.812000E 00
E	-0.000000E-38	-0.410000E-01	0.251000E 00

---STATOR---

	WHIRL VELOCITY	FLOW ANGLE AT THE SHOCK	SOLIDITY
A	-0.000000E-38	-0.182100E 01	-0.268000E 00
B	-0.000000E-38	0.100000E 01	0.100000E 01
C	0.000000E-38	0.258750E 02	0.184600E 01
D	-0.000000E-38	-0.886900E 01	-0.744000E 00
E	-0.000000E-38	0.295200E 01	0.226000E 00

*** 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	19.0880	23.0000	21.722	0.000	2.4800	401.0000	0.9063
-STATOR-	2.500	20.5220	23.0000	21.429	0.000	2.1250	401.0000	0.8936

	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--	0.925	0.9825	0.9825	1.4831	1.1306	3.0796	1.4280	0.8825
-STATOR-	1.122	0.9800	0.9800	1.4754	1.1306	3.0636	1.4280	0.977[illegible]

	LOSS DATA SET USED
-ROTOR--	1
-STATOR-	2

----- R O T O R   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	19.7932	559.230	526.91	219.93	799.215	0.6269	41.246	35.153
2	20.3788	566.564	511.40	193.48	787.387	0.6168	40.503	37.942
3	20.9392	572.124	499.13	168.05	777.620	0.6080	39.931	40.315
4	21.4794	576.023	489.67	143.62	769.547	0.6004	39.517	42.361
5	22.0029	579.350	481.86	120.18	762.312	0.5935	39.205	44.192
6	22.5117	580.706	473.86	97.98	755.882	0.5874	38.821	45.853
7	23.0080	581.077	458.11	76.64	750.567	0.5818	38.585	47.321
8	23.4942	581.387	464.38	56.18	746.201	0.5767	38.486	48.635
9	23.9729	579.404	463.20	36.57	742.696	0.5719	38.585	49.821
10	24.4464	576.173	463.81	17.89	739.378	0.5674	38.820	50.911
11	24.9168	571.345	466.73	0.13	737.750	0.5631	39.245	51.923

S.L. NO.	TOTAL TEMP. RATIO	TOTAL PRES. RATIO	ADIABATIC EFFICIENCY	DIFFUSION FACTOR	WHEEL SPEED (FT/SEC)	SOLIDITY	AN/S	LOSS COEFF.
1	1.1278	1.4373	0.9334	0.4632	950.07	1.756	0.5851	0.0648
2	1.1277	1.4857	0.9320	0.4559	978.18	1.687	0.5694	0.0640
3	1.1278	1.4847	0.9289	0.4509	1005.08	1.624	0.5556	0.0649
4	1.1283	1.4839	0.9233	0.4477	1031.01	1.567	0.5435	0.0675
5	1.1291	1.4833	0.9172	0.4455	1056.14	1.515	0.5326	0.0716
6	1.1296	1.4827	0.9128	0.4420	1080.56	1.469	0.5220	0.0736
7	1.1304	1.4823	0.9061	0.4402	1104.38	1.427	0.5121	0.0775
8	1.1316	1.4819	0.8974	0.4399	1127.72	1.390	0.5030	0.0831
9	1.1332	1.4815	0.8854	0.4418	1150.70	1.357	0.4946	0.0916
10	1.1352	1.4813	0.8714	0.4449	1173.43	1.328	0.4868	0.1017
11	1.1377	1.4810	0.8548	0.4459	1196.01	1.303	0.4796	0.1140

S.L. NO.	TOTAL TEMP. (DEGREES)	TOTAL PRES. (LB/SQ IN.)	STATIC TEMP. (DEGREES)	STATIC PRES. (LB/SQ IN.)	SLOPE (DEGREES)	CURVATURE 1/IN.	REL. VEL. (FT/SEC)	REL. MACH NUMBER
1	730.70	45.26	677.91	34.75	21.47	-0.00239	734.9627	0.5765
2	730.95	45.26	679.72	35.03	18.86	-0.00094	759.1721	0.5947
3	732.10	45.26	682.14	35.27	16.38	0.00098	782.0238	0.6115
4	734.18	45.26	685.26	35.49	14.01	0.00297	803.4211	0.6268
5	736.07	45.26	688.07	35.68	11.75	0.00472	823.8515	0.6415
6	738.00	45.26	690.62	35.85	9.59	0.00619	845.5257	0.6571
7	740.83	45.26	694.32	36.00	7.52	0.00729	865.4839	0.6709
8	744.53	45.26	698.57	36.14	5.53	0.00767	883.8491	0.6831
9	749.20	45.26	703.58	36.27	3.62	0.00691	899.8372	0.6930
10	754.75	45.26	709.60	36.40	1.78	0.00462	914.2449	0.7012
11	761.44	45.26	716.57	36.52	0.01	0.00040	926.4307	0.7071

****----** S T A T O R   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	20.6211	624.380	-0.00	229.64	665.271	0.5158	-0.000	56.094
2	21.1017	631.452	-0.00	201.82	662.921	0.5138	-0.000	56.796
3	21.5667	637.517	-0.00	175.66	661.276	0.5120	-0.000	57.430
4	22.0183	642.929	-0.00	150.90	660.401	0.5106	-0.000	58.000
5	22.4562	647.438	-0.00	127.21	659.816	0.5094	-0.000	58.530
6	22.8878	651.290	-0.00	104.53	659.625	0.5086	-0.000	59.019
7	23.3081	654.946	-0.00	82.85	660.166	0.5080	-0.000	59.456
8	23.7204	658.509	-0.00	61.96	661.417	0.5077	-0.000	59.847
9	24.1256	662.086	-0.00	41.62	663.394	0.5076	-0.000	60.193
10	24.5247	665.681	-0.00	21.70	666.034	0.5078	-0.000	60.499
11	24.9183	669.415	-0.00	2.06	669.419	0.5082	-0.000	60.765

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	0.9932	0.9164	0.3777	989.81	1.568	0.6490	0.0293
2	1.0000	0.9937	0.9161	0.3721	1012.88	1.516	0.6502	0.0281
3	1.0000	0.9941	0.9141	0.3682	1035.20	1.467	0.6503	[illegible]
4	1.0000	0.9944	0.9100	0.3656	1056.88	1.421	0.6494	[illegible]
5	1.0000	0.9947	0.9041	0.3636	1078.00	1.379	0.6478	0.0251
6	1.0000	0.9949	0.9003	0.3612	1098.61	1.340	0.6472	0.0243
7	1.0000	0.9952	0.8943	0.3594	1118.79	1.305	0.6455	0.0236
8	1.0000	0.9954	0.8862	0.3581	1138.58	1.273	0.6428	0.0230
9	1.0000	0.9955	0.8748	0.3574	1158.03	1.245	0.6386	0.0225
10	1.0000	0.9957	0.8613	0.3569	1177.18	1.220	0.6333	0.0220
11	1.0000	0.9958	0.8452	0.3568	1196.08	1.198	0.6264	0.0216

S.L. NO.	TOTAL TEMP. (DEGREES)	TOTAL PRES. (LB/SQ IN.)	STATIC TEMP. (DEGREES)	STATIC PRES. (LB/SQ IN.)	SLOPE (DEGREES)	CURVATURE 1/IN.	REL. VEL. (FT/SEC)	REL. MACH NUMBER
1	730.70	44.95	694.14	37.51	20.19	-0.02011	1192.6079	0.9246
2	730.95	44.97	694.65	37.58	17.74	-0.01966	1210.5355	0.9382
3	732.10	44.99	695.99	37.64	15.42	-0.01937	1228.3838	0.9511
4	734.18	45.00	698.17	37.69	13.23	-0.01898	1246.2428	0.9635
5	736.07	45.02	700.12	37.73	11.14	-0.01829	1263.8956	0.9758
6	736.00	45.03	702.08	37.76	9.14	-0.01723	1281.4272	0.9879
7	740.83	45.04	704.80	37.78	7.23	-0.01567	1299.0414	0.9996
8	744.53	45.05	708.43	37.80	5.39	-0.01331	1316.7517	1.0107
9	749.20	45.06	712.89	37.81	3.61	-0.00979	1334.5875	1.0212
10	754.75	45.06	718.17	37.81	1.87	-0.00463	1352.5395	1.0312
11	761.44	45.07	724.51	37.81	0.18	0.00262	1370.6669	1.0406

--- 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
MAXIMUM TIP TANGENTIAL VELOCITY	1000.0

---ROTOR---

	PRESSURE PROFILE	FLOW ANGLE AT THE SHOCK	SOLIDITY
A	-0.000000E-38	0.267000E 01	-0.166000E 00
B	-0.000000E-38	0.100000E 01	0.100000E 01
C	0.100000E 01	0.405700E 02	0.178700E 01
D	-0.000000E-38	0.117220E 02	-0.594000E 00
E	-0.000000E-38	-0.300800E 01	0.190000E 00

---STATOR---

	WHIRL VELOCITY	FLOW ANGLE AT THE SHOCK	SOLIDITY
A	-0.000000E-38	0.298900E 01	-0.149000E 00
B	-0.000000E-38	0.100000E 01	0.100000E 01
C	0.000000E-38	0.194970E 02	0.162900E 01
D	-0.000000E-38	-0.285400E 01	-0.463000E 00
E	-0.000000E-38	0.105500E 01	0.124000E 00

*** 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--	2.499	21.1500	25.0000	19.313	0.000	1.7920	401.0000	0.9111
-STATOR-	2.409	21.6250	25.0000	16.554	0.000	1.5980	401.0000	0.8981

	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--	0.923	0.9800	0.9800	1.4301	1.1165	4.3812	1.5944	0.8778
-STATOR-	1.081	0.9800	0.9800	1.4232	1.1165	4.3600	1.5944	0.8743

	LOSS DATA SET USED
-ROTOR--	1
-STATOR-	2

----- R O T O R   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	21.2338	597.287	501.17	169.68	802.433	0.5944	38.650	39.579
2	21.6315	598.967	491.66	166.57	792.615	0.5866	38.338	41.325
3	22.0199	600.134	483.87	144.85	784.394	0.5796	38.088	42.870
4	22.4005	601.087	477.39	124.33	777.664	0.5734	37.874	44.244
5	22.7743	601.361	471.93	104.76	771.578	0.5678	37.709	45.503
6	23.1420	601.170	467.38	86.07	766.325	0.5629	37.582	46.655
7	23.5049	600.219	464.86	68.14	762.233	0.5584	37.580	47.679
8	23.8638	599.267	463.14	50.98	759.091	0.5543	37.599	48.605
9	24.2198	597.225	463.89	34.43	757.004	0.5506	37.792	49.429
10	24.5744	594.139	466.82	18.52	755.824	0.5472	38.144	50.172
11	24.9288	589.868	472.23	3.25	755.617	0.5441	38.679	50.842

S.L. NO.	TOTAL TEMP. RATIO	TOTAL PRES. RATIO	ADIABATIC EFFICIENCY	DIFFUSION FACTOR	WHEEL SPEED (FT/SEC)	SOLIDITY	A*/S	LOSS COEFF.
1	1.1150	1.4324	0.9287	0.4410	1019.22	1.612	0.5575	0.0622
2	1.1148	1.4317	0.9283	0.4390	1038.31	1.567	0.5488	0.0611
3	1.1149	1.4312	0.9270	0.4375	1056.96	1.526	0.5407	0.0609
4	1.1149	1.4307	0.9253	0.4363	1075.22	1.487	0.5333	0.0611
5	1.1152	1.4303	0.9222	0.4354	1093.16	1.451	0.5263	0.0626
6	1.1156	1.4299	0.9181	0.4347	1110.82	1.419	0.5199	0.0648
7	1.1163	1.4296	0.9116	0.4354	1128.23	1.390	0.5140	0.0690
8	1.1170	1.4293	0.9052	0.4363	1145.46	1.364	0.5081	0.0732
9	1.1182	1.4290	0.8956	0.4392	1162.55	1.341	0.5029	0.0801
10	1.1197	1.4288	0.8832	0.4438	1179.57	1.321	0.4982	0.0892
11	1.1217	1.4286	0.8679	0.4505	1196.58	1.303	0.4940	0.1009

S.L. NO.	TOTAL TEMP. (DEGREES)	TOTAL PRES. (LB/SQ IN.)	STATIC TEMP. (DEGREES)	STATIC PRES. (LB/SQ IN.)	SLOPE (DEGREES)	CURVATURE 1/IN.	REL. VEL. (FT/SEC)	REL. MACH NUMBER
1	814.70	64.39	761.82	50.75	17.62	-0.02641	813.0878	0.6023
2	814.90	64.39	763.31	51.05	15.55	-0.01952	827.8497	0.6127
3	816.19	64.39	765.68	51.33	13.58	-0.01308	842.3583	0.6224
4	818.55	64.39	768.93	51.57	11.70	-0.00728	856.8357	0.6318
5	820.86	64.39	772.01	51.78	9.90	-0.00224	870.9401	0.6410
6	823.32	64.39	775.14	51.98	8.16	0.00188	884.7786	0.6499
7	827.00	64.39	779.35	52.15	6.49	0.00486	897.2034	0.6573
8	831.66	64.39	784.42	52.31	4.87	0.00649	909.5515	0.6642
9	837.73	64.39	790.78	52.45	3.31	0.00649	919.7801	0.6691
10	845.09	64.39	798.32	52.58	1.79	0.00435	929.0901	0.6720
11	854.09	64.39	807.38	52.70	0.32	-0.00045	934.1539	0.6727

****-----** S T A T O R   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	21.5976	639.157	-0.00	177.96	663.469	0.4863	-0.000	57.501
2	22.0449	640.891	-0.00	158.28	660.147	0.4837	-0.000	58.041
3	22.3855	643.019	-0.00	139.40	657.956	0.4816	-0.000	58.519
4	22.7203	645.457	-0.00	121.16	656.770	0.4800	-0.000	58.943
5	23.0497	647.835	-0.00	103.37	656.030	0.4787	-0.000	59.334
6	23.3740	650.099	-0.00	85.97	655.759	0.4776	-0.000	59.695
7	23.6938	652.662	-0.00	68.94	656.312	0.4771	-0.000	60.012
8	24.0094	655.474	-0.00	52.20	657.549	0.4767	-0.000	60.292
9	24.3215	658.611	-0.00	35.74	659.580	0.4765	-0.000	60.534
10	24.6305	662.037	-0.00	19.46	662.323	0.4764	-0.000	60.742
11	24.9370	665.872	-0.00	3.28	655.880	0.4765	-0.000	60.913

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	0.9941	0.9126	0.3852	1041.49	1.473	0.6534	0.0279
2	1.0000	0.9944	0.9130	0.3823	1058.15	1.441	0.6509	0.0271
3	1.0000	0.9946	0.9123	0.3800	1074.51	1.409	0.6483	0.0264
4	1.0000	0.9949	0.9113	0.3778	1090.58	1.379	0.6458	0.0258
5	1.0000	0.9951	0.9088	0.3761	1106.39	1.351	0.6433	0.0252
6	1.0000	0.9953	0.9052	0.3745	1121.95	[illegible]	0.6408	0.0246
7	1.0000	0.9954	0.8993	0.3736	1137.30	[illegible]	0.6375	0.0241
8	1.0000	0.9956	0.8934	0.3727	1152.45	1.277	0.6343	0.0237
9	1.0000	0.9957	0.8642	0.3728	1167.43	1.256	0.6299	0.0233
10	1.0000	0.9958	0.8722	0.3736	1182.27	1.236	0.6243	0.0229
11	1.0000	0.9959	0.8574	0.3752	1196.97	.219	0.6173	0.0227

S.L. NO.	TOTAL TEMP. (DEGREES)	TOTAL PRES. (LB/SQ IN.)	STATIC TEMP. (DEGREES)	STATIC PRES. (LB/SQ IN.)	SLOPE (DEGREES)	CURVATURE 1/IN.	REL. VEL. (FT/SEC)	REL. MACH NUMBER
1	814.70	64.01	778.58	54.49	15.56	-0.01562	1234.8628	0.9051
2	814.90	64.02	779.14	54.60	13.89	-0.01530	1247.1898	0.9138
3	816.19	64.04	780.67	54.68	12.27	-0.01570	1259.9485	0.9223
4	818.50	64.06	783.18	54.75	10.67	-0.01642	1273.0688	0.9304
5	820.86	64.07	785.57	54.81	9.11	-0.01714	1286.2610	0.9387
6	823.32	64.08	788.06	54.85	7.57	-0.01762	1299.5388	0.9469
7	827.00	64.09	791.69	54.89	6.06	-0.01747	1313.0882	0.9546
8	831.66	64.10	796.23	54.91	4.58	-0.01623	1326.8458	0.9619
9	837.73	64.11	802.10	54.93	3.12	-0.01340	1340.8752	0.9686
10	845.09	64.12	809.19	54.94	1.69	-0.00832	1355.1474	0.9748
11	854.09	64.12	817.33	54.94	0.28	-0.00025	1369.7244	0.9802

--- 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 HUB MACH NUMBER LIMIT (IN)	0.7300
STATOR HUB D-FACTOR LIMIT	0.4700
MAXIMUM TIP TANGENTIAL VELOCITY	1000.0

---ROTOR---

	PRESSURE PROFILE	FLOW ANGLE AT THE SHOCK	SOLIDITY
A	-0.000000E-38	0.624000E 00	0.450000E-01
B	-0.000000E-38	0.100000E 01	0.100000E 01
C	0.100000E 01	0.442480E 02	0.146300E 01
D	-0.000000E-38	0.820600E 01	-0.240000E 00
E	-0.000000E-38	-0.136400E 01	0.540000E-01

---STATOR---

	WHIRL VELOCITY	FLOW ANGLE AT THE SHOCK	SOLIDITY
A	-0.000000E-38	-0.460900E 01	-0.176000E 00
B	-0.000000E-38	0.100000E 01	0.100000E 01
C	0.000000E-38	0.265020E 02	0.161900E 01
D	-0.000000E-38	-0.835300E 01	-0.402000E 00
E	-0.000000E-38	0.381200E 01	0.114000E 00

*** STAGE SCALER QUANITITIES ***

	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--	2.496	21.9910	25.0000	15.147	0.000	1.3520	401.0000	0.9199
-STATOR-	1.910	22.4000	25.0000	14.557	0.000	1.5750	401.0000	0.9077

	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--	0.915	0.9800	0.9800	1.3830	1.1032	6.0298	1.7590	0.8749
-STATOR-	1.110	0.9800	0.9800	1.3773	1.1032	6.0053	1.7590	0.8724

	LOSS DATA SET USED
-ROTOR--	1
-STATOR-	2

---- ROTOR EXIT **----**

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	22.0552	563.768	485.14	151.04	773.924	0.5437	38.819	43.565
2	22.3612	566.896	477.04	135.10	768.289	0.5395	38.383	44.716
3	22.6613	569.524	470.53	119.35	763.666	0.5357	38.036	45.739
4	22.9564	591.739	465.41	103.83	759.959	0.5322	37.764	46.654
5	23.2473	593.379	460.96	88.54	756.587	0.5289	37.536	47.508
6	23.5343	594.626	457.09	73.52	753.603	0.5259	37.340	48.303
7	23.8182	594.985	455.34	58.73	751.529	0.5231	37.293	49.006
8	24.1000	594.406	455.51	44.22	750.174	0.5204	37.387	49.638
9	24.3807	592.714	456.19	30.02	749.768	0.5180	37.670	50.191
10	24.6614	589.930	462.99	16.17	750.096	0.5156	38.115	50.689
11	24.9434	585.739	470.47	2.74	751.290	0.5133	38.771	51.134

S.L. NO.	TOTAL TEMP. RATIO	TOTAL PRES. RATIO	ADIABATIC EFFICIENCY	DIFFUSION FACTOR	WHEEL SPEED (FT/SEC)	SOLIDITY	A*/S	LOSS COEFF.
1	1.1029	1.3845	0.9274	0.4523	1058.65	1.502	0.5344	0.0590
2	1.1026	1.3841	0.9296	0.4461	1073.34	1.474	0.5274	0.0563
3	1.1023	1.3837	0.9306	0.4412	1087.74	1.449	0.5212	0.0545
4	1.1022	1.3834	0.9308	0.4376	1101.91	1.425	0.5157	0.0537
5	1.1022	1.3831	0.9300	0.4345	1115.87	1.403	0.5106	0.0536
6	1.1023	1.3828	0.9286	0.4319	1129.64	1.383	0.5057	0.0539
7	1.1026	1.3826	0.9247	0.4313	1143.27	1.365	0.5015	0.0564
8	1.1032	1.3824	0.9183	0.4325	1156.80	1.347	0.4976	0.0608
9	1.1042	1.3822	0.9085	0.4362	1170.27	1.331	0.4943	0.0679
10	1.1055	1.3821	0.8964	0.4420	1183.75	1.316	0.4914	0.0770
11	1.1072	1.3820	0.8811	0.4503	1197.28	1.302	0.4889	0.0887

S.L. NO.	TOTAL TEMP. (DEGREES)	TOTAL PRES. (LB/SQ IN.)	STATIC TEMP. (DEGREES)	STATIC PRES. (LB/SQ IN.)	SLOPE (DEGREES)	CURVATURE 1/IN.	REL. VEL. (FT/SEC)	REL. MACH NUMBER
1	898.53	88.61	849.73	72.56	14.51	-0.00661	832.1732	0.5846
2	898.47	88.61	850.38	72.79	12.95	-0.00444	847.5068	0.5951
3	899.72	88.61	852.22	72.99	11.45	-0.00179	861.8178	0.6045
4	902.24	88.61	855.21	73.17	9.35	0.00105	875.2565	0.6129
5	904.77	88.61	858.17	73.34	8.49	0.00383	888.1664	0.6209
6	907.52	88.61	861.30	73.49	7.05	0.00640	900.7295	0.6286
7	911.66	88.61	865.91	73.64	5.64	0.00842	911.4287	0.6344
8	917.51	88.61	871.76	73.77	4.26	0.00938	920.3743	0.6386
9	925.03	88.61	879.36	73.90	2.90	0.00871	926.9682	0.6405
10	934.25	88.61	888.59	74.03	1.57	0.00579	931.5396	0.6404
11	945.63	88.61	899.67	74.15	0.27	-0.00008	933.4655	0.6378

---- S T A T O R   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	22.4550	643.459	-0.00	157.94	662.540	0.4620	-0.000	58.421
2	22.7187	647.110	-0.00	141.16	662.328	0.4618	-0.000	58.727
3	22.9782	650.667	-0.00	124.84	662.555	0.4617	-0.000	59.006
4	23.2340	654.240	-0.00	108.91	663.243	0.4615	-0.000	59.260
5	23.4865	657.368	-0.00	93.25	663.950	0.4614	-0.000	59.504
6	23.7360	660.213	-0.00	77.86	664.789	0.4613	-0.000	59.737
7	23.9823	663.284	-0.00	62.75	666.245	0.4612	-0.000	59.940
8	24.2273	666.526	-0.00	47.80	668.237	0.4612	-0.000	60.117
9	24.4698	670.138	-0.00	32.94	670.947	0.4613	-0.000	60.263
10	24.7108	674.078	-0.00	18.06	674.320	0.4614	-0.000	60.381
11	24.9507	678.491	-0.00	3.05	678.498	0.4615	-0.000	60.467

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	0.9953	0.9132	0.3619	1077.84	1.438	0.6157	0.0261
2	1.0000	0.9954	0.9159	0.3574	1090.50	1.415	0.6163	0.0255
3	1.0000	0.9956	0.9174	0.3538	1102.95	1.391	0.6163	0.0249
4	1.0000	0.9958	0.9180	0.3510	1115.23	1.369	0.6158	0.0244
5	1.0000	0.9959	0.9176	0.3486	1127.35	1.347	0.6151	0.0239
6	1.0000	0.9960	0.9166	0.3465	1139.33	1.326	0.6143	0.0234
7	1.0000	0.9961	0.9130	0.3452	1151.17	1.307	0.6124	0.0230
8	1.0000	0.9962	0.9070	0.3446	1162.91	1.290	0.6095	0.0227
9	1.0000	0.9963	0.8976	0.3451	1174.55	1.273	0.6052	0.0224
10	1.0000	0.9963	0.8857	0.3462	1186.12	1.259	0.5996	0.0222
11	1.0000	0.9964	0.8709	0.3483	1197.63	1.245	0.5923	0.0221

S.L. NO.	TOTAL TEMP. (DEGREES)	TOTAL PRES. (LB/SQ IN.)	STATIC TEMP. (DEGREES)	STATIC PRES. (LB/SQ IN.)	SLOPE (DEGREES)	CURVATURE 1/IN.	REL. VEL. (FT/SEC)	REL. MACH NUMBER
1	898.53	88.19	862.79	76.27	13.79	-0.01108	1265.1852	0.8822
2	898.47	88.21	862.75	76.29	12.31	-0.01188	1275.8769	0.8897
3	899.72	88.22	863.98	76.31	10.86	-0.01274	1286.6567	0.8966
4	902.24	88.24	866.43	76.33	9.45	-0.01350	1297.5501	0.9029
5	904.77	88.25	868.90	76.35	8.06	-0.01406	1308.3407	0.9092
6	907.52	88.26	871.57	76.36	6.73	-0.01433	1319.0957	0.9153
7	911.86	88.27	875.77	76.38	5.41	-0.01411	1330.0691	0.9208
8	917.51	88.28	881.22	76.39	4.10	-0.01304	1341.2297	0.9257
9	925.03	88.28	888.48	76.39	2.81	-0.01068	1352.6784	0.9299
10	934.25	88.29	897.37	76.40	1.54	-0.00658	1364.3993	0.9335
11	945.63	88.29	908.33	76.40	0.26	-0.00017	1376.4741	0.9363

-- FINAL FLOW PARAMETERS FOR STAGE NUMBER 6 ***--***

*** 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
MAXIMUM TIP TANGENTIAL VELOCITY	1000.0

---ROTOR---

	PRESSURE PROFILE	FLOW ANGLE AT THE SHOCK	SOLIDITY
A	-0.000000E-38	0.463600E 01	0.167000E 00
B	-0.000000E-38	0.100000E 01	0.100000E 01
C	0.100000E 01	0.407240E 02	0.128800E 01
D	-0.000000E-38	0.945100E 01	-0.530000E-01
E	-0.000000E-38	-0.[illegible]85300E 01	-0.180000E-01

---STATOR---

	WHIRL VELOCITY	FLOW ANGLE AT THE SHOCK	SOLIDITY
A	-0.000000E-38	0.312000E 00	-0.125000E 00
B	-0.000000E-38	0.100000E 01	0.100000E 01
C	0.000000E-38	0.205990E 02	0.152100E 01
D	-0.000000E-38	-0.315200E 01	-0.298000E 00
E	-0.000000E-38	0.155400E 01	0.820000E-01

*** 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--	1.684	22.7230	25.0000	13.566	0.000	1.3800	401.0000	0.9267
-STATOR-	2.464	23.9460	25.0000	13.154	0.000	0.9200	401.0000	0.9134

	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--	0.951	0.9800	0.9800	1.3573	1.0954	8.1510	1.9268	0.8732
-STATOR-	1.056	0.9800	0.9800	1.3517	1.0954	8.1173	1.9268	0.8708

	LOSS DATA SET USED
-ROTOR--	1
-STATOR-	2

----- R O T O R   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	22.7806	610.464	483.65	144.09	798.231	0.5364	37.294	43.840
2	23.0059	621.176	477.60	128.01	793.942	0.5333	36.981	44.657
3	23.2264	623.497	472.69	112.49	790.467	0.5305	36.726	45.391
4	23.4485	625.409	469.08	97.47	787.829	0.5278	36.542	46.044
5	23.6606	620.373	465.84	82.89	785.399	0.5253	36.379	46.663
6	23.8829	627.854	463.34	68.71	783.329	0.5230	36.264	47.241
7	24.0978	626.271	462.70	54.88	782.195	0.5209	36.267	47.737
8	24.3120	627.836	464.16	41.37	781.877	0.5199	36.416	48.164
9	24.5260	626.564	468.00	28.17	782.562	0.5170	36.750	48.513
10	24.7406	624.275	474.26	15.27	784.135	0.5152	37.215	48.799
11	24.9567	620.759	483.33	2.69	786.741	0.5135	37.905	49.019

S.L. NO.	TOTAL TEMP. RATIO	TOTAL PRES. RATIO	ADIABATIC EFFICIENCY	DIFFUSION FACTOR	WHEEL SPEED (FT/SEC)	SOLIDITY	A*/S	LOSS COEFF.
1	1.0952	1.3582	0.9320	0.4312	1093.47	1.450	0.5183	0.0540
2	1.0950	1.3580	0.9339	0.4279	1104.28	1.430	0.5147	0.0516
3	1.0943	1.3576	0.9353	0.4253	1114.96	1.412	0.5114	0.0498
4	1.0940	1.3570	0.9358	0.4237	1125.53	1.396	0.5083	0.0489
5	1.0946	1.3574	0.9359	0.4222	1136.00	1.381	0.5053	0.0483
6	1.0940	1.3572	0.9343	0.4213	1146.38	1.367	0.5024	0.0486
7	1.0948	1.3571	0.9318	0.4220	1156.70	1.353	0.4999	0.0504
8	1.0953	1.3570	0.9261	0.4247	1166.98	1.340	0.4976	0.0545
9	1.0961	1.3566	0.9177	0.4297	1177.25	1.328	0.4957	0.0607
10	1.0971	1.3566	0.9064	0.4371	1187.55	1.315	0.4942	0.0693
11	1.0985	1.3567	0.8922	0.4472	[illegible]97.92	1.303	0.4930	0.0804

S.L. NO.	TOTAL TEMP. (DEGREES)	TOTAL PRES. (LB/SQ IN.)	STATIC TEMP. (DEGREES)	STATIC PRES. (LB/SQ IN.)	SLOPE (DEGREES)	CURVATURE 1/IN.	REL. VEL. (FT/SEC)	REL. MACH NUMBER
1	984.03	119.79	932.64	98.69	13.12	-0.00592	880.4190	0.5913
2	983.80	119.79	932.90	98.90	11.65	-0.00414	891.6199	0.5987
3	984.98	119.79	934.53	99.09	10.23	-0.00173	902.1753	0.6053
4	98[illegible].62	119.79	937.53	99.27	8.86	0.00101	911.9009	0.6109
5	990.35	119.79	940.56	99.44	7.54	0.00382	921.3841	0.6163
6	993.37	119.79	943.69	99.60	6.25	0.00650	930.3047	0.6212
7	998.31	119.79	949.00	99.75	5.00	0.00869	937.7440	0.6246
8	1004.95	119.79	955.71	99.88	3.77	0.00983	943.3145	0.6262
9	1013.89	119.79	964.62	100.02	2.58	0.00925	946.7850	0.6257
10	1024.98	119.79	975.57	100.14	1.40	0.00623	948.0185	0.6231
11	1038.76	119.79	989.10	100.27	0.23	-0.00008	946.5638	0.6181

--- ** S T A T O R   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	22.9908	661.784	-0.00	141.46	676.735	0.4511	-0.000	58.482
2	23.1928	661.149	-0.00	125.90	673.030	0.4487	-0.000	58.844
3	23.39[illegible]	661.046	-0.00	111.03	670.307	0.4465	-0.000	59.165
4	23.5927	661.467	-0.00	96.72	668.520	0.4447	-0.000	59.445
5	23.7939	662.030	-0.00	82.80	667.187	0.4431	-0.000	59.705
6	23.9879	662.763	-0.00	69.21	666.368	0.44[illegible]	-0.000	59.[illegible]0
7	24.1839	664.200	-0.00	55.92	666.550	0.4409	-0.000	60.175
8	24.3789	666.270	-0.00	42.77	66[illegible].642	0.4402	-0.000	60.293
9	24.5732	669.150	-0.00	29.63	6[illegible].[illegible]06	0.4398	-0.000	60.409
10	24.7671	672.773	-0.00	16.34	672.[illegible]72	0.4395	-0.000	60.487
11	24.9606	677.269	-0.00	2.73	67[illegible].274	0.4395	-0.000	60.521

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	0.9955	0.9176	0.3691	1103.56	1.392	0.6228	0.0256
2	1.0000	0.9956	0.9198	0.3706	1113.25	1.375	0.6230	0.0254
3	1.0000	0.9957	0.9215	0.3719	1122.88	1.357	0.6228	0.0251
4	1.0000	0.9957	0.922[illegible]	0.3733	1132.45	1.340	0.6222	0.0249
5	1.0000	0.9958	0.9225	0.3744	1141.96	1.324	0.6214	0.0246
6	1.0000	0.9959	0.9217	0.3753	1151.42	1.308	0.6205	0.0243
7	1.0000	0.9960	0.91[illegible]0	0.3766	1160.83	1.293	0.6187	0.0241
8	1.0000	0.9960	0.9135	0.3782	1170.19	1.279	0.6158	0.0239
9	1.0000	0.9961	0.9054	0.3803	1179.52	1.267	0.6118	0.0238
10	1.0000	0.9961	0.8944	0.3829	1188.82	1.255	0.6064	0.0237
11	1.0000	0.9962	0.8805	0.3853	1198.11	1.244	0.5994	0.0236

S.L. NO.	TOTAL TEMP. (DEGREES)	TOTAL PRES. (LB/SQ IN.)	STATIC TEMP. (DEGREES)	STATIC PRES. (LB/SQ IN.)	SLOPE (DEGREES)	CURVATURE 1/IN.	REL. VEL. (FT/SEC)	REL. MACH NUMBER
1	984.09	119.25	947.14	103.86	12.07	-0.01977	1294.5325	0.8630
2	983.80	119.26	947.25	104.02	10.78	-0.01728	1300.8843	0.8672
3	984.98	119.27	948.73	104.16	9.52	-0.01572	1307.7349	0.8711
4	987.62	119.28	951.58	104.29	8.30	-0.01481	1315.0507	0.8747
5	990.33	119.29	954.44	104.39	7.11	-0.01429	1322.5786	0.8785
6	993.37	119.30	957.59	104.48	5.94	-0.01398	1330.3423	0.8822
7	998.31	119.30	962.55	104.55	4.80	-0.01356	1338.5831	0.8855
8	1004.95	119.31	969.08	104.60	3.66	-0.01255	1347.2517	0.8883
9	1013.89	119.32	977.82	104.64	2.52	-0.01042	1356.4299	0.8906
10	1024.93	119.32	988.61	104.67	1.38	-0.00659	1366.0844	0.8922
11	1038.76	119.33	1001.99	104.68	0.23	-0.00036	1376.2872	0.8931

--- 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
MAXIMUM TIP TANGENTIAL VELOCITY	1000.0

	---ROTOR---				---STATOR---		
	PRESSURE PROFILE	FLOW ANGLE AT THE SHOCK	SOLIDITY		WHIRL VELOCITY	FLOW ANGLE AT THE SHOCK	SOLIDITY
A	-0.000000E-38	0.916000E 00	0.570000E-01	A	-0.000000E-38	-0.549300E 01	-0.340000E-01
B	-0.000000E-38	0.100000E 01	0.100000E 01	B	-0.000000E-38	0.100000E 01	0.100000E 01
C	0.100000E 01	0.428680E 02	0.135900E 01	C	0.000000E-38	0.263740E 02	0.146200E 01
D	-0.000000E-38	0.796000E 01	-0.101000E 00	D	-0.000000E-38	-0.642000E 01	-0.141000E 00
E	-0.000000E-38	-0.289500E 01	0.130000E-01	E	-0.000000E-38	0.319800E 01	0.240000E-01

*** 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--	1.466	23.2400	25.0000	11.781	0.000	1.4000	401.0000	0.9346
-STATOR-	1.956	23.3000	25.0000	3.814	0.000	0.9000	401.0000	0.9183

	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--	0.996	0.9800	0.9800	[illegible]	1.0886	10.8462	2.0975	0.8720
-STATOR-	0.984	0.9800	0.9800	1.3300	1.0987	10.7963	2.0976	0.8695

	LOSS DATA SET USED
-ROTOR--	1
-STATOR-	2

----- R O T O R   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	23.2765	665.159	488.01	99.58	830.970	0.5356	35.964	43.094
2	23.4475	660.589	483.06	88.48	823.457	0.5306	35.918	43.930
3	23.6176	657.416	479.11	77.81	817.185	0.5261	35.894	44.675
4	23.7872	654.372	476.35	67.49	812.198	0.5221	35.909	45.329
5	23.9561	652.657	474.01	57.47	807.865	0.5184	35.926	45.935
6	24.1245	649.262	472.23	47.73	804.254	0.5152	35.956	46.488
7	24.2925	647.675	472.29	38.21	802.011	0.5125	36.077	46.944
8	24.4603	644.782	474.57	28.88	801.121	0.5101	36.326	47.303
9	24.6283	642.366	479.39	19.72	801.771	0.5083	36.721	47.558
10	24. 967	639.533	486.83	10.69	803.896	0.5069	37.271	47.715
11	24.9660	636.332	497.48	1.90	807.721	0.5060	38.018	47.764

S.L. NO.	TOTAL TEMP. RATIO	TOTAL PRES. RATIO	ADIABATIC EFFICIENCY	DIFFUSION FACTOR	WHEEL SPEED (FT/SEC)	SOLIDITY	A*/S	LOSS COEFF.
1	1.0388	1.3367	0.9359	0.4185	1117.27	1.413	0.5148	0.0497
2	1.0885	1.3366	0.9380	0.4177	1125.48	1.398	0.5100	0.0476
3	1.0883	1.3365	0.9396	0.4175	1133.65	1.385	0.5058	0.0458
4	1.0882	1.3364	0.9407	0.4179	1141.78	1.372	0.5021	0.0448
5	1.0881	1.3362	0.9410	0.4182	1149.84	1.360	0.4987	0.0442
6	1.0881	1.3361	0.9405	0.4187	1157.98	1.349	0.4956	0.0443
7	1.0882	1.3361	0.9380	0.4209	1166.04	1.339	0.4930	0.0457
8	1.0886	1.3360	0.9333	0.4248	1174.09	1.329	0.4910	0.0494
9	1.0892	1.3359	0.9255	0.4308	1182.16	1.319	0.4894	0.0553
10	1.0901	1.3358	0.9150	0.4392	1190.24	1.310	0.4884	0.0636
11	1.0913	1.3358	0.9011	0.4504	1198.37	1.301	0.4880	0.0747

S.L. NO.	TOTAL TEMP. (DEGREES)	TOTAL PRES. (LB/SQ IN.)	STATIC TEMP. (DEGREES)	STATIC PRES. (LB/SQ IN.)	SLOPE (DEGREES)	CURVATURE 1/IN.	REL. VEL. (FT/SEC)	REL. MACH NUMBER
1	1071.43	159.40	1016.23	131.45	8.52	-0.11676	921.0417	0.5937
2	1070.89	159.40	1016.69	131.91	7.62	-0.10415	925.9805	0.5967
3	1071.97	159.40	1018.60	132.32	6.74	-0.09140	930.4537	0.5994
4	1074.71	159.40	1022.00	132.69	5.88	-0.07864	935.7147	0.6015
5	1077.57	159.40	1025.45	133.03	5.03	-0.06597	940.6281	0.6037
6	1080.67	159.40	1029.23	133.32	4.19	-0.05349	945.5487	0.6059
7	1086.58	159.40	1035.06	133.58	3.37	-0.04137	949.6526	0.6067
8	1093.97	159.40	1042.32	133.80	2.56	-0.02956	951.7947	0.6060
9	1104.33	159.40	1053.16	133.99	1.75	-0.01926	952.3152	0.6035
10	1117.51	159.40	1065.95	134.14	0.95	-0.00994	950.3059	0.5991
11	1133.58	159.40	1081.84	134.25	0.16	-0.00223	946.6573	0.5923

****-----** S T A T O R   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	23.3352	650.821	-0.00	47.91	652.582	0.4165	-0.000	59.774
2	23.5005	646.800	-0.00	43.05	648.291	0.4138	-0.000	60.113
3	23.6655	643.862	-0.00	38.33	645.002	0.4114	-0.000	60.411
4	23.8295	641.799	-0.00	33.72	642.684	0.4094	-0.000	60.669
5	23.9935	640.210	-0.00	29.17	640.874	0.4077	-0.000	60.905
6	24.1565	639.221	-0.00	24.65	639.536	0.4062	-0.000	61.117
7	24.3193	639.135	-0.00	20.14	639.452	0.4051	-0.000	61.286
8	24.4816	640.071	-0.00	15.59	640.251	0.4042	-0.000	61.416
9	24.6436	642.126	-0.00	10.93	642.221	0.4036	-0.000	61.501
10	24.8054	645.246	-0.00	6.07	645.277	0.4033	-0.000	61.545
11	24.9671	649.560	-0.00	0.91	649.581	0.4032	-0.000	61.541

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	0.9949	0.9189	0.4201	1120.03	1.426	0.6329	0.0289
2	1.0000	0.9951	0.9214	0.4193	1128.02	1.415	0.6292	0.0287
3	1.0000	0.9952	0.9235	0.4186	1135.93	1.405	0.6258	0.0284
4	1.0000	0.9953	0.9247	0.4185	1143.82	1.395	0.6223	0.02[illegible]2
5	1.0000	0.9954	0.9253	0.4181	1151.68	1.384	0.6192	0.0280
6	1.0000	0.9955	0.9252	0.4176	1159.51	1.374	0.6162	0.0277
7	1.0000	0.9955	0.9232	0.4181	1167.33	1.365	0.6130	0.0276
8	1.0000	0.9956	0.9185	0.4192	1175.12	1.356	0.6091	0.0274
9	1.0000	0.9955	0.9110	0.4211	1182.89	1.347	0.6044	0.0274
10	1.0000	0.9957	0.9006	0.4241	1190.66	1.338	0.5988	0.0274
11	1.0000	0.9957	0.8870	0.4283	1198.42	1.330	0.5921	0.0275

S.L. NO.	TOTAL TEMP. (DEGREES)	TOTAL PRES. (LB/SQ IN.)	STATIC TEMP. (DEGREES)	STATIC PRES. (LB/SQ IN.)	SLOPE (DEGREES)	CURVATURE 1/IN.	REL. VEL. (FT/SEC)	REL. MACH NUMBER
1	1071.43	158.59	1037.43	140.98	4.21	0.01278	1296.3277	0.8274
2	1070.69	158.61	1037.34	141.21	3.81	0.01173	1301.0458	0.8304
3	1071.97	158.63	1038.76	141.42	3.41	0.01030	1306.2612	0.8332
4	1074.71	158.64	1041.75	141.59	3.02	0.00862	1312.0064	0.8357
5	1077.57	158.66	1044.31	141.74	2.62	0.00678	1317.9842	0.8384
6	1080.87	158.67	1048.25	141.86	2.22	0.00484	1324.2397	0.8410
7	1085.38	158.68	1053.79	141.97	1.82	0.00295	1330.9957	0.8432
8	1093.97	158.69	1061.34	142.05	1.41	0.00131	1338.7214	0.8449
9	1104.33	158.70	1071.53	142.10	0.98	0.00013	1345.9892	0.8460
10	1117.31	158.70	1084.26	142.14	0.54	-0.00032	1354.2729	0.8464
11	1135.56	158.70	1100.15	142.16	0.08	0.00025	1363.1477	0.8461

--- OUTLET FLOW PARAMETERS ***---***

STA NO.	AXIAL COORDINATE (IN.)	GEOMETRIC HUB RADIUS (IN.)	GEOMETRIC TIP RADIUS (IN.)	HUB BLOCKAGE FACTOR	TIP BLOCKAGE FACTOR
20	39.000	23.405	25.000	0.980	0.980
21	40.000	23.423	25.000	0.980	0.980
22	41.000	23.441	25.000	0.980	0.980

STATION NUMBER 20

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	TOTAL TEMP. (DEG.S R)	TOTAL PRES. (LB/SQ IN.)
1	23.4384	694.381	-0.00	36.35	695.33	0.4447	1071.43	158.6
2	23.5940	692.324	-0.00	32.74	693.10	0.4434	1070.89	158.6
3	23.7488	691.016	-0.00	29.16	691.63	0.4422	1071.97	158.6
4	23.9031	690.444	-0.00	25.60	690.92	0.4412	1074.71	158.6
5	24.0567	690.119	-0.00	22.03	690.47	0.4403	1077.57	158.7
6	24.2097	690.126	-0.00	18.46	690.37	0.4395	1080.87	158.7
7	24.3622	690.998	-0.00	14.91	691.16	0.4390	1086.38	158.7
8	24.5143	692.682	-0.00	11.36	692.78	0.4385	1093.97	158.7
9	24.6660	695.365	-0.00	7.82	695.41	0.4382	1104.33	158.7
10	24.8176	699.006	-0.00	4.27	699.02	0.4380	1117.31	158.7
11	24.9691	703.768	-0.00	0.70	703.79	0.4379	1133.58	158.7

STATION NUMBER 21

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	TOTAL TEMP. (DEG.S R)	TOTAL PRES. (LB/SQ IN.)
1	23.4556	705.263	-0.00	12.10	705.37	0.4514	1071.43	158.6
2	23.6093	702.717	-0.00	11.07	702.80	0.4498	1070.89	158.6
3	23.7624	700.967	-0.00	9.99	701.04	0.4484	1071.97	158.6
4	23.9146	700.002	-0.00	8.86	700.06	0.4472	1074.71	158.6
5	24.0667	699.340	-0.00	7.70	699.38	0.4462	1077.57	158.7
6	24.2181	699.070	-0.00	6.50	699.10	0.4453	1080.87	158.7
7	24.3690	699.736	-0.00	5.28	699.76	0.4446	1086.38	158.7
8	24.5194	701.284	-0.00	4.04	701.30	0.4441	1093.97	158.7
9	24.6695	703.901	-0.00	2.79	703.91	0.4437	1104.33	158.7
10	24.8195	707.536	-0.00	1.52	707.54	0.4435	1117.31	158.7
11	24.9694	712.366	-0.00	0.23	712.37	0.4435	1133.58	158.7

STATION NUMBER 22

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	TOTAL TEMP. (DEG.S R)	TOTAL PRES. (LB/SQ IN.)
1	23.4727	705.915	-0.00	0.00	705.92	0.4518	1071.43	158.6
2	23.6255	705.905	-0.00	0.00	705.91	0.4519	1070.89	158.6
3	23.7774	706.415	-0.00	0.00	706.42	0.4520	1071.97	158.6
4	23.9285	707.443	-0.00	0.00	707.44	0.4521	1074.71	158.6
5	24.0788	708.508	-0.00	0.00	708.51	0.4522	1077.57	158.7
6	24.2284	709.702	-0.00	0.00	709.70	0.4523	1080.87	158.7
7	24.3774	711.581	-0.00	0.00	711.58	0.4524	1086.38	158.7
8	24.5259	714.094	-0.00	0.00	714.09	0.4525	1093.97	158.7
9	24.6740	717.434	-0.00	0.00	717.43	0.4526	1104.33	158.7
10	24.8219	721.552	-0.00	0.00	721.55	0.4526	1117.31	158.7
11	24.9698	726.625	-0.00	0.00	726.62	0.4527	1133.58	158.7

EXAMPLE - AXIAL VELOCITY RATIO SPECIFIED (PROGRAM III)

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****---*** ADVANCED MULTISTAGE AXIAL-FLOW COMPRESSOR ***---****
           **--** ANALYSIS AT DESIGN CONDITIONS **--**

                  ----I N P U T   D A T A----

THE MACHINE IS TO HAVE NO MORE THAN 10 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 IN.
THE INLET MASS FLOW RATE IS 401.00 LB/SEC               THE INLET TOTAL TEMPERATURE IS 518.69 DEG. R
MOLECULAR WEIGHT OF THE FLUID IS  28.97                 THE TIP SPEED IS 1200.0 FT./SEC.
AXIAL VELOCITY TOLERANCE IS 0.0100                      THE LOADING LIMIT TOLERANCE IS 0.0100
THE EFFICIENCY TOLERANCE IS 0.0100                      THE CONTINUITY TOLERANCE IS 0.000
THE AXIAL VELOCITY RATIO TOLERANCE IS 0.0100
THE FRACTION OF THE TOTAL MASS FLOW BETWEEN THE HUB AND THE I-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
THE INLET GUIDE VANE EXIT TANGENTIAL VELOCITY IS SPECIFIED BY
A =  -0.000000E-38   B =  -0.000000E-38C =  -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 + -0.78356E-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 0.9400, 0.9300, 0.9200 .
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----INLET DESCRIPTION----

STATION NO.	AXIAL COORDINATE (IN.)	HUB RADIUS (IN.)	HUB BLOCKAGE FACTOR	TIP RADIUS (IN.)	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

-- GEOMETRIC PARAMETERS *--*

BLADE ROW EXIT STA.	AXIAL VEL. RATIO (O/I)	ASPECT RATIO	HUB RAMP ANGLE LIMIT	HUB BLOCKAGE FACTOR	TIP RAMP ANGLE LIMIT	TIP BLOCKAGE FACTOR
6	0.950	4.000	40.000	0.992	0.000	0.992
7	1.050	4.000	37.200	0.990	0.000	0.990
8	0.950	3.500	34.500	0.987	0.000	0.987
9	1.050	3.500	31.700	0.985	0.000	0.985
10	0.950	2.500	28.900	0.983	0.000	0.983
11	1.050	2.500	26.200	0.980	0.000	0.980
12	0.950	2.500	23.400	0.980	0.000	0.980
13	1.050	2.500	20.600	0.980	0.000	0.980
14	0.950	2.500	17.900	0.980	0.000	0.980
15	1.050	2.500	15.100	0.980	0.000	0.980
16	0.950	2.500	12.300	0.980	0.000	0.980
17	1.050	2.500	9.500	0.980	0.000	0.980
18	0.950	2.500	6.800	0.980	0.000	0.980
19	1.050	2.500	4.000	0.980	0.000	0.980
20	0.950	2.500	4.000	0.980	0.000	0.980
21	1.050	2.500	4.000	0.980	0.000	0.98
22	0.950	2.500	4.000	0.980	0.000	0.9
23	1.050	2.500	4.000	0.980	0.000	0.9
24	0.950	2.500	4.000	0.980	0.000	0.98
25	1.050	2.500	4.000	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 FROM THE GEOMETRIC HUB.)
0.000	0.0070	0.0060	0.0080	
0.100	0.0073	0.0060	0.0083	
0.150	0.0076	0.0068	0.0090	
0.200	0.0080	0.0072	0.0095	
0.250	0.0083	0.0077	0.0103	
0.300	0.0090	0.0080	0.0114	
0.350	0.0097	0.0089	0.0127	
0.400	0.0108	0.0097	0.0141	
0.450	0.0121	0.0108	0.0159	
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	0.0176	0.0285	
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	0.0628	
0.900	0.0464	0.0397	0.0764	
0.950	0.0534	0.0464	0.0924	
1.000	0.0604	0.0531	0.1084	

.... LOSS DATA SET NUMBER 2 ....

D-FACTOR	AT 10 PERCENT	AT 50 PERCENT	AT 90 PERCENT (OF BLADE HEIGHT FROM THE GEOMETRIC HUB.)
0.000	0.0060	0.0060	0.0060
0.100	0.0060	0.0060	0.0060
0.150	0.0068	0.0068	0.0068
0.200	0.0072	0.0072	0.0072
0.250	0.0077	0.0077	0.0077
0.300	0.0080	0.0080	0.0080
0.350	0.0089	0.0089	0.0089
0.400	0.0097	0.0097	0.0097
0.450	0.0108	0.0108	0.0108
0.500	[illegible]	0.0119	0.0119
0.550	[illegible]	0.0134	0.0134
0.600	0.0152	0.0152	0.0152
0.650	0.0176	0.0176	0.0176
0.700	0.0204	0.0204	0.0204
0.750	0.0236	0.0236	0.0235
0.800	0.0277	0.0277	0.0277
0.850	[illegible]	0.0330	0.0330
0.900	0.0397	0.0397	0.0397
0.950	0.0464	0.0464	0.0464
1.000	0.0531	0.0531	0.0531

----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 1/IN.	FLOW ANGLE (DEGREES)
1	7.0000	0.413	453.78	453.78	0.0000	0.00	0.00000	0.0
2	10.3247	0.413	453.78	453.78	0.0000	0.00	0.00000	0.0
3	12.8141	0.413	453.78	453.78	0.0000	0.00	0.00000	0.0
4	14.8930	0.413	453.78	453.78	0.0000	0.00	0.00000	0.0
5	16.7153	0.413	453.78	453.76	0.0000	0.00	0.00000	0.0
6	18.3576	0.413	453.78	453.78	0.0000	0.00	0.00000	0.0
7	19.8645	0.413	453.78	453.78	0.0000	0.00	0.00000	0.0
8	21.2650	0.413	453.78	453.78	0.0000	0.00	0.00000	0.0
9	22.5788	0.413	453.78	453.78	0.0000	0.00	0.00000	0.0
10	23.8202	0.413	453.78	453.78	0.0000	0.00	0.00000	0.0
11	25.0000	0.413	453.78	453.78	0.0000	0.00	0.00000	0.0

S.L. NO.	STREAMLINE RADIUS (IN.)	TOTAL PRES. (LB/SQ IN.)	TOTAL TEMP. (DEGREES)
1	7.0000	14.70	518.69
2	10.3247	14.70	518.69
3	12.8141	14.70	518.69
4	14.8930	14.70	518.69
5	16.7153	14.70	518.69
6	18.3576	14.70	518.69
7	19.8645	14.70	518.69
8	21.2650	14.70	518.69
9	22.5788	14.70	518.69
10	23.8202	14.70	518.69
11	25.0000	14.70	518.69

----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 1/IN.	FLOW ANGLE (DEGREES)
1	7.4150	0.264	292.57	282.92	74.4991	14.75	0.07536	0.0
2	11.3936	0.349	385.32	373.15	96.0721	14.47	-0.05949	0.0
3	13.9326	0.394	432.97	422.41	95.0727	12.73	-0.09094	0.0
4	15.9190	0.422	463.33	455.21	86.3904	10.79	-0.09567	0.0
5	17.6008	0.442	484.08	478.31	74.4888	8.90	-0.08912	0.0
6	19.0863	0.45[illegible]	498.60	494.82	61.3275	7.10	-0.07705	0.0
7	20.4340	0.465	508.74	506.48	47.9154	5.44	-0.06226	0.0
8	21.6793	0.472	515.62	514.45	34.8140	3.90	-0.04636	0.0
9	22.8454	0.476	519.99	519.51	22.3477	2.48	-0.03031	0.0
10	23.9484	0.478	522.35	522.24	10.7062	1.18	-0.01473	0.0
11	25.0000	0.479	523.07	523.07	-0.0000	-0.00	0.00000	0.0

S.L. NO.	STREAMLINE RADIUS (IN.)	TOTAL PRES. (LB/SQ IN.)	TOTAL TEMP. (DEGREES)
1	7.4150	14.70	518.69
2	11.3936	14.70	518.69
3	13.9326	14.70	518.69
4	15.9190	14.70	518.69
5	17.6008	14.70	518.69
6	19.0863	14.70	518.69
7	20.4340	14.70	518.69
8	21.6793	14.70	518.69
[illegible]	22.[illegible]	[illegible]	518.[illegible]

10	23.9484	14.70	518.69
11	25.0000	14.70	518.69

----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 1/IN.	FLOW ANGLE (DEGREES)
1	8.5800	0.340	375.17	337.01	164.8544	26.07	0.04873	0.0
2	11.8726	0.396	435.14	415.58	129.0190	17.46	0.08958	0.0
3	14.1692	0.425	466.63	454.85	104.1973	13.19	0.09565	0.0
4	16.0368	0.444	486.15	478.84	84.0020	10.26	0.09003	0.0
5	17.6545	0.456	498.97	494.47	66.8789	8.00	0.07941	0.0
6	19.1054	0.464	507.54	504.86	52.0842	6.16	0.06654	0.0
7	20.4356	0.470	513.22	511.72	39.1371	4.60	0.05278	0.0
8	21.6736	0.473	516.80	516.06	27.6891	3.24	0.03889	0.0
9	22.8385	0.475	518.80	518.50	17.4772	2.05	0.02531	0.0
10	23.9440	0.476	519.53	519.46	8.2994	0.97	0.01230	0.0
11	25.0000	0.475	519.21	519.21	0.0000	0.00	0.00000	0.0

S.L. NO.	STREAMLINE RADIUS (IN.)	TOTAL PRES. (LB/SQ IN.)	TOTAL TEMP. (DEGREES)
1	8.5800	14.70	518.69
2	11.8726	14.70	518.69
3	14.1692	14.70	518.69
4	16.0368	14.70	518.69
5	17.6545	14.70	518.69
6	19.1054	14.70	518.69
7	20.4356	14.70	518.69
8	21.6736	14.70	518.69
9	22.8385	14.70	518.69
10	23.9440	14.70	518.69
11	25.0000	14.70	518.69

----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 1/IN.	FLOW ANGLE (DEGREES)
1	10.3500	0.349	384.85	319.88	213.9708	33.78	0.03021	0.0
2	13.2804	0.419	459.86	417.20	193.4427	24.88	-0.00278	0.0
3	15.3385	0.463	506.23	477.45	168.2307	19.41	-0.02091	0.0
4	17.0049	0.493	537.44	518.27	142.2514	15.35	-0.02878	0.0
5	18.4442	0.514	559.25	546.87	117.0311	12.09	-0.03061	0.0
6	19.7338	0.529	574.61	567.01	93.1187	9.34	-0.0[illegible]389	0.0
7	20.9167	0.539	585.24	580.96	70.6849	6.95	-0.02515	0.0
8	22.0195	0.546	592.24	590.15	49.7490	4.93	-0.02037	0.0
9	23.0558	0.550	596.38	595.61	30.2646	2.91	-0.01519	0.0
10	24.0502	0.552	598.19	598.07	12.1540	1.17	-0.01004	0.0
11	25.0000	0.552	598.10	598.08	-4.5769	-0.45	-0.00521	0.0

S.L. NO.	STREAMLINE RADIUS (IN.)	TOTAL PRES. (LB/SQ IN.)	TOTAL TEMP. (DEGREES)
1	10.3500	14.70	518.69
2	13.2804	14.70	518.69
3	15.3385	14.70	518.69
4	17.0049	14.70	518.69
5	18.4442	14.70	518.69
6	19.7338	14.70	518.69
7	20.9167	14.70	518.69
8	22.0195	14.70	518.69

9	23.0558	14.70	518.69
10	24.0502	14.70	518.69
11	25.0000	14.70	518.69

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

S.L. NO.	STREAMLINE RADIUS (IN.)	ABS. MACH NUMBER	ABS. VEL. (FT/SEC)	AXIAL VEL. (FT/SEC)	RADIAL VEL. (FT/SEC)	STREAMLINE SLOPE (DEG)	STREAMLINE CURVATURE 1/IN.	FLOW ANGLE (DEGREES)
1	12.5934	0.530	575.54	450.1[illegible]	358.5633	38.54	0.01375	-0.0
2	14.6547	0.561	608.06	533.70	291.3769	28.66	0.03528	-0.0
3	16.2836	0.580	627.17	581.21	235.6869	22.13	0.04302	-0.0
4	17.6842	0.592	639.48	610.87	189.1357	17.29	0.04358	-0.0
5	18.9394	0.601	647.85	630.35	149.5652	13.45	0.04022	-0.0
6	20.0917	0.607	653.72	643.48	115.2983	10.26	0.03471	-0.0
7	21.1665	0.611	657.87	652.33	85.2007	7.53	0.02818	-0.0
8	22.1801	0.614	660.76	658.17	58.5039	5.16	0.02139	-0.0
9	23.1439	0.615	662.69	661.79	34.6472	3.05	0.01484	-0.0
10	24.0662	0.617	663.86	663.73	13.2138	1.17	0.00889	-0.0
11	24.9531	0.617	664.43	664.40	-6.0849	-0.52	0.00383	-0.0

S.L. NO.	STREAMLINE RADIUS (IN.)	TOTAL PRES. (LB/SQ IN.)	TOTAL TEMP. (DEGREES)	REL. VEL. (FT/SEC)	WHIRL VEL. (FT/SEC)	RELATIVE MACH NO.	REL. FLOW ANG.(DEG)	WHEEL SPEED (FT/SEC)
1	12.5934	14.70	518.69	834.65	-0.00	0.768	46.405	604.483
2	14.6547	14.70	518.69	929.81	-0.00	0.858	49.159	703.[illegible]26
3	16.[illegible]6	14.70	518.69	1002.13	-0.00	0.927	51.256	781.613
4	17.6842	14.70	518.69	1062.77	-0.00	0.985	53.007	848.842
5	18.9394	14.70	518.69	1116.31	-0.00	1.035	54.525	909.089
6	20.0917	14.70	518.69	1165.09	-0.00	1.081	55.868	964.402
7	21.1665	14.70	518.69	1210.39	-0.00	1.124	57.076	1015.992
8	22.1801	14.70	518.69	1253.03	-0.00	1.164	58.174	1064.645
9	23.1439	14.70	518.69	1293.55	-0.00	1.201	59.183	1110.907
10	24.0662	14.70	518.69	1332.35	-0.00	1.238	60.115	1155.176
11	24.9531	14.70	518.69	1369.70	-0.00	1.272	60.981	1197.748

ITERATION ON LOADING WAS TAKING PLACE

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

*** STAGE INPUT PARAMETERS ***

ROTOR 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
MAXIMUM TIP TANGENTIAL VELOCITY	1000.0

---ROTOR---

	PRESSURE PROFILE	FLOW ANGLE AT THE SHOCK	SOLIDITY
A	-0.000000E-38	-0.000000E-38	0.483000E 01
B	-0.000000E-38	-0.000000E-38	0.100000E 01
C	0.100000E 01	0.374000E 02	-0.252800E 01
D	-0.000000E-38	0.166000E 02	0.191700E 01
E	-0.000000E-38	-0.000000E-38	-0.504000E 00

---STATOR---

	WHIRL VELOCITY	FLOW ANGLE AT THE SHOCK	SOLIDITY
A	-0.000000E-38	-0.000000E-38	-0.000000E-38
B	-0.000000E-38	-0.000000E-38	-0.000000E-38
C	0.000000E-38	0.365000E 02	0.185700E 01
D	-0.000000E-38	-0.650000E 01	-0.171500E 01
E	-0.000000E-38	-0.000000E-38	0.858000E 00

*** 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--	3.689	15.3432	25.0000	40.000	0.000	3.3883	401.0000	0.9025
-STATOR-	4.000	15.4708	25.0000	25.037	0.000	2.4142	401.0000	0.8892

	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--	0.944	0.9925	0.9925	1.4484	1.1238	1.4484	1.1239	0.9025
-STATOR-	1.057	0.9900	0.9900	1.4409	1.1237	1.4409	1.1237	0.8892

	LOSS DATA SET USED
-ROTOR--	1
-STATOR-	2

----- R O T O R 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	15.4381	525.795	484.67	361.05	801.076	0.7130	37.231	21.897
2	16.7720	560.185	448.32	290.99	774.255	0.6867	35.382	29.472
3	17.9368	580.037	422.74	237.85	756.123	0.6688	33.093	34.955
4	18.9933	592.332	404.98	194.06	743.322	0.6560	33.012	39.108
5	19.9717	601.228	393.23	156.70	733.696	0.6463	32.132	42.454
6	20.8902	607.181	378.85	123.64	726.280	0.6387	31.442	45.195
7	21.7616	610.531	370.69	93.79	720.384	0.6323	30.969	47.491
8	22.5958	611.501	365.52	66.55	715.521	0.6268	30.720	49.456
9	23.4002	610.625	362.35	41.59	711.258	0.6218	30.627	51.187
10	24.1804	607.907	361.20	18.63	707.366	0.6170	30.706	52.738
11	24.9415	603.411	361.92	-2.49	703.633	0.6122	30.955	54.155

S.L. NO.	TOTAL TEMP. RATIO	TOTAL PRES. RATIO	ADIABATIC EFFICIENCY	DIFFUSION FACTOR	WHEEL SPEED (FT/SEC)	SOLIDITY	A*/S	LOSS COEFF.
1	1.1153	1.4484	0.9687	0.2679	741.03	2.278	0.6550	0.0383
2	1.1159	1.4484	0.9640	0.3169	805.06	1.926	0.6422	0.0369
3	1.1168	1.4484	0.9559	0.3356	860.97	1.733	0.6239	0.0402
4	1.1185	1.4484	0.9424	0.3442	911.68	1.609	0.6050	0.0485
5	1.1201	1.4484	0.9301	0.3457	958.64	1.525	0.5852	0.0551
6	1.1219	1.4484	0.9159	0.3451	1002.73	1.464	0.5656	0.0630
7	1.1243	1.4484	0.8986	0.3445	1044.56	1.417	0.5467	0.0730
8	1.1273	1.4484	0.8776	0.3447	1084.60	1.380	0.5288	0.0854
9	1.1306	1.4484	0.8549	0.3453	1123.21	1.350	0.5115	0.0989
10	1.1346	1.4484	0.8299	0.3469	1160.66	1.324	0.4950	0.1139
11	1.1391	1.4484	0.8030	0.3494	1197.19	1.301	0.4793	0.1305

S.L. NO.	TOTAL TEMP. (DEGREES)	TOTAL PRES. (LB/SQ IN.)	STATIC TEMP. (DEGREES)	STATIC PRES. (LB/SQ IN.)	SLOPE (DEGREES)	CURVATURE 1/IN.	REL. VEL. (FT/SEC)	REL. MACH NUMBER
1	578.50	21.29	525.07	15.17	34.48	-0.07095	687.4134	0.6119
2	578.79	21.29	528.89	15.53	27.45	-0.06101	725.0845	0.6431
3	579.30	21.29	531.70	15.77	22.30	-0.05099	764.8907	0.6766
4	580.17	21.29	534.18	15.94	18.15	-0.04156	803.7801	0.7089
5	580.98	21.29	536.17	16.07	14.62	-0.03283	842.0965	0.7418
6	581.94	21.29	538.04	16.18	11.53	-0.02471	879.3074	0.7732
7	583.16	21.29	539.97	16.26	8.75	-0.01737	914.1383	0.8024
8	584.70	21.29	542.09	16.33	6.23	-0.01108	946.2747	0.8290
9	586.45	21.29	544.35	16.40	3.91	-0.00605	976.4754	0.8537
10	588.49	21.29	546.85	16.46	1.76	-0.00248	1004.5040	0.8762
11	590.83	21.29	549.63	16.53	-0.24	-0.00058	1030.4309	0.8966

\----- S T A T O R   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	16.5778	575.784	-0.00	325.53	661.434	0.5795	-0.000	50.266
2	17.6692	597.159	-0.00	273.45	656.793	0.5750	-0.000	52.245
3	18.6639	613.147	-0.00	229.75	654.776	0.5728	-0.000	53.837
4	19.5867	625.424	-0.00	191.34	654.038	0.5717	-0.000	55.175
5	20.4535	634.774	-0.00	156.73	653.936	0.5711	-0.000	56.337
6	21.2752	641.969	-0.00	125.14	654.052	0.5708	-0.000	57.362
7	22.0597	647.535	-0.00	96.06	654.622	0.5707	-0.000	58.274
8	22.8131	651.874	-0.00	69.10	655.525	0.5707	-0.000	59.094
9	23.5401	655.199	-0.00	43.90	656.668	0.5709	-0.000	59.837
10	24.2445	657.736	-0.00	20.22	658.047	0.5711	-0.000	60.513
11	24.9292	659.629	-0.00	-2.20	659.633	0.5714	-0.000	61.134

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	0.9908	0.9433	0.3389	795.74	1.838	0.7337	0.0320
2	1.0000	0.9925	0.9434	0.3295	848.12	1.627	0.7383	0.0278
3	1.0000	0.9936	0.9385	0.3247	895.37	1.465	0.7410	0.0247
4	1.0000	0.9943	0.9272	0.3236	940.16	1.338	0.7420	0.0225
5	1.0000	0.9949	0.9165	0.3237	981.77	1.237	0.7434	0.0209
6	1.0000	0.9953	0.9036	0.3245	1021.21	1.159	0.7442	0.0196
7	1.0000	0.9956	0.8873	0.3255	1058.86	1.097	0.7438	0.0186
8	1.0000	0.9958	0.8672	0.3262	1095.73	1.054	0.7421	0.0179
9	1.0000	0.9960	0.8452	0.3254	1129.93	1.024	0.7394	0.0173
10	1.0000	0.9962	0.8208	0.3236	1163.73	1.005	0.7356	0.0170
11	1.0000	0.9963	0.7944	0.3199	1196.50	1.000	0.7303	0.0167

S.L. NO.	TOTAL TEMP. (DEGREES)	TOTAL PRES. (LB/SQ IN.)	STATIC TEMP. (DEGREES)	STATIC PRES. (LB/SQ IN.)	SLOPE (DEGREES)	CURVATURE 1/IN.	REL. VEL. (FT/SEC)	REL. MACH NUMBER
1	578.50	21.09	542.08	16.80	29.48	0.05049	1034.7425	0.9065
2	578.79	21.13	542.89	16.88	24.65	0.05379	1072.6995	0.9391
3	579.30	21.15	543.61	16.93	20.63	0.05066	1109.6424	0.9708
4	580.1[illegible]	21.17	544.57	16.96	17.13	0.04471	1145.2811	1.0011
5	580.98	21.18	545.40	16.97	14.01	0.03740	1179.5633	1.0303
6	581.94	21.19	546.34	16.99	11.17	0.02942	1212.7027	1.0583
7	583.16	21.19	547.50	16.99	8.56	0.02155	1244.8780	1.0853
8	584.70	21.20	548.94	17.00	6.15	0.01438	1274.2444	1.1112
9	586.45	21.20	550.57	17.00	3.91	0.00840	1306.8835	1.1362
10	588.49	21.20	552.46	17.00	1.90	0.00399	1336.9002	1.1603
11	590.33	21.21	554.63	17.00	-0.19	0.00145	1366.3697	1.1835

--- 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
MAXIMUM TIP TANGENTIAL VELOCITY	1000.0

	---ROTOR---				---STATOR---		
	PRESSURE PROFILE	FLOW ANGLE AT THE SHOCK	SOLIDITY		WHIRL VELOCITY	FLOW ANGLE AT THE SHOCK	SOLIDITY
A	-0.000000E-38	-0.000000E-38	0.247300E 01	A	-0.000000E-39	-0.000000E-38	-0.000000E-38
B	-0.000000E-38	-0.000000E-38	0.100000E 01	B	-0.000000E-38	-0.000000E-38	-0.000000E-38
C	0.100000E 01	0.387000E 02	-0.473000E 00	C	0.000000E-38	0.380000E 02	0.171600E 01
D	-0.000000E-38	0.127000E 02	0.916000E 00	D	-0.000000E-38	-0.200000E 01	-0.107600E 01
E	-0.000000E-38	-0.000000E-38	-0.380000E 00	E	-0.000000E-38	-0.000000E-38	0.480000E 00

*** 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--	3.500	18.0779	25.0000	33.404	0.000	2.4369	401.0000	0.8961
-STATOR-	3.500	18.8672	25.0000	21.755	0.000	1.9777	401.0000	0.8824

	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--	0.943	0.9875	0.9875	1.4697	1.1295	2.1177	1.2692	0.8870
-STATOR-	1.053	0.9850	0.9850	1.4615	1.1294	2.1058	1.2692	0.8797

	LOSS DATA SET USED
-ROTOR--	1
-STATOR-	2

------ R O T O R   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	18.1807	576.673	491.68	312.48	819.914	0.6865	36.847	30.142
2	18.9982	588.557	472.75	265.46	800.222	0.6682	36.212	34.223
3	19.7630	595.321	459.69	223.10	784.539	0.6533	35.870	37.542
4	20.4885	599.684	448.75	185.50	771.626	0.6407	35.561	40.425
5	21.1818	603.378	437.36	151.95	760.554	0.6301	35.104	42.957
6	21.8479	605.208	428.50	121.27	751.395	0.6210	34.769	45.137
7	22.4922	605.395	422.16	93.00	743.890	0.6132	34.576	47.028
8	23.1188	604.413	417.74	66.85	737.758	0.6064	34.487	48.691
9	23.7313	601.966	415.67	42.51	732.772	0.6004	34.560	50.166
10	24.3327	598.611	415.06	19.84	728.701	0.5950	34.722	51.498
11	24.9253	594.183	416.19	-1.35	725.443	0.5900	35.009	52.709

S.L. NO.	TOTAL TEMP. RATIO	TOTAL PRES. RATIO	ADIABATIC EFFICIENCY	DIFFUSION FACTOR	WHEEL SPEED (FT/SEC)	SOLIDITY	A*/S	LOSS COEFF.
1	1.1232	1.4756	0.9522	0.3680	872.67	1.979	0.6356	0.0469
2	1.1237	1.4731	0.9439	0.3768	911.91	1.820	0.6133	0.0572
3	1.1250	1.4715	0.9311	0.3844	948.63	1.710	0.5947	0.0613
4	1.1263	1.4704	0.9195	0.3888	983.45	1.628	0.5786	0.0688
5	1.1271	1.4696	0.9125	0.3884	1016.72	1.563	0.5625	0.0719
6	1.1282	1.4690	0.9034	0.3881	1048.70	1.509	0.5478	0.0769
7	1.1298	1.4685	0.8918	0.3889	1079.62	1.462	0.5340	0.0836
8	1.1316	1.4682	0.8786	0.3894	1109.70	1.420	0.5210	0.0917
9	1.1340	1.4679	0.8623	0.3919	1139.10	1.380	0.5089	0.1022
10	1.1367	1.4677	0.8448	0.3949	1167.97	1.342	0.4974	0.1135
11	1.1399	1.4675	0.8255	0.3991	1196.42	1.304	0.4864	0.1244

S.L. NO.	TOTAL TEMP. (DEGREES)	TOTAL PRES. (LB/SQ IN.)	STATIC TEMP. (DEGREES)	STATIC PRES. (LB/SQ IN.)	SLOPE (DEGREES)	CURVATURE 1/IN.	REL. VEL. (FT/SEC)	REL. MACH NUMBER
1	649.77	31.12	593.95	22.71	28.49	-0.07897	759.7246	0.6353
2	650.40	31.12	597.24	23.07	24.28	-0.07221	780.8545	0.6520
3	651.73	31.12	600.63	23.37	20.55	-0.06323	802.0202	0.6678
4	653.46	31.12	604.05	23.62	17.20	-0.05337	824.5817	0.6847
5	654.83	31.12	606.83	23.82	14.15	-0.04312	850.1842	0.7043
6	656.57	31.12	609.72	24.00	11.34	-0.03279	875.0026	0.7232
7	658.84	31.12	612.93	24.15	8.75	-0.02207	898.5593	0.7407
8	661.67	31.12	616.51	24.28	6.32	-0.01456	921.1959	0.7572
9	665.06	31.12	620.52	24.40	4.05	-0.00774	942.0832	0.7719
10	668.96	31.12	624.92	24.50	1.90	-0.00303	962.0795	0.7855
11	673.46	31.12	629.83	24.60	-0.13	-0.00071	980.7194	0.7976

---- S T A T O R 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	18.9738	625.992	-0.00	262.56	678.826	0.5602	-0.000	53.301
2	19.6605	628.534	-0.00	224.51	667.710	0.5502	-0.000	54.719
3	20.3189	631.263	-0.00	191.01	659.530	0.5425	-0.000	55.932
4	20.9532	633.564	-0.00	160.83	653.558	0.5366	-0.000	56.979
5	21.5663	635.443	-0.00	133.20	649.254	0.5322	-0.000	57.905
6	22.1609	637.308	-0.00	107.71	646.345	0.5290	-0.000	58.716
7	22.7389	639.310	-0.00	83.84	644.784	0.5267	-0.000	59.429
8	23.3022	641.459	-0.00	61.27	644.379	0.5252	-0.000	60.053
9	23.8525	643.760	-0.00	39.76	644.987	0.5243	-0.000	60.605
10	24.3911	646.171	-0.00	19.12	646.454	0.5239	-0.000	61.094
11	24.9192	648.729	-0.00	-0.74	648.730	0.5240	-0.000	61.526

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	0.9919	0.9311	0.3486	910.74	1.699	0.7245	0.0302
2	1.0000	0.9927	0.9250	0.3521	943.71	1.583	0.7207	0.0283
3	1.0000	0.9933	0.9141	0.3566	975.31	1.485	0.7154	0.0267
4	1.0000	0.9939	0.9040	0.3602	1005.75	1.402	0.7108	0.0254
5	1.0000	0.9943	0.8982	0.3621	1035.18	1.333	0.7087	0.0242
6	1.0000	0.9947	0.8902	0.3635	1063.72	1.274	0.7053	0.0232
7	1.0000	0.9950	0.8795	0.3646	1091.47	1.226	0.7018	0.0224
8	1.0000	0.9952	0.8670	0.3649	1118.51	1.189	0.6980	0.0217
9	1.0000	0.9954	0.8514	0.3648	1144.92	1.159	0.6933	0.0212
10	1.0000	0.9956	0.8346	0.3637	1170.77	1.136	0.6882	0.0207
11	1.0000	0.9957	0.8158	0.3616	1196.12	1.121	0.6823	0.0204

S.L. NO.	TOTAL TEMP. (DEGREES)	TOTAL PRES. (LB/SQ IN.)	STATIC TEMP. (DEGREES)	STATIC PRES. (LB/SQ IN.)	SLOPE (DEGREES)	CURVATURE 1/IN.	REL. VEL. (FT/SEC)	REL. MACH NUMBER
1	649.77	30.87	611.52	24.95	22.75	0.01178	1135.8950	0.9374
2	650.40	30.89	613.43	25.15	19.67	0.01540	1156.0355	0.9526
3	651.73	30.91	615.63	25.31	16.88	0.01606	1177.3716	0.9684
4	653.46	30.93	618.01	25.43	14.31	0.01494	1199.5030	0.9848
5	654.83	30.94	619.86	25.52	11.91	0.01262	1221.9399	1.0017
6	656.57	30.96	621.91	25.59	9.67	0.00945	1244.6947	1.0187
7	658.84	30.97	624.36	25.64	7.54	0.00604	1267.6923	1.0355
8	661.67	30.97	627.23	25.67	5.51	0.00303	1290.8453	1.0520
9	665.06	30.98	630.56	25.69	3.57	0.00096	1314.0962	1.0682
10	668.96	30.98	634.31	25.70	1.72	0.00035	1337.3882	1.0839
11	673.46	30.99	638.58	25.71	-0.07	0.00162	1360.7177	1.0992

--- 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
MAXIMUM TIP TANGENTIAL VELOCITY	1000.0

---ROTOR---

	PRESSURE PROFILE	FLOW ANGLE AT THE SHOCK	SOLIDITY
A	-0.000000E-38	-0.000000E-38	0.379000E 00
B	-0.000000E-38	-0.000000E-38	0.100000E 01
C	0.100000E 01	0.420000E 02	0.138900E 01
D	-0.000000E-38	0.880000E 01	-0.369000E 00
E	-0.000000E-38	-0.000000E-38	0.900000E-01

---STATOR---

	WHIRL VELOCITY	FLOW ANGLE AT THE SHOCK	SOLIDITY
A	-0.000000E-38	-0.000000E-38	-0.000000E-38
B	-0.000000E-38	-0.000000E-38	-0.000000E-38
C	0.000000E-38	0.400000E 02	0.156300E 01
D	-0.000000E-38	-0.100000E 01	-0.591000E 00
E	-0.000000E-33	-0.000000E-38	0.218000E 00

*** 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--	2.500	19.9396	25.0000	23.614	0.000	2.4531	401.0000	0.9062
-STATOR-	2.500	20.4767	25.0000	14.859	0.000	2.0241	401.0000	0.8920

	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--	0.944	0.9825	0.9825	1.4896	1.1321	3.1369	1.4369	0.8810
-STATOR-	1.049	0.9800	0.9800	1.4809	1.1321	3.1184	1.4369	0.9757

	LOSS DATA SET USED
-ROTOR--	1
-STATOR-	2

---- R O T O P   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	20.0392	557.762	526.68	214.03	824.939	0.6473	39.676	34.428
2	20.5824	599.348	513.29	167.15	810.996	0.6352	39.266	37.098
3	21.1080	600.331	502.91	161.90	799.702	0.6249	38.967	39.375
4	21.6187	600.888	494.49	138.05	790.345	0.6160	38.731	41.382
5	22.1165	600.904	487.12	115.40	782.108	0.6082	38.523	43.194
6	22.6027	601.414	479.80	93.99	775.077	0.6014	38.246	44.830
7	23.0786	600.908	474.80	73.44	769.365	0.5953	38.107	46.276
8	23.5464	599.520	471.76	53.76	764.771	0.5899	38.088	47.568
9	24.0080	596.993	470.94	34.90	761.187	0.5849	38.221	48.731
10	24.4654	593.215	472.27	16.90	758.441	0.5803	38.513	49.792
11	24.9203	588.330	475.45	-0.21	756.431	0.5759	38.943	50.775

S.L. NO.	TOTAL TEMP. RATIO	TOTAL PRES. RATIO	ADIABATIC EFFICIENCY	DIFFUSION FACTOR	WHEEL SPEED (FT/SEC)	SOLIDITY	A*/S	LOSS COEFF.
1	1.1290	1.4934	0.9352	0.4416	[illegible]	1.754	0.5979	0.0621
2	1.1290	1.4922	0.9331	0.4399	[illegible]	1.679	0.5799	0.0624
3	1.1293	1.4912	0.9289	0.4391	1113.18	1.615	0.5644	0.0647
4	1.1299	1.4904	0.9236	0.4387	[illegible]	1.559	0.5508	0.0680
5	1.1306	1.4897	0.9172	0.4380	[illegible]	1.509	0.5385	0.0719
6	1.1311	1.4892	0.9127	0.4361	1[illegible]4.93	1.465	0.5269	0.0741
7	1.1320	1.4887	0.9057	0.4359	1107.77	1.426	0.5165	0.0785
8	1.1332	1.4884	0.8967	0.4370	1130.23	1.391	0.5070	0.0846
9	1.1348	1.4881	0.8350	0.4398	1152.39	1.359	0.4984	0.0929
10	1.1369	1.4878	0.8797	0.4444	1174.34	1.330	0.4906	0.1035
11	1.1394	1.4876	0.8545	0.4503	1196.17	1.304	0.4833	0.1157

S.L. NO.	TOTAL TEMP. (DEGREES)	TOTAL PRES. (LB/SQ IN.)	STATIC TEMP. (DEGREES)	STATIC PRES. (LB/SQ IN.)	SLOPE (DEGREES)	CURVATURE 1/IN.	REL. VEL. (FT/SEC)	REL. MACH NUMBER
1	733.56	46.10	677.33	34.90	19.70	-0.06286	769.7567	0.6040
2	734.27	46.10	679.93	35.15	17.34	-0.05455	787.1136	0.6155
3	736.00	46.10	683.16	35.45	15.10	-0.04613	804.3570	0.6285
4	738.32	46.10	686.73	35.71	12.95	-0.03789	821.7044	0.6404
5	740.33	46.10	689.82	35.93	10.98	-0.03000	839.2964	0.6527
6	742.63	46.10	693.03	36.12	8.89	-0.02251	858.3162	0.6660
7	745.78	46.10	696.92	36.29	6.98	-0.01554	875.8614	0.6777
8	749.78	46.10	701.52	36.45	5.13	-0.00949	892.1264	0.6881
9	754.72	46.10	706.92	36.59	3.35	-0.00475	906.6329	0.6965
10	760.55	46.10	713.12	36.72	1.64	-0.00173	919.2856	0.7033
11	767.35	46.10	720.20	36.84	-0.02	-0.00080	930.3600	0.7084

----- S T A T O R   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	20.5769	611.020	-0.00	192.53	640.634	0.4947	-0.000	57.032
2	21.0588	615.465	-0.00	170.75	638.711	0.4929	-0.000	57.712
3	21.5263	619.856	-0.00	149.80	637.699	0.4915	-0.000	58.319
4	21.9824	624.062	-0.00	129.51	637.359	0.4905	-0.000	58.866
5	22.4270	627.728	-0.00	109.76	637.252	0.4897	-0.000	59.376
6	22.8614	631.120	-0.00	90.62	637.593	0.4892	-0.000	59.842
7	23.2869	634.493	-0.00	72.07	638.574	0.4889	-0.000	60.261
8	23.7043	637.881	-0.00	54.02	640.164	0.4886	-0.000	60.637
9	24.1147	641.356	-0.00	36.34	642.384	0.4889	-0.000	60.971
10	24.5189	644.915	-0.00	18.86	645.190	0.4892	-0.000	61.268
11	24.9176	648.581	-0.00	1.49	648.583	0.4897	-0.000	61.530

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	0.9921	0.9158	0.4292	987.69	1.551	0.6761	0.0321
2	1.0000	0.9927	0.9152	0.4246	1010.82	1.491	0.6732	0.0305
3	1.0000	0.9932	0.9123	0.4212	1033.29	1.438	0.6699	0.0292
4	1.0000	0.9937	0.9080	0.4184	1055.16	1.391	0.6666	0.0281
5	1.0000	0.9940	0.9027	0.4160	1076.49	1.349	0.6636	0.0271
6	1.0000	0.9943	0.8990	0.4133	1097.35	1.312	0.6617	0.0262
7	1.0000	0.9946	0.8927	0.4111	1117.77	1.280	0.6590	0.0255
8	1.0000	0.9948	0.8843	0.4093	1137.81	1.252	0.6555	0.0248
9	1.0000	0.9950	0.8732	0.4079	1157.51	1.229	0.6509	0.0243
10	1.0000	0.9952	0.8594	0.4070	1176.91	1.209	0.6451	0.0238
11	1.0000	0.9953	0.8437	0.4062	1196.04	1.193	0.6382	0.0235

S.L. NO.	TOTAL TEMP. (DEGREES)	TOTAL PRES. (LB/SQ IN.)	STATIC TEMP. (DEGREES)	STATIC PRES. (LB/SQ IN.)	SLOPE (DEGREES)	CURVATURE 1/IN.	REL. VEL. (FT/SEC)	REL. MACH NUMBER
1	733.56	45.74	699.68	38.71	17.49	0.04742	1177.2621	0.9092
2	734.27	45.76	700.59	38.78	15.53	0.04199	1195.7070	0.9228
3	736.00	45.79	702.42	38.93	13.63	0.03600	1214.2235	0.9359
4	738.32	45.81	704.79	38.88	11.73	0.02984	1232.7128	0.9486
5	740.33	45.82	706.82	38.91	9.98	0.02373	1250.9719	0.9613
6	742.63	45.84	709.08	38.94	8.23	0.01794	1269.1330	0.9737
7	745.78	45.85	712.14	38.95	6.53	0.01257	1287.3175	0.9856
8	749.78	45.86	715.98	38.97	4.98	0.00811	1305.5337	0.9949
9	754.72	45.87	720.70	38.97	3.27	0.00491	1323.8129	1.0076
10	760.55	45.88	726.25	38.97	1.69	0.00339	1342.1553	1.0177
11	767.35	45.88	732.70	38.96	0.13	0.00400	1360.5811	1.0272

-- 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
MAXIMUM TIP TANGENTIAL VELOCITY	1000.0

---ROTOR---

	PRESSURE PROFILE	FLOW_ANGLE AT THE SHOCK	SOLIDITY
A	-0.000000E-38	-0.000000E-38	0.526000E 00
B	-0.000000E-38	-0.000000E-38	0.100000E 01
C	0.100000E 01	0.410000E 02	0.112400E 01
D	-0.000000E-38	0.108000E 02	-0.127000E 00
E	-0.000000E-38	-0.000000E-38	0.400000E-01

---STATOR---

	WHIRL VELOCITY	FLOW ANGLE AT THE SHOCK	SOLIDITY
A	-0.000000E-38	-0.000000E-38	-0.000000E-38
B	-0.000000E-38	-0.000000E-38	-0.000000E-38
C	0.000000E-38	0.395000E 02	0.149800E 01
D	-0.000000E-38	-0.100000E 01	-0.384000E 00
E	-0.000000E-38	-0.000000E-38	0.960000E-01

*** 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--	2.500	21.1636	25.0000	20.788	0.000	1.8093	401.0000	0.9098
-STATOR-	2.500	21.5554	25.0000	14.325	0.000	1.5346	401.0000	0.8961

	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--	0.943	0.9800	0.9800	1.4348	1.1177	4.4744	1.6061	0.8757
-STATOR-	1.048	0.9800	0.9800	1.4274	1.1178	4.4513	1.6061	0.8720

	LOSS DATA SET USED
-ROTOR--	1
-STATOR-	2

---- R O T O R   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	21.2471	580.566	511.72	182.79	795.189	0.5869	40.055	39.857
2	21.6475	585.146	501.68	162.16	787.641	0.5808	39.564	41.510
3	22.0371	588.894	493.42	142.14	781.319	0.5751	39.162	42.972
4	22.4178	591.792	486.59	122.72	775.918	0.5700	38.838	44.284
5	22.7908	593.807	480.52	103.88	770.906	0.5652	38.559	45.500
6	23.1569	595.140	475.44	85.65	766.530	0.5609	38.334	46.612
7	23.5175	595.482	472.31	67.99	763.085	0.5568	38.239	47.607
8	23.8739	594.924	470.95	50.91	760.475	0.5531	38.264	48.504
9	24.2272	594.002	470.64	34.44	758.634	0.5496	38.344	49.321
10	24.5785	591.943	472.44	18.53	757.599	0.5463	38.580	50.061
11	24.9291	588.815	476.25	3.20	757.316	0.5432	38.966	50.737

S.L. NO.	TOTAL TEMP. RATIO	TOTAL PRES. RATIO	ADIABATIC EFFICIENCY	DIFFUSION FACTOR	WHEEL SPEED (FT/SEC)	SOLIDITY	A*/S	LOSS COEFF.
1	1.1170	1.4377	0.9224	0.4510	1019.86	1.636	0.5439	0.0705
2	1.1167	1.4368	0.9226	0.4476	1039.08	1.575	0.5356	0.0685
3	1.1166	1.4361	0.9223	0.4448	1057.78	1.524	0.5279	0.0672
4	1.1165	1.4355	0.9212	0.4426	1076.06	1.492	0.5209	0.0668
5	1.1167	1.4350	0.9191	0.4405	1093.95	1.445	0.5141	0.0672
6	1.1169	1.4345	0.9162	0.4389	1111.	1.414	0.5078	0.0684
7	1.1174	1.4342	0.9113	0.4387	1128.84	1.386	0.5020	0.0713
8	1.1182	1.4338	0.9045	0.4399	1145.95	1.362	0.4965	0.0758
9	1.1190	1.4336	0.8973	0.4416	1162.91	1.340	0.4911	0.0807
10	1.1202	1.4333	0.8874	0.4451	1179.77	1.321	0.4862	0.0879
11	1.1217	1.4332	0.8753	0.4503	1196.59	1.303	0.4816	0.0969

S.L. NO.	TOTAL TEMP. (DEGREES)	TOTAL PRES. (LB/SQ IN.)	STATIC TEMP. (DEGREES)	STATIC PRES. (LB/SQ IN.)	SLOPE (DEGREES)	CURVATURE 1/IN.	REL. VEL. (FT/SEC)	REL. MACH NUMBER
1	819.36	65.76	767.46	52.13	17.48	-0.06284	792.8910	0.5852
2	819.97	65.76	769.05	52.37	15.49	-0.05618	810.8541	0.5979
3	821.78	65.76	771.69	52.60	13.57	-0.04863	827.9554	0.6095
4	824.36	65.76	774.97	52.80	11.72	-0.04058	844.2431	0.6202
5	826.70	65.76	777.96	52.99	9.93	-0.03239	860.0601	0.6306
6	829.44	65.76	781.25	53.16	8.20	-0.02434	875.2977	0.6405
7	833.34	65.76	785.61	53.32	6.52	-0.01683	888.9629	0.6487
8	838.37	65.76	790.99	53.47	4.90	-0.01039	901.1934	0.6555
9	844.52	65.76	797.39	53.61	3.32	-0.00533	912.8311	0.6613
10	851.95	65.76	804.99	53.74	1.80	-0.00209	922.5236	0.6653
11	860.74	65.76	813.85	53.86	0.31	-0.00119	930.3817	0.6674

****-----** S T A T O R   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	21.6297	608.551	-0.00	171.12	632.152	0.4610	-0.000	58.664
2	21.9857	612.067	-0.00	151.66	630.577	0.4597	-0.000	59.141
3	22.3342	615.426	-0.00	133.06	629.546	0.4584	-0.000	59.573
4	22.6762	618.583	-0.00	115.18	629.215	0.4574	-0.000	59.969
5	23.0124	621.262	-0.00	97.87	628.923	0.4565	-0.000	60.344
6	23.3432	623.765	-0.00	81.10	629.015	0.4558	-0.000	60.691
7	23.6691	626.428	-0.00	64.83	629.773	0.4553	-0.000	61.000
8	23.9909	629.278	-0.00	48.94	631.178	0.4550	-0.000	61.273
9	24.3089	632.327	-0.00	33.39	633.208	0.4548	-0.000	61.512
10	24.6237	635.641	-0.00	18.17	635.901	0.4548	-0.000	61.719
11	24.9358	639.256	-0.00	3.19	639.264	0.4549	-0.000	61.894

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	0.9937	0.9056	0.4210	1038.23	1.490	0.6354	0.0303
2	1.0000	0.9940	0.9066	0.4188	1055.31	1.451	0.6358	0.0294
3	1.0000	0.9943	0.9070	0.4171	1072.04	1.416	0.6356	0.0285
4	1.0000	0.9945	0.9065	0.4158	1088.46	1.383	0.6349	0.0278
5	1.0000	0.9947	0.9050	0.4146	1104.59	1.353	0.6340	0.0271
6	1.0000	0.9949	0.9026	0.4135	1120.47	1.324	0.6328	0.0265
7	1.0000	0.9951	0.8982	0.4130	1136.12	1.299	0.6307	0.0259
8	1.0000	0.9952	0.8919	0.4130	1151.56	1.275	0.6277	0.0255
9	1.0000	0.9954	0.8851	0.4130	1166.83	1.252	0.6244	0.0250
10	1.0000	0.9955	0.8757	0.4137	1181.94	1.232	0.6198	0.0246
11	1.0000	0.9956	0.8641	0.4150	1196.92	1.214	0.6142	0.0243

S.L. NO.	TOTAL TEMP. (DEGREES)	TOTAL PRES. (LB/SQ IN.)	STATIC TEMP. (DEGREES)	STATIC PRES. (LB/SQ IN.)	SLOPE (DEGREES)	CURVATURE 1/IN.	REL. VEL. (FT/SEC)	REL. MACH NUMBER
1	819.36	65.34	796.58	56.52	15.71	0.03993	1215.5369	0.8965
2	819.97	65.36	787.35	56.59	13.92	0.03535	1229.3531	0.8961
3	821.78	65.38	789.27	56.65	12.21	0.03001	1243.2724	0.9052
4	824.36	65.40	791.90	56.70	10.56	0.02422	1257.2404	0.9139
5	826.70	65.41	794.28	56.74	8.97	0.01825	1271.0913	0.9226
6	829.44	65.42	797.01	56.79	7.43	0.01237	1284.9580	0.9311
7	833.34	65.43	800.65	56.80	5.93	0.00697	1298.9915	0.9391
8	838.37	65.44	805.75	56.83	4.46	0.00258	1313.1945	0.9466
9	844.52	65.45	811.71	56.84	3.03	-0.00029	1327.5685	0.9535
10	851.95	65.46	818.88	56.85	1.64	-0.00109	1342.1427	0.9598
11	860.74	65.47	827.35	56.85	0.29	0.00085	1356.9337	0.9656

-- 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 HUB MACH NUMBER LIMIT (IN)	0.7300
STATOR HUB D-FACTOR LIMIT	0.4700
MAXIMUM TIP TANGENTIAL VELOCITY	1000.0

---ROTOR---

	PRESSURE PROFILE	FLOW ANGLE AT THE SHOCK	SOLIDITY
A	-0.000000E-38	-0.000000E-38	0.630000E-01
B	-0.000000E-38	-0.000000E-38	0.100000E 01
C	0.100000E 01	0.434000E 02	0.144500E 01
D	-0.000000E-38	0.910000E 01	-0.222000E 00
E	-0.000000E-38	-0.000000E-38	0.450000E-01

---STATOR---

	WHIRL VELOCITY	FLOW ANGLE AT THE SHOCK	SOLIDITY
A	-0.000000E-38	-0.000000E-38	-0.000000E-38
B	-0.000000E-38	-0.000000E-38	-0.000000E-38
C	0.000000E-38	0.383000E 02	0.143900E 01
D	-0.000000E-39	-0.000000E-38	-0.269000E 00
E	-0.000000E-38	-0.000000E-38	0.700000E-01

*** 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--	2.420	22.0151	25.0000	17.900	0.000	1.4231	401.0000	0.9217
-STATOR-	2.500	22.2934	25.0000	13.121	0.000	1.1940	401.0000	0.9082

	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--	0.944	0.9800	0.9800	1.3845	1.1033	6.1628	1.7720	0.8732
-STATOR-	1.046	0.9800	0.9800	1.3783	1.1033	6.1353	1.7721	0.8705

	LOSS DATA SET USED
-ROTOR--	1
-STATOR-	2

----- R O T O R   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	22.0788	583.370	488.77	160.73	777.852	0.5449	38.929	43.339
2	22.3807	585.299	481.31	142.16	771.000	0.5397	38.628	44.552
3	22.6773	586.791	475.26	124.39	765.299	0.5349	38.391	45.634
4	22.9695	588.016	470.09	107.35	760.445	0.5305	38.184	46.616
5	23.2578	588.765	465.41	90.92	755.991	0.5265	37.998	47.536
6	23.5426	589.057	461.71	75.07	752.197	0.5228	37.966	48.378
7	23.8246	588.854	459.64	59.72	749.392	0.5195	37.833	49.127
8	24.1048	587.929	459.49	44.84	747.528	0.5164	37.928	49.792
9	24.3840	585.952	461.64	30.39	746.575	0.5136	38.195	50.382
10	24.6633	583.090	465.87	16.40	746.523	0.5110	38.613	50.908
11	24.9438	578.968	472.59	2.87	747.365	0.5086	39.223	51.378

S.L. NO.	TOTAL TEMP. RATIO	TOTAL PRES. RATIO	ADIABATIC EFFICIENCY	DIFFUSION FACTOR	WHEEL SPEED (FT/SEC)	SOLIDITY	A*/S	LOSS COEFF.
1	1.1031	1.3860	0.9281	0.4435	1059.78	1.502	0.5160	0.0605
2	1.1029	1.3856	0.9296	0.4400	1074.27	1.474	0.5101	0.0581
3	1.1027	1.3853	0.9304	0.4374	1088.51	1.449	0.5046	0.0565
4	1.1025	1.3849	0.9308	0.4351	1102.54	1.426	0.4995	0.0553
5	1.1025	1.3846	0.9305	0.4329	1116.37	1.404	0.4945	0.0547
6	1.1025	1.3844	0.9291	0.4314	1130.04	1.384	0.4900	0.0550
7	1.1028	1.3841	0.9261	0.4312	1143.58	1.365	0.4857	0.0568
8	1.1032	1.3839	0.9207	0.4327	1157.03	1.348	0.4819	0.0604
9	1.1041	1.3837	0.9121	0.4364	1170.43	1.332	0.4785	0.0647
10	1.1052	1.3836	0.9011	0.4420	1183.94	1.317	0.4754	0.0750
11	1.1068	1.3834	0.8870	0.4500	1197.30	1.302	0.4728	0.0859

S.L. NO.	TOTAL TEMP. (DEGREES)	TOTAL PRES. (LB/SQ IN.)	STATIC TEMP. (DEGREES)	STATIC PRES. (LB/SQ IN.)	SLOPE (DEGREES)	CURVATURE 1/IN.	REL. VEL. (FT/SEC)	REL. MACH NUMBER
1	903.86	90.57	854.59	74.11	15.40	-0.06007	931.9971	0.5828
2	904.31	90.57	855.91	74.39	13.65	-0.05330	845.2174	0.5916
3	906.16	90.57	858.48	74.64	11.97	-0.04565	857.9317	0.5996
4	908.87	90.57	861.81	74.87	10.35	-0.03748	870.2120	0.6071
5	911.40	90.57	864.91	75.08	8.78	-0.02907	882.4157	0.6146
6	914.47	90.57	868.45	75.26	7.26	-0.02073	894.0299	0.6214
7	918.97	90.57	873.31	75.45	5.79	-0.01292	904.4817	0.6270
8	924.93	90.57	879.53	75.61	4.36	-0.00626	913.3668	0.6310
9	932.43	90.57	887.18	75.76	2.97	-0.00152	920.1365	0.6330
10	94[illegible].61	90.57	896.41	75.90	1.61	0.00048	925.0656	0.6332
11	952.63	90.57	907.38	76.03	0.29	-0.00115	927.5984	0.6313

----- S T A T O R   E X I T **-----**

S.L. NO.	STREAMLINE RADIUS (IN.)	AXIAL VEL. (F./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	22.3508	617.106	-0.00	135.70	631.851	0.4335	-0.000	59.504
2	22.6213	616.056	-0.00	120.01	627.637	0.4353	-0.000	59.971
3	22.8890	615.597	-0.00	105.16	624.514	0.4327	-0.000	60.385
4	23.1540	615.569	-0.00	90.98	622.256	0.4304	-0.000	60.756
5	23.4166	615.626	-0.00	77.32	620.462	0.4285	-0.000	61.101
6	23.6767	616.016	-0.00	64.12	619.345	0.4270	-0.000	61.411
7	23.9346	617.037	-0.00	51.33	619.160	0.4258	-0.000	61.678
8	24.1905	618.689	-0.00	38.86	619.908	0.4250	-0.000	61.903
9	24.4446	620.981	-0.00	26.61	621.551	0.4244	-0.000	62.089
10	24.6973	623.952	-0.00	14.52	624.121	0.4241	-0.000	62.234
11	24.9487	627.635	-0.00	2.52	627.640	0.4241	-0.000	62.341

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	0.9949	0.9128	0.4069	1072.84	1.433	0.6157	0.0282
2	1.0000	0.9950	0.9148	0.4077	1085.82	1.407	0.6143	0.0278
3	1.0000	0.9952	0.9160	0.4085	1098.67	1.383	0.6127	0.0273
4	1.0000	0.9953	0.9168	0.4089	1111.39	1.360	0.6110	0.0259
5	1.0000	0.9955	0.9169	0.4091	1123.99	1.339	0.6094	0.0265
6	1.0000	0.9956	0.9159	0.4092	1136.48	1.320	0.6075	0.0261
7	1.0000	0.9957	0.9132	0.4094	1148.86	1.302	0.6051	0.0258
8	1.0000	0.9958	0.9082	0.4099	1161.14	1.285	0.6018	0.0255
9	1.0000	0.9959	0.9000	0.4110	1173.34	1.270	0.5973	0.0252
10	1.0000	0.9959	0.8893	0.4125	1185.47	1.255	0.5917	0.0250
11	1.0000	0.9960	0.8756	0.4147	1197.54	1.242	0.5847	0.0249

S.L. NO.	TOTAL TEMP. (DEGREES)	TOTAL PRES. (LB/SQ IN.)	STATIC TEMP. (DEGREES)	STATIC PRES. (LB/SQ IN.)	SLOPE (DEGREES)	CURVATURE 1/IN.	REL. VEL. (FT/SEC)	REL. MACH NUMBER
1	903.86	90.10	871.38	79.04	12.40	-0.01051	1245.0753	0.8640
2	904.31	90.12	872.26	79.20	11.02	-0.00912	1254.1688	0.8699
3	906.16	90.13	874.43	79.33	9.69	-0.00885	1263.7625	0.8755
4	908.87	90.15	877.39	79.45	8.41	-0.00935	1273.7333	0.8810
5	911.40	90.16	880.11	79.55	7.16	-0.01035	1283.8757	0.8867
6	914.47	90.17	883.29	79.63	5.94	-0.01157	1294.2855	0.8923
7	918.97	90.18	887.83	79.69	4.76	-0.012[illegible]7	1305.0851	0.8975
8	924.93	90.19	893.73	79.74	3.59	-0.01273	1316.2590	0.9023
9	932.43	90.20	901.09	79.77	2.45	-0.01129	1327.8024	0.9067
10	941.61	90.20	910.04	79.80	1.33	-0.00741	1339.7271	0.9105
11	952.63	90.21	920.74	79.80	0.23	-0.00017	1352.0480	0.9137

-- FINAL FLOW PARAMETERS FOR STAGE NUMBER 6 ***--***

*** 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
MAXIMUM TIP TANGENTIAL VELOCITY	1000.0

---ROTOR---

	PRESSURE PROFILE	FLOW ANGLE AT THE SHOCK	SOLIDITY
A	-0.000000E-38	-0.000000E-38	0.105000E 00
B	-0.000000E-38	-0.000000E-38	0.100000E 01
C	0.100000E 01	0.465000E 02	0.135000E 01
D	-0.000000E-38	0.810000E 01	-0.102000E 00
E	-0.000000E-38	-0.000000E-38	0.000000E-38

---STATOR---

	WHIRL VELOCITY	FLOW ANGLE AT THE SHOCK	SOLIDITY
A	-0.000000E-38	-0.000000E-38	-0.000000E-38
B	-0.000000E-38	-0.000000E-38	-0.000000E-38
C	0.000000E-38	0.371000E 02	0.139200E 01
D	-0.000000E-38	-0.000000E-38	-0.200000E 00
E	-0.000000E-38	-0.000000E-38	0.480000E-01

*** 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--	1.931	22.5990	25.0000	12.300	0.000	1.4016	401.0000	0.9297
-STATOR-	1.943	22.8058	25.0000	9.500	0.000	1.2356	401.0000	0.9166

	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--	0.941	0.9800	0.9800	1.3440	1.0918	8.2458	1.9348	0.8718
-STATOR-	1.045	0.9800	0.9800	1.3387	1.0918	8.2135	1.9348	0.8696

	LOSS DATA SET USED
-ROTOR--	1
-STATOR-	2

---- ROTOR EXIT **----**

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	22.6495	583.754	472.92	110.89	759.423	0.5090	38.517	45.951
2	22.8863	582.808	466.60	98.53	753.054	0.5035	38.288	46.914
3	23.1207	581.985	461.60	86.59	747.848	0.4994	38.114	47.769
4	23.3551	581.280	457.50	75.04	743.520	0.4957	37.975	48.542
5	23.5837	580.499	453.83	63.81	739.606	0.4923	37.851	49.268
6	23.8127	579.739	450.92	52.89	736.360	0.4892	37.761	49.931
7	24.0405	578.695	449.77	42.22	734.142	0.4864	37.781	50.512
8	24.2678	576.986	450.87	31.79	732.943	0.4839	37.963	51.015
9	24.4952	574.480	454.33	21.59	732.742	0.4817	38.319	51.450
10	24.7237	571.038	460.29	11.65	733.542	0.4796	38.865	51.825
11	24.9542	566.273	469.15	1.99	735.371	0.4777	39.641	52.147

S.L. NO.	TOTAL TEMP. RATIO	TOTAL PRES. RATIO	ADIABATIC EFFICIENCY	DIFFUSION FACTOR	WHEEL SPEED (FT/SEC)	SOLIDITY	A*/S	LOSS COFF.
1	1.0920	1.3449	0.9319	0.4405	1087.18	1.451	0.4995	0.0539
2	1.0917	1.3447	0.9347	0.4365	1098.54	1.431	0.4933	0.0510
3	1.0914	1.3445	0.9366	0.4333	1109.79	1.414	0.4878	0.0489
4	1.0912	1.3443	0.9379	0.4308	1120.95	1.398	0.4828	0.0473
5	1.0911	1.3441	0.9384	0.4285	1132.02	1.382	0.4782	0.0465
6	1.0910	1.3439	0.9381	0.4268	1143.01	1.369	0.4741	0.0462
7	1.0912	1.3438	0.9358	0.4267	1153.95	1.354	0.4705	0.0476
8	1.0916	1.3436	0.9305	0.4289	1164.85	1.341	0.4674	0.0513
9	1.0923	1.3435	0.9219	0.4334	1175.77	1.328	0.4649	0.0577
10	1.0934	1.3434	0.9102	0.4405	1186.74	1.315	0.4629	0.0666
11	1.0948	1.3434	0.8949	0.4505	1197.80	1.303	0.4614	0.0786

S.L. NO.	TOTAL TEMP. (DEGREES)	TOTAL PRES. (LB/SQ IN.)	STATIC TEMP. (DEGREES)	STATIC PRES. (LB/SQ IN.)	SLOPE (DEGREES)	CURVATURE 1/IN.	REL. VEL. (FT/SEC)	REL. MACH NUMBER
1	987.01	121.18	940.47	101.79	10.75	-0.03561	854.6187	0.5717
2	987.20	121.18	941.44	102.10	9.60	-0.03099	865.2859	0.5785
3	988.98	121.18	943.86	102.38	8.46	-0.02583	875.4210	0.5846
4	991.76	121.18	947.18	102.63	7.36	-0.02039	885.2586	0.5902
5	994.41	121.18	950.32	102.86	6.27	-0.01481	894.9771	0.5957
6	997.72	121.18	954.02	103.07	5.21	-0.00931	904.3659	0.6008
7	1002.75	121.18	959.35	103.26	4.17	-0.00421	912.4306	0.6046
8	1009.65	121.18	966.42	103.43	3.15	-0.00008	918.5295	0.6065
9	1018.52	121.18	975.36	103.58	2.15	0.00242	922.4786	0.6064
10	1029.54	121.18	986.34	103.72	1.17	0.00252	924.0945	0.6042
11	1042.96	121.18	999.61	103.86	0.20	-0.00067	922.8255	0.5995

----- S T A T O R   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	22.8517	611.706	-0.00	83.20	617.338	0.4097	-0.000	60.629
2	23.0672	609.318	-0.00	74.11	613.808	0.4072	-0.000	60.997
3	23.2814	607.743	-0.00	65.35	611.247	0.4051	-0.000	61.323
4	23.4945	606.782	-0.00	56.87	609.441	0.4033	-0.000	61.513
5	23.7065	606.076	-0.00	48.58	608.020	0.4018	-0.000	61.883
6	23.9173	605.846	-0.00	40.48	607.197	0.4006	-0.000	62.125
7	24.1270	606.395	-0.00	32.55	607.269	0.3996	-0.000	62.329
8	24.3358	607.744	-0.00	24.75	608.247	0.3989	-0.000	62.494
9	24.5438	609.906	-0.00	17.01	610.143	0.3985	-0.000	62.620
10	24.7511	612.914	-0.00	9.30	612.984	0.3983	-0.000	62.708
11	24.9580	616.823	-0.00	1.57	616.825	0.3983	-0.000	62.757

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	0.9956	0.9174	0.4116	1096.98	1.388	0.5900	0.0276
2	1.0000	0.9957	0.9206	0.4114	1107.22	1.369	0.5881	0.0272
3	1.0000	0.9958	0.9229	0.4112	1117.51	1.351	0.5861	0.0269
4	1.0000	0.9959	0.9245	0.4110	1127.74	1.334	0.5840	0.0265
5	1.0000	0.9960	0.9253	0.4107	1137.91	1.318	0.5821	0.0262
6	1.0000	0.9961	0.9253	0.4104	1148.03	1.303	0.5802	0.0259
7	1.0000	0.9962	0.9233	0.4104	1158.10	1.289	0.5776	0.0256
8	1.0000	0.9963	0.9182	0.4111	1168.12	1.276	0.5740	0.0254
9	1.0000	0.9963	0.9100	0.4125	1178.10	1.264	0.5692	0.0252
10	1.0000	0.9964	0.8985	0.4147	1188.05	1.253	0.5631	0.0251
11	1.0000	0.9964	0.9835	0.4179	1197.98	1.242	0.5553	0.0251

S.L. NO.	TOTAL TEMP. (DEGREES)	TOTAL PRES. (LB/SQ IN.)	STATIC TEMP. (DEGREES)	STATIC PRES. (LB/SQ IN.)	SLOPE (DEGREES)	CURVATURE 1/IN.	REL. VEL. (FT/SEC)	REL. MACH NUMBER
1	987.01	120.64	956.28	107.62	7.75	-0.03051	1258.6727	0.8352
2	987.20	120.66	956.83	107.78	6.93	-0.02749	1265.9798	0.8399
3	988.98	120.67	958.86	107.91	6.14	-0.02513	1273.7524	0.8442
4	991.76	120.69	961.83	108.03	5.36	-0.02321	1281.8771	0.8483
5	994.41	120.70	964.63	108.13	4.58	-0.02156	1290.1669	0.8526
6	997.72	120.71	968.03	108.21	3.82	-0.02005	1298.7151	0.8569
7	1002.75	120.72	973.08	108.28	3.07	-0.01841	1307.6555	0.8605
8	1009.65	120.73	979.90	108.33	2.33	-0.01620	1316.9505	0.8638
9	1018.52	120.74	988.62	108.37	1.60	-0.01291	1326.7238	0.8665
10	1029.54	120.74	999.40	108.39	0.87	-0.00793	1336.8698	0.8686
11	1042.96	120.75	1012.49	108.40	0.15	-0.00057	1347.4567	0.8701

-- 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
MAXIMUM TIP TANGENTIAL VELOCITY	1000.0

	---ROTOR---				---STATOR---		
	PRESSURE PROFILE	FLOW ANGLE AT THE SHOCK	SOLIDITY		WHIRL VELOCITY	FLOW ANGLE AT THE SHOCK	SOLIDITY
A	-0.000000E-38	-0.000000E-38	0.126000E 00	A	-0.000000E-38	-0.000000E-38	-0.000000E-38
B	-0.000000E-38	-0.000000E-38	0.100000E 01	B	-0.000000E-38	-0.000000E-38	-0.000000E-38
C	0.100000E 01	0.499000E 02	0.129000E 01	C	0.000000E-38	0.330000E 02	0.136800E 01
D	-0.000000E-38	0.578000E 02	-0.430000E-01	D	-0.000000E-38	0.170000E 01	-0.990000E-01
E	-0.000000E-38	-0.000000E-38	-0.100000E-01	E	-0.000000E-38	-0.000000E-38	0.600000E-01

*** 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--	1.245	23.0160	25.0000	6.800	0.000	1.7631	401.0000	0.9301
-STATOR-	0.896	23.1709	25.0000	4.000	0.000	2.2153	401.0000	0.9173

	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--	0.942	0.9800	0.9800	1.3076	1.0821	10.7397	2.0937	0.8701
-STATOR-	1.041	0.9800	0.9800	1.3030	1.0821	10.7019	2.0937	0.8683

	LOSS DATA SET USED
-ROTOR--	1
-STATOR-	2

****-----** R O T O R   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	23.0574	572.172	458.61	51.37	735.082	0.4718	38.601	48.448
2	23.2510	571.845	452.95	46.20	730.963	0.4691	38.292	49.134
3	23.4432	571.552	448.61	41.04	727.741	0.4666	38.057	49.741
4	23.6342	571.262	445.25	35.89	725.171	0.4643	37.979	50.290
5	23.8241	570.856	442.32	30.76	722.822	0.4621	37.730	50.811
6	24.0132	570.432	440.15	25.67	720.959	0.4602	37.626	51.290
7	24.2016	569.647	439.84	20.61	719.984	0.4584	37.654	51.703
8	24.3899	568.129	441.92	15.58	719.934	0.4567	37.867	52.052
9	24.5789	565.734	446.53	10.61	720.805	0.4551	38.279	52.343
10	24.7692	562.215	453.93	5.72	722.615	0.4537	38.916	52.585
11	24.9619	557.151	464.53	0.94	725.403	0.452[illegible]	39.820	52.786

S.L. NO.	TOTAL TEMP. RATIO	TOTAL PRES. RATIO	ADIABATIC EFFICIENCY	DIFFUSION FACTOR	WHEEL SPEED (FT/SEC)	SOLIDITY	A*/S	LOSS COEFF.
1	1.0824	1.3082	0.9308	0.4381	1106.75	1.413	0.4783	0.0525
2	1.0820	1.3081	0.9342	0.4329	1116.05	1.397	0.4735	0.0493
3	1.0817	1.3079	0.9368	0.4289	1125.27	1.384	0.4693	0.0469
4	1.0815	1.3078	0.9385	0.4258	1134.44	1.372	0.4655	0.0452
5	1.0814	1.3076	0.9393	0.4232	1143.56	1.360	0.4620	0.0442
6	1.0813	1.3075	0.9392	0.4212	1152.63	1.349	0.4589	0.0439
7	1.0815	1.3074	0.9370	0.4212	1161.68	1.339	0.4563	0.0453
8	1.0819	1.3073	0.9314	0.4237	1170.72	1.330	0.4541	0.0492
9	1.0825	1.3072	0.9225	0.4289	1179.79	1.320	0.4525	0.0557
10	1.0835	1.3072	0.9101	0.4370	1188.92	1.311	0.4514	0.0652
11	1.0849	1.3071	0.8938	0.4487	1198.17	1.302	0.4508	0.0780

S.L. NO.	TOTAL TEMP. (DEGREES)	TOTAL PRES. (LB/SQ IN.)	STATIC TEMP. (DEGREES)	STATIC PRES. (LB/SQ IN.)	SLOPE (DEGREES)	CURVATURE 1/IN.	REL. VEL. (FT/SEC)	REL. MACH NUMBER
1	1068.32	157.83	1025.14	135.79	5.13	-0.02395	866.0857	0.5559
2	1068.18	157.83	1025.48	136.02	4.62	-0.02100	876.8341	0.5627
3	1069.83	157.83	1027.51	136.24	4.11	-0.01790	886.6950	0.5685
4	1072.63	157.83	1030.63	136.43	3.59	-0.01474	895.8878	0.5736
5	1075.37	157.83	1033.66	136.62	3.08	-0.01157	904.7407	0.5785
6	1078.88	157.83	1037.40	136.78	2.57	-0.00845	913.0526	0.5828
7	1084.44	157.83	1043.11	136.94	2.07	-0.00552	919.7680	0.5855
8	1092.29	157.83	1051.00	137.09	1.57	-0.00297	924.2066	0.5862
9	1102.58	157.83	1061.24	137.22	1.07	-0.00105	92[illegible].1890	0.5848
10	1115.52	157.83	1074.04	137.35	0.58	-0.00009	925.3801	0.5810
11	1131.47	157.83	1089.75	137.48	0.10	-0.00045	921.2156	0.5744

----- S T A T O R   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	23.2089	594.173	-0.00	35.26	595.219	0.3795	-0.000	61.885
2	23.3885	593.363	-0.00	31.67	594.207	0.3788	-0.000	62.109
3	23.5670	593.118	-0.00	28.22	593.789	0.3783	-0.000	62.304
4	23.7444	593.272	-0.00	24.85	593.793	0.3778	-0.000	62.481
5	23.9208	593.500	-0.00	21.55	593.891	0.3774	-0.000	62.650
6	24.0962	594.028	-0.00	18.28	594.310	0.3770	-0.000	62.804
7	24.2708	595.203	-0.00	15.04	595.393	0.3768	-0.000	62.930
8	24.4448	597.082	-0.00	11.75	597.197	0.3766	-0.000	63.025
9	24.6183	599.694	-0.00	8.33	599.752	0.3765	-0.000	63.090
10	24.7916	603.089	-0.00	4.68	603.107	0.3765	-0.000	63.123
11	24.9647	607.336	-0.00	0.68	607.337	0.3766	-0.000	63.123

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	0.9961	0.9169	0.4195	1114.03	1.366	0.5583	0.0276
2	1.0000	0.9962	0.9206	0.4153	1122.65	1.357	0.5583	0.0272
3	1.0000	0.9963	0.9234	0.4124	1131.21	1.349	0.5578	0.0269
4	1.0000	0.9964	0.9253	0.4097	1139.73	1.343	0.5571	0.0266
5	1.0000	0.9965	0.9264	0.4071	1148.20	1.338	0.5563	0.0264
6	1.0000	0.9965	0.9265	0.4046	1156.62	1.333	0.5552	0.0261
7	1.0000	0.9966	0.9245	0.4026	1165.00	1.330	0.5533	0.0260
8	1.0000	0.9966	0.9192	0.4015	1173.35	1.328	0.5502	0.0259
9	1.0000	0.9966	0.9105	0.4013	1181.68	1.327	0.5457	0.0258
10	1.0000	0.9966	0.8982	0.4020	1190.00	1.327	0.5395	0.0259
11	1.0000	0.9966	0.8821	0.4038	1198.31	1.329	0.5313	0.0260

S.L. NO.	TOTAL TEMP. (DEGREES)	TOTAL PRES. (LB/SQ IN.)	STATIC TEMP. (DEGREES)	STATIC PRES. (LB/SQ IN.)	SLOPE (DEGREES)	CURVATURE 1/IN.	REL. VEL. (FT/SEC)	REL. MACH NUMBER
1	1068.32	157.22	1040.03	142.56	3.40	-0.00815	1263.0686	0.8052
2	1068.18	157.24	1039.99	142.62	3.06	-0.00782	1270.2067	0.8098
3	1069.83	157.25	1041.68	142.67	2.72	-0.00746	1277.5883	0.8139
4	1072.63	157.26	1044.49	142.72	2.40	-0.00704	1285.1352	0.8176
5	1075.37	157.27	1047.23	142.76	2.08	-0.00656	1292.6952	0.8214
6	1078.88	157.28	1050.72	142.79	1.76	-0.00602	1300.3728	0.8250
7	1084.44	157.29	1056.20	142.82	1.45	-0.00539	1308.3270	0.8280
8	1092.29	157.29	1063.90	142.84	1.13	-0.00459	1316.5860	0.8303
9	1102.58	157.30	1073.98	142.86	0.80	-0.00352	1325.1682	0.8320
10	1115.52	157.30	1086.65	142.87	0.45	-0.00209	1334.1016	0.8329
11	1131.47	157.30	1102.25	142.87	0.06	-0.00015	1343.4276	0.8331

-- OUTLET FLOW PARAMETERS ***--***

STA NO.	AXIAL COORDINATE (IN.)	GEOMETRIC HUB RADIUS (IN.)	GEOMETRIC TIP RADIUS (IN.)	HUB BLOCKAGE FACTOR	TIP BLOCKAGE FACTOR
20	41.486	23.285	25.000	0.980	0.980
21	43.702	23.304	25.000	0.980	0.980
22	45.917	23.323	25.000	0.980	0.980

STATION NUMBER 20

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	TOTAL TEMP. (DEG.S R)	TOTAL PRES. (LB/SQ IN.)
1	23.3203	639.156	-0.00	18.73	639.43	0.4085	1068.32	157.2
2	23.4875	638.285	-0.00	16.63	638.50	0.4079	1068.18	157.2
3	23.6540	638.045	-0.00	14.63	638.21	0.4074	1069.83	157.2
4	23.8199	638.239	-0.00	12.70	638.37	0.4069	1072.63	157.3
5	23.9851	638.507	-0.00	10.83	638.60	0.4066	1075.37	157.3
6	24.1497	639.088	-0.00	9.02	639.15	0.4063	1078.88	157.3
7	24.3137	640.349	-0.00	7.24	640.39	0.4061	1084.44	157.3
8	24.4772	642.347	-0.00	5.50	642.37	0.4059	1092.29	157.3
9	24.6405	645.121	-0.00	3.78	645.13	0.4058	1102.58	157.3
10	24.8037	648.731	-0.00	2.07	648.73	0.4058	1115.52	157.3
11	24.9668	653.276	-0.00	0.36	653.28	0.4059	1131.47	157.3

STATION NUMBER 21

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	TOTAL TEMP. (DEG.S R)	TOTAL PRES. (LB/SQ IN.)
1	23.3388	646.196	-0.00	5.40	646.22	0.4129	1068.32	157.2
2	23.5041	645.634	-0.00	5.05	645.65	0.4126	1068.18	157.2
3	23.6688	645.682	-0.00	4.65	645.70	0.4123	1069.83	157.2
4	23.8328	646.142	-0.00	4.20	646.16	0.4121	1072.63	157.3
5	23.9962	646.649	-0.00	3.70	646.66	0.4119	1075.37	157.3
6	24.1590	647.448	-0.00	3.16	647.46	0.4117	1078.88	157.3
7	24.3212	648.911	-0.00	2.59	648.92	0.4115	1084.44	157.3
8	24.4829	651.095	-0.00	2.00	651.10	0.4116	1092.29	157.3
9	24.6444	654.033	-0.00	1.38	654.03	0.4116	1102.58	157.3
10	24.8058	657.781	-0.00	0.75	657.78	0.4117	1115.52	157.3
11	24.9672	662.426	-0.00	0.11	662.43	0.4118	1131.47	157.3

STATION NUMBER 22

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	TOTAL TEMP. (DEG.S R)	TOTAL PRES. (LB/SQ IN.)
1	23.3572	652.021	-0.00	0.00	652.02	0.4167	1068.32	157.2
2	23.5221	652.233	-0.00	0.00	652.23	0.4169	1068.18	157.2
3	23.6858	652.963	-0.00	0.00	652.96	0.4171	1069.83	157.2
4	23.8485	654.020	-0.00	0.00	654.02	0.4172	1072.63	157.3
5	24.0103	655.040	-0.00	0.00	655.04	0.4174	1075.37	157.3
6	24.1711	656.273	-0.00	0.00	656.27	0.4175	1078.88	157.3
7	24.3312	658.100	-0.00	0.00	658.10	0.4177	1084.44	157.3
8	24.4907	660.567	-0.00	0.00	660.59	0.4178	1092.29	157.3
9	24.6499	663.768	-0.00	0.00	663.77	0.4179	1102.59	157.3
10	24.8087	667.702	-0.00	0.00	667.70	0.4181	1115.52	157.3
11	24.9676	672.478	-0.00	0.00	672.48	0.4182	1131.47	157.3