NASA CR-72427
August 1968
Allison EDR-5898

N69 10873

Axial Flow Compressor Computer Program for Calculating Off-Design Performance (Program IV)

by

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Prepared for

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Contract NAS3-7277

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COMPUTER PROGRAM FOR CALCULATING OFF-DESIGN PERFORMANCE OF MULTISTAGE AXIAL-FLOW COMPRESSORS

by

H. F. Creveling and R. H. Carmody

SUMMARY

The technical objectives of the contract included generating a computer (IBM 7094) programmed axial-flow compressor off-design aerodynamic performance calculation which accounts for variable specific heat and full radial equilibrium of the flow, including streamline curvature and radial gradients in total enthalpy and entropy. The resulting performance computation is iterative, with efficiencies determined from a total pressure loss coefficient which is taken as the sum of a calculated reference loss coefficient and an off-reference increment in loss coefficient. The reference loss is established through the use of correlated blade element profile loss data and the loss associated with a normal shock in the blade passage, where appropriate, for diffusion factors from 0 to 1.0 and Mach numbers from 0 to 1.6. A compressor of specified geometry is considered and energy addition for a given flow rate and rotational speed is determined through the use of blade element performance data concerning reference incidence angle and deviation angle.

Tabular data for loss, incidence angle, and deviation angle are available in the program for NACA 65-series and double-circular-arc blade sections. Calculations for reference incidence and deviation angle can be made using NASA 2-D or 3-D design rules. Deviation angles for nonreference incidence conditions are obtained by adding increments to the reference values.

The program accepts input data describing the geometry of a compressor having up to 12 stages and, barring any error messages from the calculation, computes the aerodynamic performance for a given rotational speed and flow rate, and for given uniform inlet conditions of total temperature and pressure. 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 mass flow at each blade row. 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 listing of the computer program is shown in Appendix B.

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

INTRODUCTION

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

The second program accounts for complete radial equilibrium of flow. Losses are evaluated on the basis of blade element loss prediction methods. Radial distribution of energy is specified as a polynomial variation of whirl velocities at the exit of each rotor blade row; rotor tip loadings are specified as are limiting values of rotor hub relative exit angles, stator hub Mach numbers, stator hub loadings, and the compressor flow path. This computer program is designated as "Axial Flow Compressor Design Program II", and is reported in Reference 2.

A third design program was also developed under this contract and is reported in Reference 3. Program III differs from Program II in that the radial distribution of total pressure is specified rather than the whirl velocity distribution, and there is the option of specifying the flow path or specifying the axial velocity ratios and calculating the resulting flow path.

The final program developed under this contract is an off-design performance calculation and is reported herein. The calculation accounts for variable specific heat and full radial equilibrium and determines energy addition and adiabatic efficiencies on the basis of data for blade element turning and loss.

The program user has available as options either double-circular-arc or NACA 65-series blade performance data as published in Reference 4, Chapters VI and VII, plus the capability of specifying reference incidence angle through tabular input for any individual blade row or through the criterion of suction surface tangency for any double-circular-arc blade row. The off-reference increment in deviation angle is furnished in the form of a correlation of selected NASA data.

Adiabatic efficiency is determined iteratively for each streamline in each blade row, using: (1) correlated reference profile loss data and reference shock loss computed on the basis of the normal shock-in-passage model of Reference 5 and (2) correlated results of NACA data expressing the off-reference increment in total pressure loss coefficient in terms of $(i-i_{ref})$ and relative inlet Mach number.

The program can handle up to 32 axial stations and, subject to this constraint, the user may use dummy blade rows as described in Appendix D. End wall blockage is input to the program at the hub and tip for each axial station and is expressed as the unblocked fraction of geometric annulus area.

SYMBOLS

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

a	sonic velocity, ft/sec
A, B, C, D, E	constants in whirl velocity polynomial
b	axial spacing of computational stations, in.
c_p	specific heat at constant pressure, BTU/lb_m - °R
c	blade chord, in.
D	diffusion factor; total derivative
F	blade force on gas, lb_f/lb_m
F, G, K, W	constants, variously defined in Equations (A-38) through (A-40) and in Equations (A-44) through (A-46)
g_c	universal gravitational constant, 32.174 ft-lb_m/lb_f-sec^2
h	inlet blade passage dimension normal to flow $h = s \cos \beta_1'$, in.
H	enthalpy, BTU/lb_m
i	incidence angle, degrees
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
O	blade throat dimension, in.
p	percent blade span
P	pressure, $lb_f/in.^2$ abs
$\dot{Q}$	heat transfer rate, BTU/lb_m-sec
R	radius, in.
R_i	i^{th} rotor
$\mathcal{R}$	gas constant, ft-lb_f/lb_m-R°
s	blade spacing, in.
S	entropy, BTU/lb_m-R°
S_i	i^{th} stator
t	time, sec; blade thickness, in.
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.

Greek

α	ramp angle, degrees
β	air angle, measured from engine axis, degrees
γ	ratio of specific heats
δ	blockage; unblocked fraction of annulus area

Greek (cont)

$\delta°$	deviation angle, degrees
Δ	change; final value minus initial value
ϵ ref	reference air turning angle, defined in Equation (3)
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
ψ	blade camber angle, degrees
ω	angular speed, radians/second
$\bar{\omega}$	blade total pressure loss coefficient

Subscripts

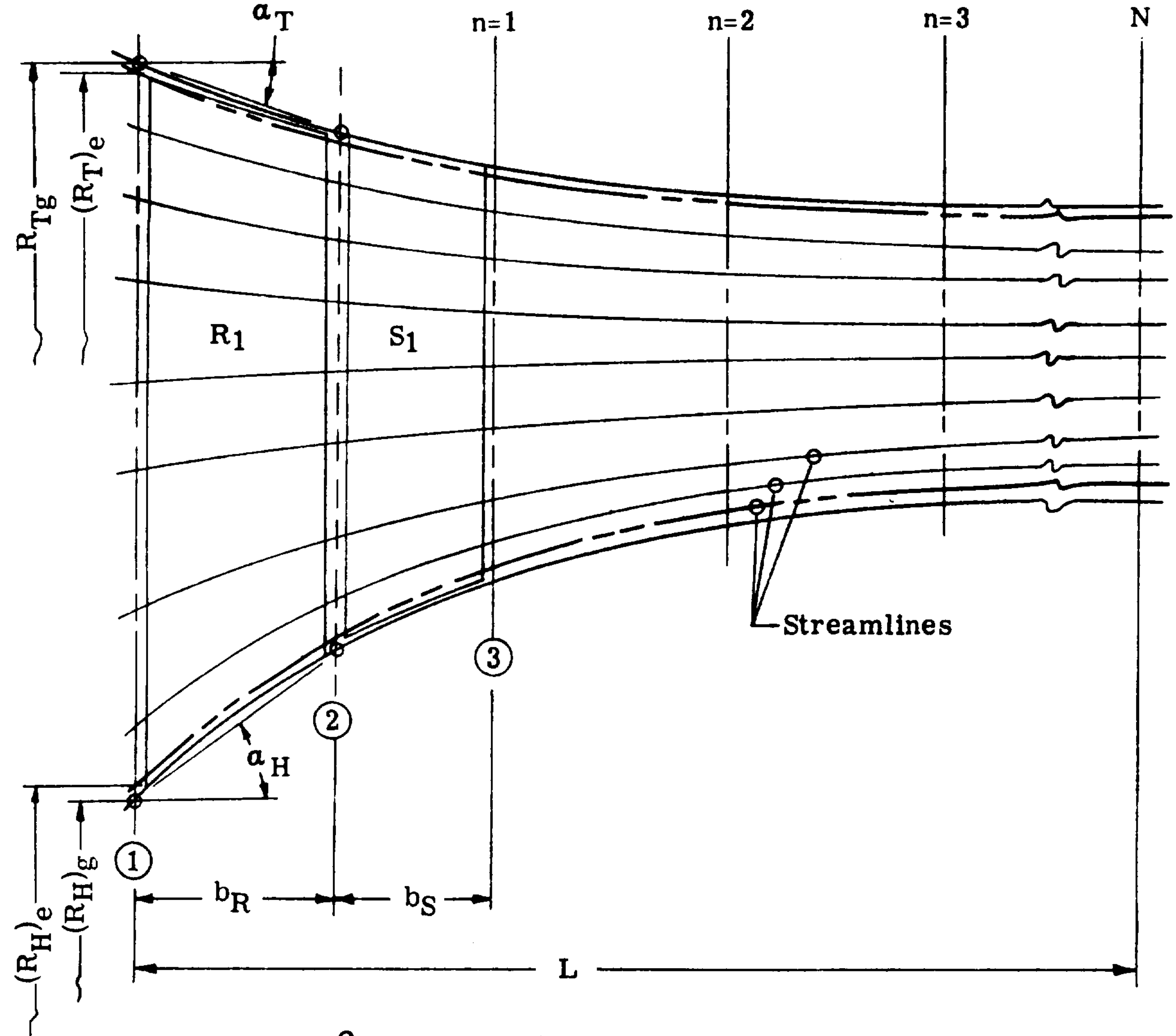
1	rotor entrance station
2	rotor exit station
3	stator exit station
2-D	designates a 2-D quantity in NASA blade element performance correlations
c	designates a 3-D quantity in NASA blade element performance correlations
e	effective value (of hub or tip radius)
g	geometric value (of hub or tip radius)
H	hub section
i	ideal
j	designates value of variable at reference streamline

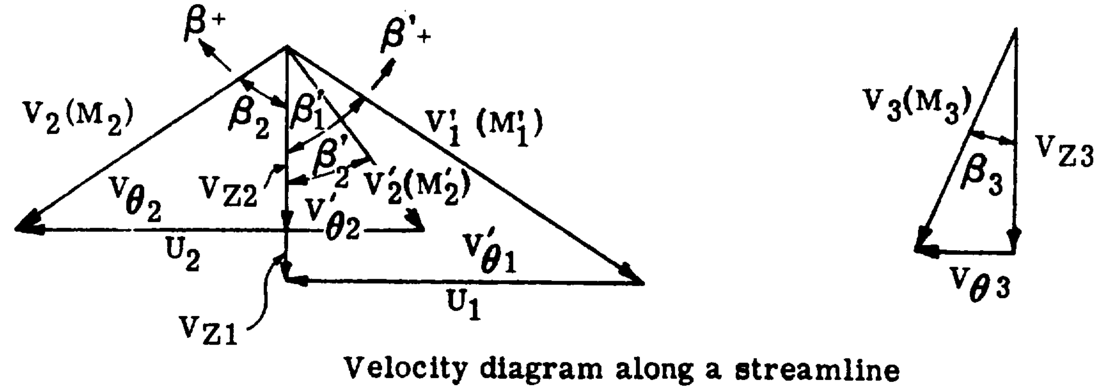
Subscripts (cont)

L	limiting value
m	metal
max	maximum value
p	profile
ref	reference, or minimum total pressure loss, conditions
R	rotor; radial component
S	stator
s	shock
ss	supersonic
T	tip section
t	total
θ	whirl component
Z	axial component

Superscripts

'	relative value of a variable
*	value of variable corresponding to a Mach number of 1.0





Velocity diagram along a streamline

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Figure 1. Schematic presentation of symbols.

TECHNICAL DISCUSSION

This off-design performance computer program, bearing designation N36, 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 its use in 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 rigorously for variable c_p. The program will not calculate supersonic axial flows; a check is made at the midstreamline of each axial station and the computation is terminated with an accompanying error message whenever an axial Mach number greater than 1.0 is encountered on three consecutive passes through the calculation.

The program requires a description of the geometry of the blading in each blade row and a description of the flow path geometry, including the location of all axial stations, plus hub and tip blockages at all stations. Required input data is described in detail in Appendix D. The iterative computation of adiabatic efficiencies at each streamline of each station is based on the total pressure loss coefficient, which is evaluated as the sum of the reference loss coefficient and an off-reference increment in loss coefficient. That is,

$$\bar{\omega}_t = \bar{\omega}_{t, ref} + (\bar{\omega}_t - \bar{\omega}_{t, ref})$$

where

$$\bar{\omega}_{t, ref} = \bar{\omega}_{p, ref} + \bar{\omega}_{s, ref}$$

The reference profile loss data is input as a correlation of blade profile loss parameter vs diffusion factor for hub, mean, and tip blade sections. This profile loss data is interpolated and extrapolated to any point along the blade span by means of a second degree curve fit. Reference shock loss is computed at each streamline position by means of the normal shock model of Reference 5, making use of the flow angle at the shock (input as a function of blade span for each blade row) and assuming flow at the computed relative inlet Mach number enters the blade passage at the reference value of incidence angle.

The program draws its input-specified reference 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. Each reference profile 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 consisting 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.

The off-reference increment in total pressure loss coefficient is established using a correlation of selected NASA data, which takes the form of those shown in Figures 2 through 4 for the hub (10%), mean (50%), and tip (90%) blade sections of rotors. These three correlations are tabled directly into the computer deck for automatic use in the performance calculations. The 50% span rotor loss data curve is tabled into the deck for use at each of the hub, mean, and tip sections of all stators. As is the case with other blade element performance data, the actual tabulated data representing plotted correlations appears in the listing of the Computer Source Deck, shown as Appendix B. For the off-reference loss data described, interpolation and extrapolation along the blade span is done by second degree curve fit, in the same manner as for reference profile loss data.

The program computes performance in any given blade row for either 65-series or double-circular-arc blades, and the user has the option of specifying or determining the reference incidence angle at each streamline for any individual blade row according to one of the four following options:

1. NASA 2-D incidence rule

2. NASA 3-D incidence rule

3. The criterion of suction surface tangency (for double-circular-arc blades only)

4. Tabulated input; i_{ref} vs radius

The third option shown above employs the expression

$$i_{ref} = 2 \tan^{-1} \left\{ \frac{c \tan \frac{\psi}{4} + t_{max} - t_{edge} \cos \frac{\psi}{2}}{c + t_{edge} \sin \frac{\psi}{2}} \right\} - \frac{\psi}{2} \qquad (1)$$

which is shown as Equation B-42 in Reference 6. Note that for the NASA 2-D and 3-D incidence rules the reference incidence angle is determined for the reference inlet air angle and Mach number occurring at the particular point being calculated. Thus, in general, the reference incidence value does not remain fixed at a given axial and radial station for different flow points on a speed line. Similar to the incidence angle options the user may elect to establish the reference deviation angle at each streamline of an individual blade row through the use of either

1. the NASA 2-D deviation rule

or

2. the NASA 3-D deviation rule.

The NASA rules describing reference blade element performance are those found in Reference 4, Chapters VI and VII, and curve fits of the correlated data plotted there appear directly in the Source Deck listing (Appendix B of this report) in tabular form. The off-reference deviation angle is expressed as

$$\delta^\circ = \delta^\circ_{ref} + (\delta^\circ - \delta^\circ_{ref}) \tag{2}$$

where the off-reference increment in deviation angle, $\delta^\circ - \delta^\circ_{ref}$, is obtained through correlation of selected NASA data, as shown in Figures 5 through 7 for both rotors and stators, where ϵ_{ref} represents the reference air turning angle:

$$\epsilon_{ref} = (\beta_{1,m} + i_{ref}) - (\beta_{2,m} + \delta^\circ_{ref}). \tag{3}$$

The correlated data revealed no significant dependence on Mach number or on position along blade span; consequently, one table representing the data plotted in Figure 5 is used for both rotors and stators and is entered for each of the hub, mean, and tip blade sections. It should be noted that, although the increases in deviation angle as incidence angles decrease from reference incidence, shown in the curve fits of Figures 5 through 7, represent the trends of the data realistically, this trend in the curve fit can cause program instability if the incidence angle is well below reference incidence.

Any interpolation or extrapolation of off-reference deviation data along blade span is performed according to a simple straight-line fit.

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:

<u>Continuity Equation</u>

$$\frac{1}{R}\frac{\partial(\rho R V_R)}{\partial R} + \frac{\partial(\rho V_Z)}{\partial Z} = 0 \tag{4}$$

<u>Radial Equation of Motion</u>

$$g_c J \frac{\partial H_t}{\partial R} = g_c F_R + g_c J T \frac{\partial S}{\partial R} + \frac{V_\theta}{R}\frac{\partial(R V_\theta)}{\partial R} + V_Z \left(\frac{\partial V_Z}{\partial R} - \frac{\partial V_R}{\partial Z}\right) \tag{5}$$

Circumferential Equation of Motion

$$0 = g_c F_\theta - \frac{1}{R}\left[V_R \frac{\partial(RV_\theta)}{\partial R} + V_Z \frac{\partial(RV_\theta)}{\partial Z}\right] \tag{6}$$

Axial Equation of Motion

$$g_c J \frac{\partial H_t}{\partial Z} = g_c F_Z + g_c JT \frac{\partial S}{\partial Z} + \frac{V_\theta}{R}\frac{\partial(RV_\theta)}{\partial Z} - V_R\left[\frac{\partial V_Z}{\partial R} - \frac{\partial V_R}{\partial Z}\right] \tag{7}$$

Energy Equation

$$\frac{DH_t}{Dt} = Q + \frac{\omega}{g_c J}\frac{D(RV_\theta)}{Dt} \tag{8}$$

Gradient of Entropy

$$\frac{DS}{Dt} = \frac{Q}{T} \tag{9}$$

Condition of Integrability

$$\frac{\partial}{\partial R}\left(\frac{F_Z}{RF_\theta}\right) = \frac{\partial}{\partial Z}\left(\frac{F_R}{RF_\theta}\right) \tag{10}$$

Equations (4) through (10) 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 (6), (7), (9), and (10) are eliminated. Equation (4) is then rewritten for convenience as

$$w = 2\pi \int_{R_H}^{R_T} \rho V_Z R\,dR \tag{11}$$

and Equation (5) is written as

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

$$- 2g_cJ \int_{R_j}^{R} T\frac{\partial S}{\partial R}\,dR + 2\int_{R_j}^{R} V_Z\left(\frac{\partial V_R}{\partial Z}\right)_R dR, \quad (12)$$

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

$$g_cJ\,(\Delta H_t) = \omega\,\Delta\,(RV_\theta) \quad (13)$$

The iterative solution of this set of equations in this application requires specifying compressor geometry, rotational speed, flow rate and inlet conditions plus blade element turning and loss performance correlations for each blade row from among the available options, as described in detail in Appendix D. The performance of any blade row, streamline by streamline and overall, is obtained through the use of blade element performance data for flow turning and total pressure loss in developing, iteratively, a converged simultaneous solution of Equations (11), (12), and (13). Clearly, Equation (13) reduces to

$$\Delta H_t = 0 \quad (14)$$

for stators, where $\omega = 0$. Performance of a whole compressor, stage by stage and overall, is obtained through satisfaction of Equations (11) through (13) simultaneously for all blade rows and for inlet and exit ducting, using the appropriate specified blade element performance correlations for each individual blade row. The program user may specify dummy blade rows in the compressor flow path as a means of providing space between adjacent blade rows or of providing extra inlet and/or exit stations. In each dummy blade row through the compressor, the performance calculation conserves moment of momentum of the flowing fluid.

The primary objective of this computer program is to determine off-design performance of given axial flow compressors in accordance with full radial equilibrium and with adiabatic efficiencies determined from blade element analysis of total pressure loss. The detailed procedure to accomplish the objectives of this program, and the development of the program logic to automate this performance calculation are discussed in the following subsection. A detailed summary of the specific calculations is given in Appendix A.

DEVELOPMENT OF PROGRAM LOGIC

The basic task of the computer program described herein is the development of the axisymmetric model flow through a given compressor at known rotational speed, flow rate, and inlet conditions. This reduces to establishing simultaneous iterative satisfaction of the energy, radial equilibrium, and continuity equations, using blade element performance data to establish flow turning and total pressure loss at each step of the iteration. Hence, energy addition and efficiency are established in the programmed flow calculation by the performance of each blade row which is in turn established by the blade element performance data.

The radial profile of axial velocity at an axial station is obtained by substituting tangential velocities into the radial equilibrium equation, (12), and integrating the resulting expression from a reference streamline j to any other streamline. 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.

The program begins a performance 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 studied, including relative error tolerances to be used in the iterative computations, and data for each of the stages. The stage data includes:

- Specification of either 65-Series or double-circular-arc blade sections for rotor and stator
- Specification of the reference profile loss data sets to be used for rotor and stator
- Specification of the desired option(s) for determination of reference incidence angle in rotor and stator
- Specification of the desired option(s) on reference deviation angle computation for rotor and stator
- Flow increments, if any, in rotor and stator
- Radial distributions of solidity, inlet and exit metal angle, maximum thickness/chord, throat/spacing and flow angle at the assumed normal shock for both rotor and stator

The first four axial stations of the flow path represent the inlet, and the last three stations represent the exit. Any extra stations desired to specify inlet or exit geometry may be added through the use of dummy blade rows. The program begins its computation by evaluating T_t, P_t, and c_p (T) in the inlet. Setting V_R and V_θ in the inlet to zero, and assuming dR/dZ and d^2R/dZ^2 both zero at the front of the machine, the program then sets mass flow rate throughout the inlet equal to the flow rate at the first station. Using flow increment data specified for each input blade row, total flow rate at each station of the entire input flow path is then computed. Further, the program establishes the number of streamtubes and the midstream index streamline to be used in axial velocity computations.

Next, the program performs a simplified analysis of the first rotor, using Carter's rule to determine deviation angles at each streamline and producing a radially constant value of exit axial velocity. This simplified estimate of V_Z is assigned to the exits of all blade rows downstream. At this point, deviation angles and efficiencies are estimated for all blade rows and an estimate of velocity vector, temperature, and pressure is established for each streamline of all axial stations.

Next, the program begins a more detailed, full radial equilibrium consideration of the first six (or seven) stations of the given flow path. Depending upon whether the entire flow path is made up of an even or odd number of stations, the program considers either six or seven stations at a time, since at each point the program has established full convergence in the performance computation, two downstream stations are added and two upstream stations are dropped from consideration. In this way the program "marches" through the entire flow path, step by step. Implicit here is the assumption that a converged flow solution at any axial station is insensitive to changes in flow properties computed six or more stations downstream. The detailed consideration of flow in any six (or seven) station portion of the flow path involves establishing an axial velocity distribution using full radial equilibrium, and performing a check on continuity. (It is important that the program does not generally force a satisfaction of continuity during early calculation passes at any station. A variable damping factor is employed in the calculation, which limits the large changes in V_{Z_j} generally required to satisfy continuity during early passes of the calculation to only a small portion of their calculated size. Conversely, for small required changes in V_{Z_j} generally encountered near convergence, the damping factor permits a change approaching the size of the actual change required to satisfy continuity. In this way, considerable calculation time is saved through not forcing a satisfaction of continuity at a given axial station until other flow properties there are also approaching their converged values.)

Next, blade element performance data is used where applicable, for all streamlines and all stations being considered, to re-establish flow turning and blade loading. Finally, total pressure loss is re-established (again using applicable blade element data) and the axial velocity distribution is re-established for each of the stations presently considered, subject to the action of the variable damping factor just described. When complete convergence of calculated values of flow properties is attained for all axial stations under consideration, the program calculation "marches" one step downstream in the manner previously described. Barring any error conditions (and the corresponding printed error messages) and with convergence re-established at each step in the manner described above, the calculation "marches" one step at a time to the rear of the given compressor flowpath. After convergence is obtained for the entire performance calculation the program performs a check for choking conditions at all streamlines for all blade rows in the machine. If choking is indicated anywhere, the program logic prints a message indicating this. There is no calculation of flow shift or any other action taken by the program logic. The program prints the computed performance output in the general form shown in Appendix E.

As indicated, 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.

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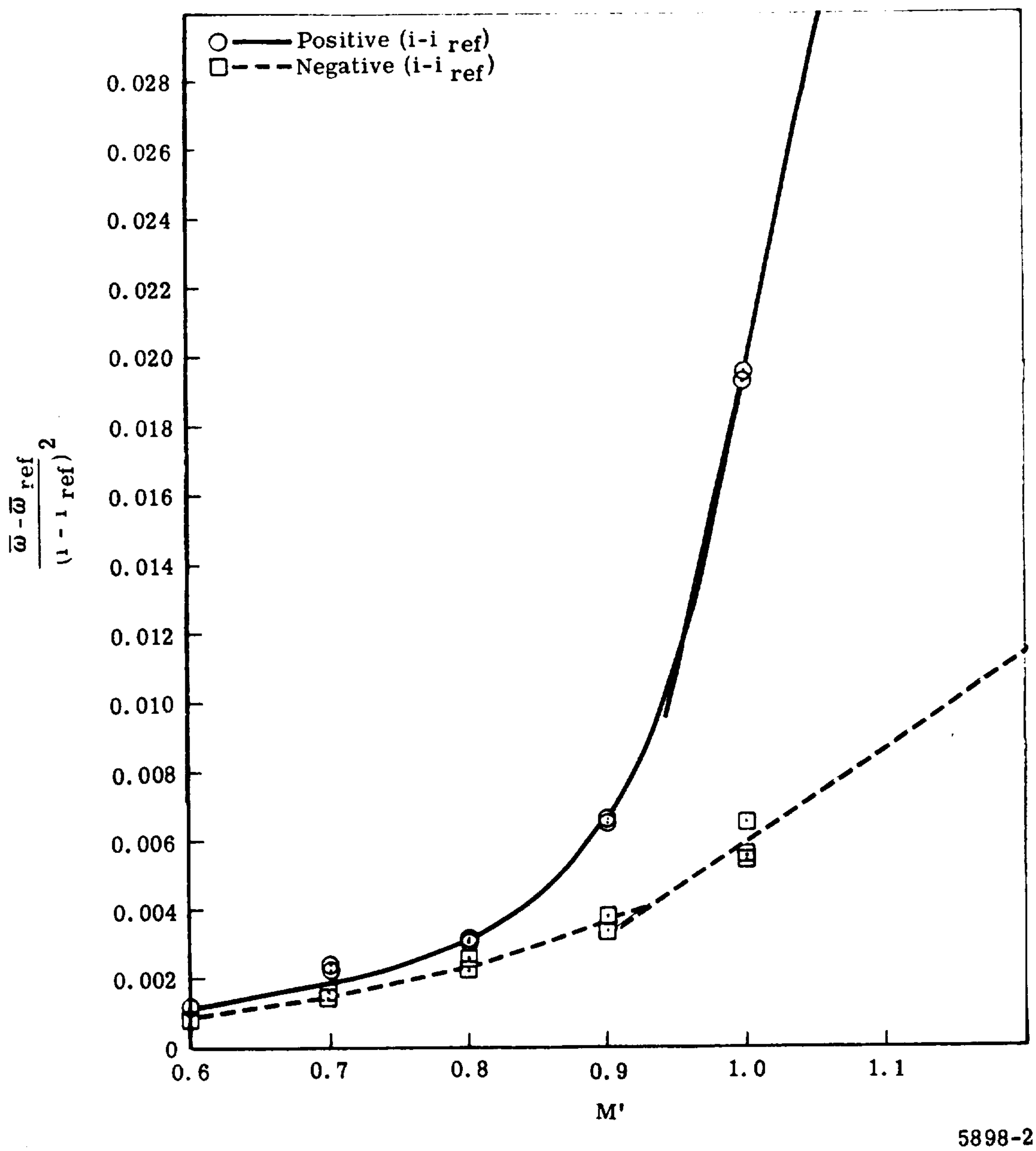


Figure 2. Off-reference total loss correlation—hub section 10% span.

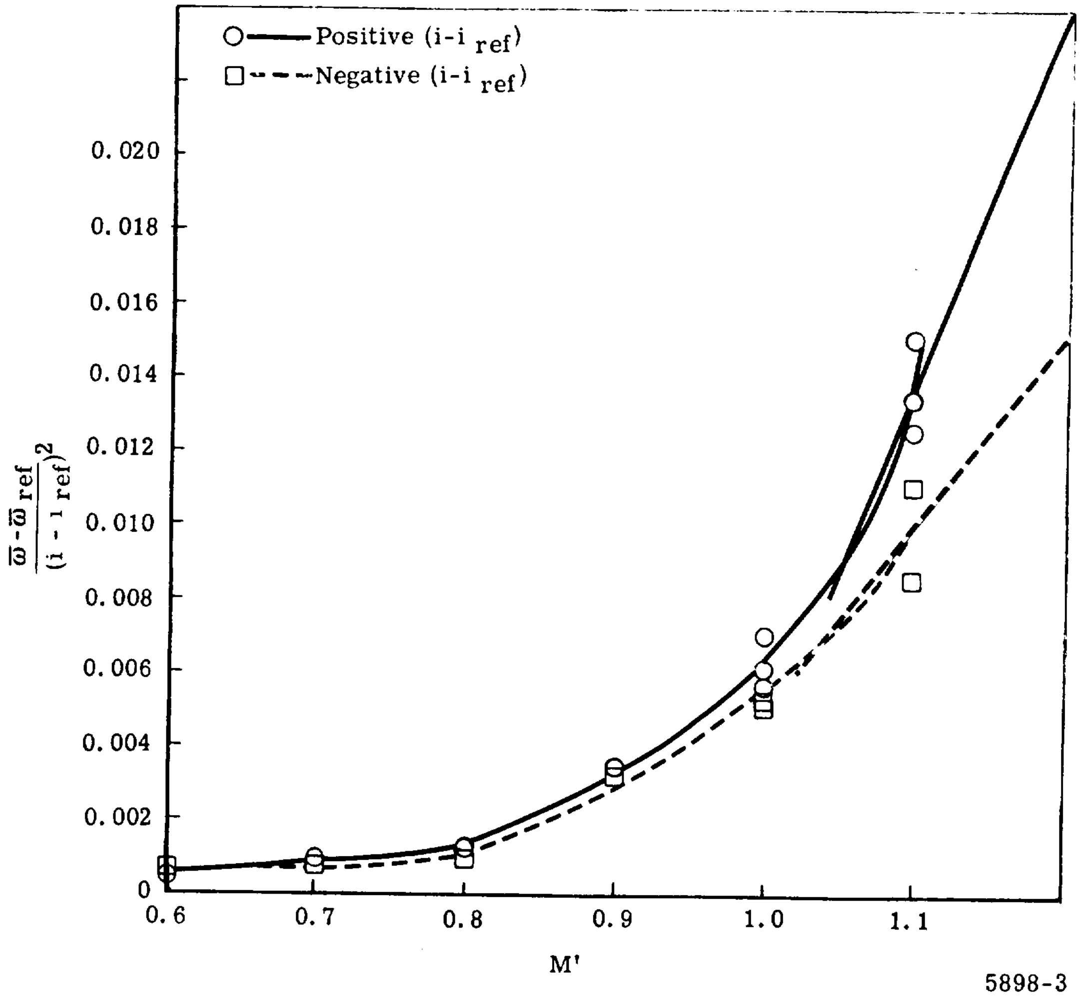


Figure 3. Off-reference total loss correlation—mean section 50% span.

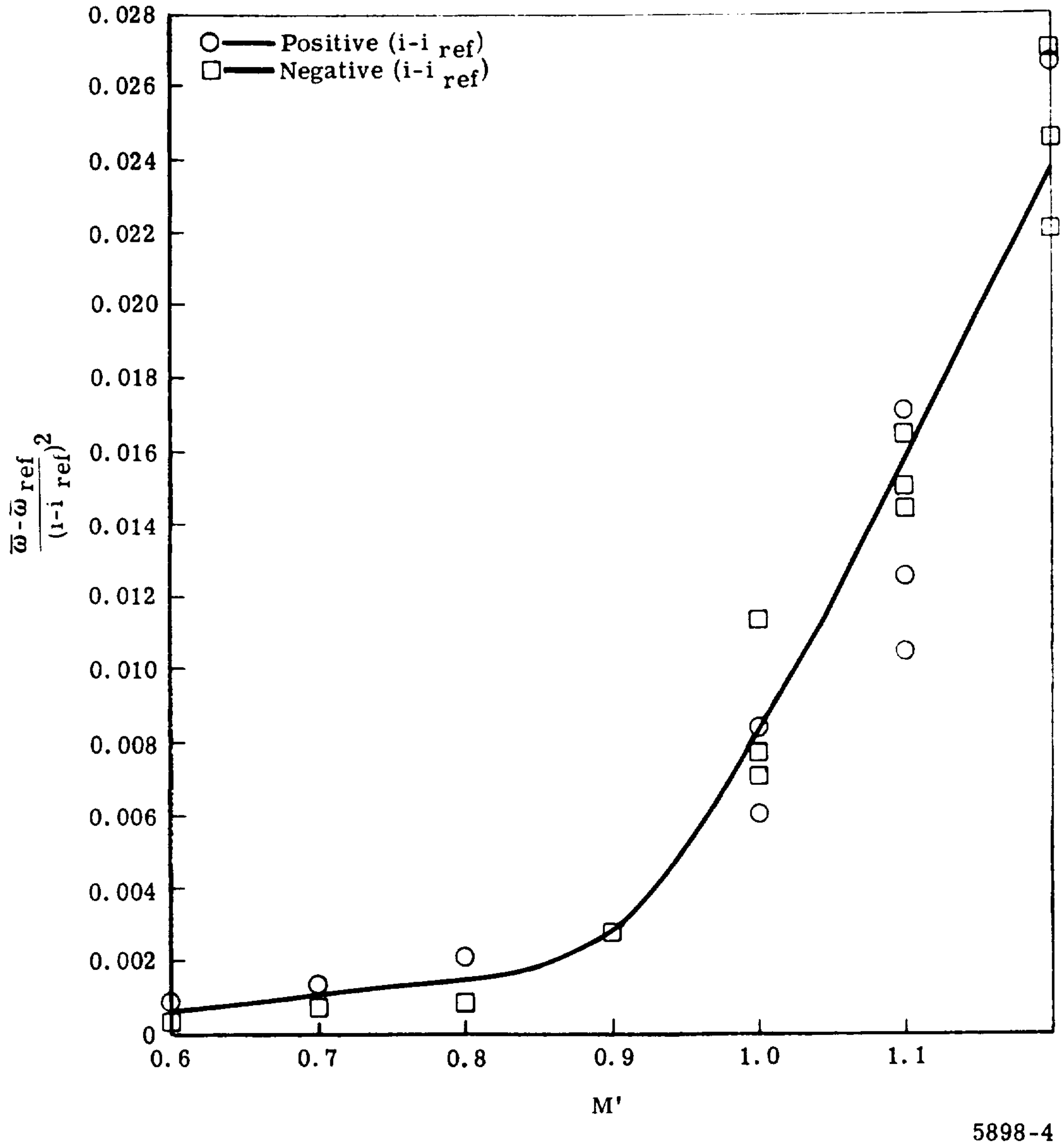


Figure 4. Off-reference total loss correlation—tip section 90% span.

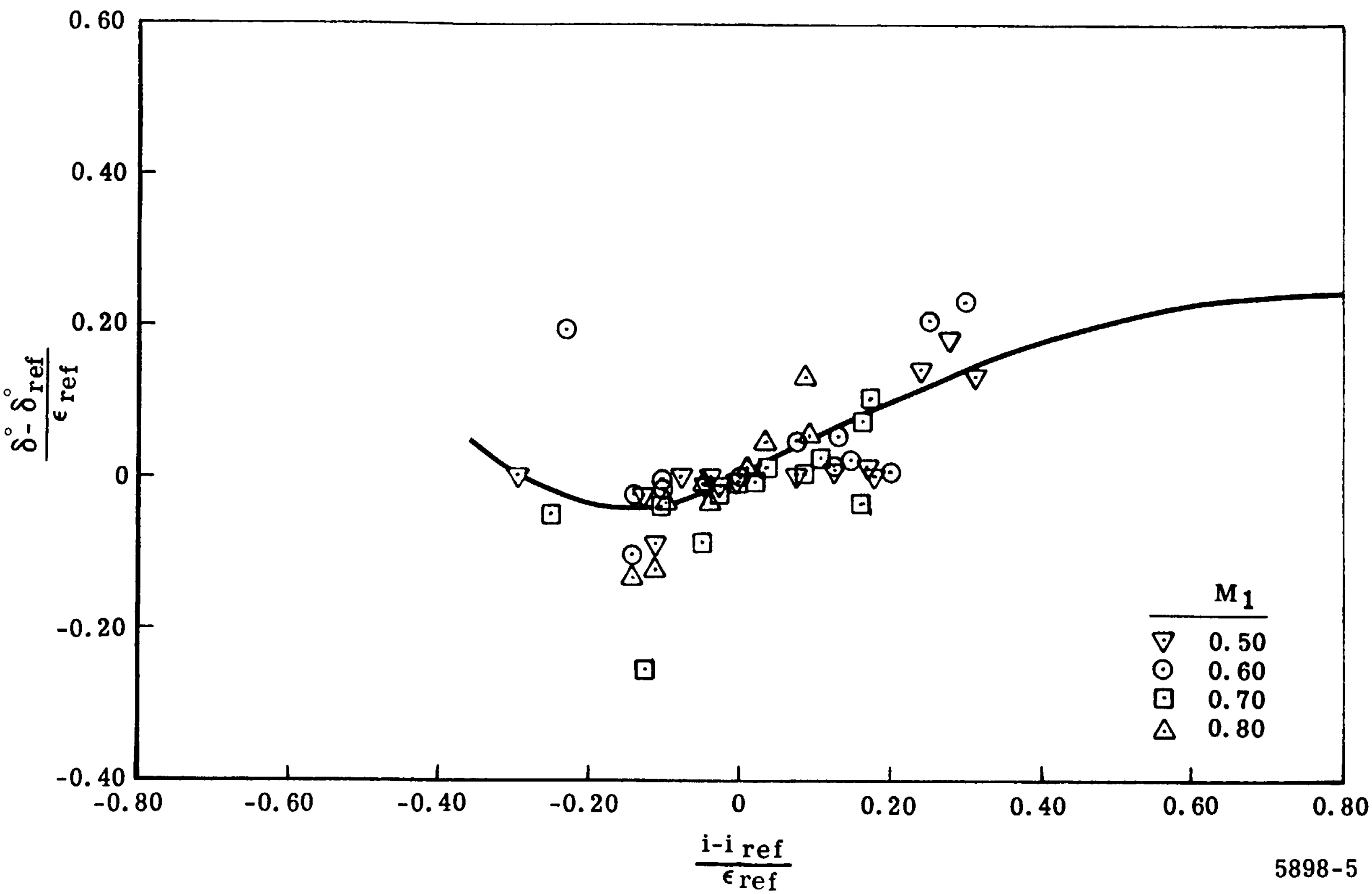


Figure 5. Off-reference deviation correlation—hub section.

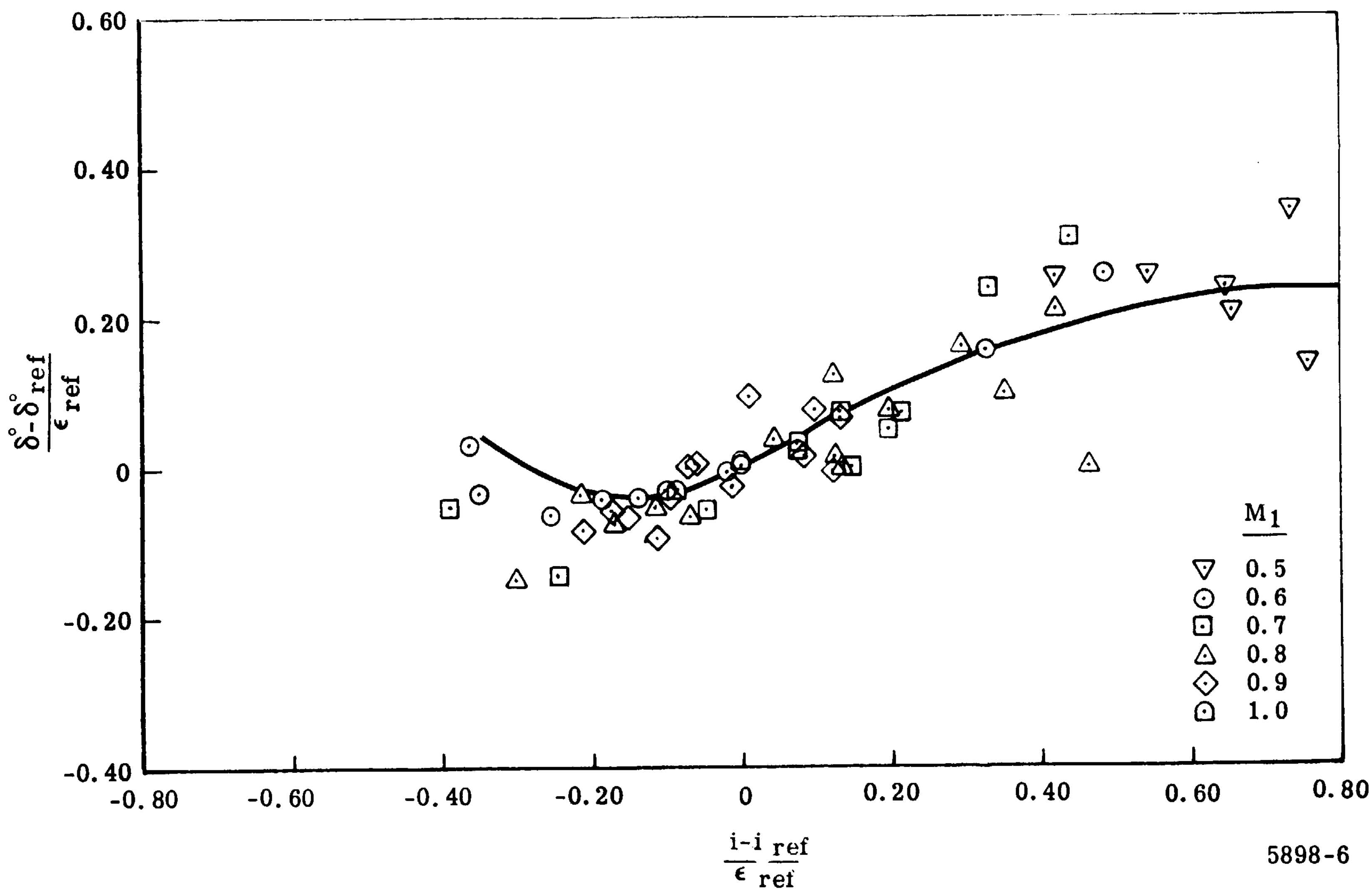


Figure 6. Off-reference deviation correlation—mean section.

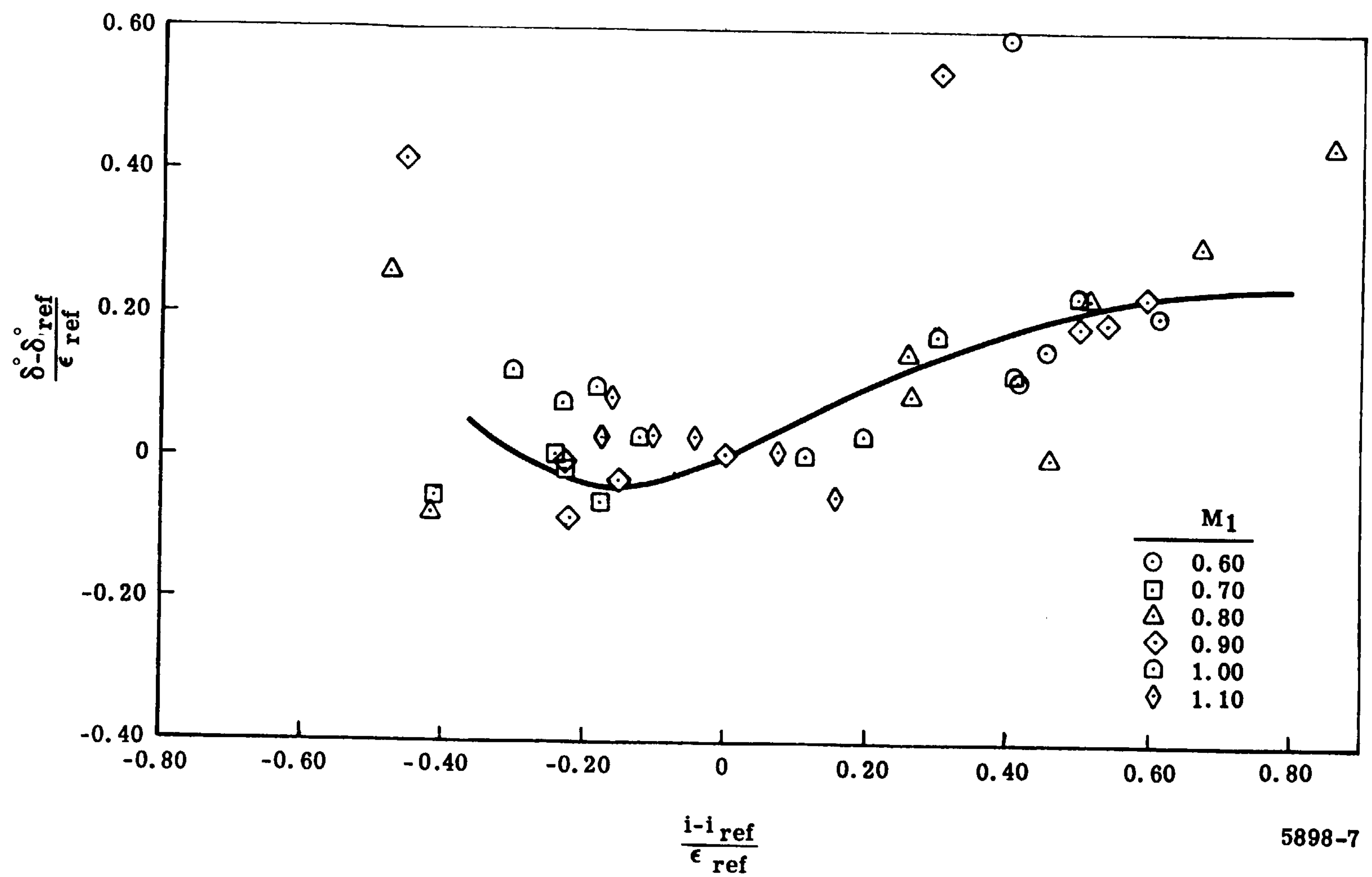


Figure 7. Off-reference deviation correlation—tip section.

APPENDIX A

SYSTEM OF EQUATIONS AND COMPUTATIONS

The system of equations and computations presented in this appendix constitute an iterative 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 performance calculation system will handle a maximum of 12 stages.

In summary, the following information is given:

- Specific heat at constant pressure, as a function of temperature
- Molecular weight of the gas
- Number of stages in the compressor to be studied
- Design speed
- Total mass flow rate
- Number of streamlines to be considered in the computation (5, 7, 9, 11)
- Fraction of the total flow passing between the hub and each successive streamline

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

- Inlet total pressure
- Inlet total temperature
- Axial location of all stations
- Hub radius and blockage factor at each axial station
- Tip radius and blockage factor at each axial station

For each of the stages of the compressor to be studied, the following items are specified:

- Axial location of all stations, annulus geometry and blockages at hub and tip for each station
- Blade section type, either 65-Series or double-circular-arc, for rotor and stator
- Reference profile loss parameter correlations at hub, mean, and tip (specified as loss data sets elected for rotor and stator)
- Desired option(s) for computation of blade element flow turning
- Radial distribution of solidity, maximum thickness, throat/spacing, inlet and exit metal angles, and flow angle at the assumed normal shock, for both rotor and stator

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, as described in the Technical Discussion section of the text, and proceeds 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

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

ENERGY EQUATION

The energy equation and the radial equilibrium equation, a discussion of which follows, involve tangential velocities directly. These are in turn computed consistent with the blade element performance data selected by the program user from among the available options. The program user is referred to Chapters VI and VII of Reference 4 and to the detailed description of available options found in Appendix D, part A, of this report.

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

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

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

solving for the upper limit of the integral.

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

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

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

$$\bar{\omega}_t = \frac{P_{t_2} - P_{t3}}{P_{t_2} - P_2} \qquad \text{(A-22)}$$

For off-reference blade operation, $\bar{\omega}_t$ is considered broken down as follows:

$$\bar{\omega}_t = \bar{\omega}_{t,\ ref} + (\bar{\omega}_t - \bar{\omega}_{t,\ ref}) \qquad \text{(A-23)}$$

where

$$(\bar{\omega}_t - \bar{\omega}_{t,\ ref}) = f(i - i_{ref},\ M',\ p) \qquad \text{(A-24)}$$

and

$$\bar{\omega}_{t,ref} = \bar{\omega}_{p,ref} + \bar{\omega}_{s,\ ref} \qquad \text{(A-25)}$$

The reference shock loss coefficient is calculated on the basis of the normal-shock-in-passage model presented in Reference 5 (See References in report) with flow at the computed inlet M' assumed to enter the passage at reference incidence. In this computation, the specific heat of the gas is evaluated at local temperature but is not treated rigorously as a variable. For each stage in a design calculation, the computer program receives as input a radial distribution of the relative flow angle at the assumed normal shock for both rotor and stator. Supersonic turning is computed as

$$\phi_{ss} = \beta_1' - \beta_s' \qquad \text{(A-26)}$$

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

$$\nu_1 = \sqrt{\frac{\gamma+1}{\gamma-1}} \tan^{-1}\sqrt{\frac{\gamma-1}{\gamma+1}\left(M_1'^2-1\right)} - \tan^{-1}\sqrt{M_1'^2-1} \qquad \text{(A-27)}$$

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

$$\nu_{ss} = \nu_1 + \phi_{ss} \;. \qquad \text{(A-28)}$$

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

$$\nu_{ss} = \sqrt{\frac{\gamma+1}{\gamma-1}} \tan^{-1}\sqrt{\frac{\gamma-1}{\gamma+1}\left(M_{ss}'^2-1\right)} - \tan^{-1}\sqrt{M_{ss}'^2-1} \qquad \text{(A-29)}$$

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

$$M_e' = \frac{1}{2}\left(M_1' + M_{ss}'\right) \quad . \tag{A-30}$$

Using the normal shock relationship, Equation (99), Reference 7 (in report),

$$\left(\frac{P_{t_2}'}{P_{t_1}'}\right)_{\substack{normal\\shock}} = \left[\frac{(\gamma + 1)\, M_e'^2}{(\gamma - 1)\, M_e'^2 + 2}\right]^{\gamma/\gamma - 1} \left[\frac{\gamma + 1}{2\gamma M_e'^2 - (\gamma - 1)}\right]^{1/\gamma - 1} \tag{A-31}$$

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

$$\bar{\omega}_s = \frac{1 - \left(\frac{P_{t_2}'}{P_{t_1}'}\right)_{normal\ shock}}{1 - \left(\frac{P_1}{P_{t_1}'}\right)} \tag{A-32}$$

where

$$\frac{P_1}{P_{t_1}'} = \left[1 + \frac{\gamma - 1}{2} M_1'^2\right]^{-\gamma/\gamma - 1} \tag{A-33}$$

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

$$M_e' = \frac{M_1'}{2}\left(1 + M_{ss}'\right) \tag{A-34}$$

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

$$\phi_{ss} = \sqrt{\frac{\gamma + 1}{\gamma - 1}} \times \tan^{-1} \sqrt{\frac{\gamma - 1}{\gamma + 1}\left(M_{ss}'^2 - 1\right)} - \tan^{-1} \sqrt{M_{ss}'^2 - 1} \tag{A-35}$$

If M'_e is greater than 1.0, $\bar{\omega}_s$ is evaluated using Equations (A-31), (A-33), and (A-32) as before.

The reference 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

$$D_R = 1.0 - \frac{V'_2}{V'_1} + \frac{V'_{\theta 1} - V'_{\theta 2}}{2\sigma V'_1} \qquad \text{(For rotors)} \qquad \text{(A-36)}$$

and

$$D_S = 1.0 - \frac{V_3}{V_2} + \frac{V_{\theta 2} - V_{\theta 3}}{2\sigma V_2} \qquad \text{(For stators)} \qquad \text{(A-37)}$$

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

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

$$\left[\frac{\bar{\omega}_p \cos\beta'_2}{2\sigma}\right]_x = \left[\frac{\bar{\omega}_p \cos\beta'_2}{2\sigma}\right]_{0.5} + 6.25\,(x - 0.5)^2 \left[\left(\frac{\bar{\omega}_p \cos\beta'_2}{2\sigma}\right)_{0.9\,,\,0.1} - \left(\frac{\bar{\omega}_p \cos\beta'_2}{2\sigma}\right)_{0.5}\right] \qquad \text{(A-38)}$$

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

The off-reference increment in total pressure loss coefficient is correlated as a function of $i-i_{ref}$, relative inlet Mach number and percent blade span as was discussed earlier. A parabolic curve fit identical to the one shown in Equation (A-38) is used in establishing the off-reference increment in total pressure loss for an arbitrarily located streamline. The values of $i-i_{ref}$ and relative inlet Mach number associated with the streamline in question are used to establish values of the parameter $\frac{\bar{\omega}_t - \bar{\omega}_{t, ref}}{(i - i_{ref})^2}$ at the hub and mean or tip and mean sections, as appropriate, and the described parabolic fit used to establish a value of the parameter at the streamline being considered. The value of $(\bar{\omega}_t - \bar{\omega}_{t, ref})$ is then established 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.

CHOKE CHECK CALCULATION

The choke check calculation is performed at all streamlines for all blade rows, after convergence is obtained for the entire performance calculation. The ratio of throat to spacing, O/s, is given as input data for each blade row in the manner described in Appendix D, Part A, and the check for a choke margin of 5% ($\frac{O}{h^*} \geq 1.05$) is accomplished at each streamline for each blade row by computing

$$\frac{h}{s} = \cos \beta_1' \tag{A-39}$$

and

$$\frac{h}{h^*} = f(M_1') \tag{A-40}$$

and evaluating

$$\frac{\frac{h}{h^*} \frac{O}{s}}{\frac{h}{s}} = \frac{O}{h^*}. \tag{A-41}$$

APPENDIX B

FORTRAN IV SOURCE DECK LISTING

INDEX

Subroutine	Page

```
      SUBROUTINE  BOSS
      LOGICAL  CIRCLE,  SIXTY5
      REAL            IREF,            JOULE,           MACH,
     X METAL,         MIN,             MINR,            MOUT,
     X MOUTR
      INTEGER BLADE,                   COUNT
      LOGICAL         OFF,             OK,              RDFLO,
     X RESTAR,        TONE
      INTEGER  RULE
      REAL KDEL,KDEL2
      COMMON  /VECTOR/
     .ALPHA(29,11),ATAR(25,11),BETA(29,11),BH(32),BLADE(25),BT(32),CIRCL
     .E(25),CO(32,11),CPCO(6),CR(32,11),CSLOPE(32,11),CU(32,11),CX(32,11
     .),CXM(11),CXNEW(11),DA(10),DELM(11),DEPV(32,11),DF(20),DFLOW(32),F
     .LOW(32),FORM(25),FOUND(20,3,10),IREF(25,11),ITYPE(25),METAL(2),MET
     .HOD(25),MIN(8,25),MINR(8,25),MOUT(8,25),MOUTR(8,25),NIN(25),NRAD(2
     .5),NS(25),NSS(25),NTC(25),NTH(25),NXIT(25),OBAR(25,11),OFFD(25),PO
     .(32,11),P(32,11),RAD(8,25),RADR(8,25),RCURVE(32,11),RH(32),RINT(11
     .),RPM(1),RS(32),RSLOPE(32,11),RULE(25),SHAPE(25),SIXTY5(25),SD(8,2
     .5),SCR(8,25),SS(8,25),SSR(8,25),TERMC(11),TH(8,25),THC(8,25),THCR(
     .8,25),THP(8,25),TITLE(36),TO(32,11),TSTAT(11),X(32)
      COMMON  /SCALAR/
     .A,AA,A101A0,A202A0,A303A0,A404A0,A505A0,ANG,B,BB,CC,CENT,CM,CMEAN,C
     .MEANP,CM2,CORLC,COUNT,CP,CPI2,CPI3,CPI4,CPI5,CPI6,CPO2,CPO3,CPO4,C
     .PO5,DAMP,DCP,DELFLO,DFACT,EMACH,EPISON,FACTM,G,GAMMER,GASK,GJ,GR2,
     .H,HIGH,HIPRES,I,IG,IGO,IOUTTR,IPASS,J,JJ,JM,JM1,JOULE,K,KDEL,KK,L,
     .LAST,LC1,LEVEL,LST,LSTAGE,M,MACH,MAXPT,MINPT,N,NBLADE,NDATA,NLINES
     .,NSETS,NSPEED,NTUBES,NX,NX1,OFF,OK,PHI,PLOW,Q,RA,RADIAN,RDFLO,REF,
     .RESTAR,RMACH,S,SOLID,SPEED,STOP,T,TERMD,THICK,TIME,TOLAT,TOLCX,TOL
     .MIN,TOLR,TONE,V,VMI,YES

      COMMON /FULL/  BUCKET, NOW
      LC1=0
      DATA FLO, ANEW / 4HFLOW, 4HEND  /
C ----- READ THE BLADE GEOMETRY ETC
    0 CALL  INPUT
      ILS=  LSTAGE
      BUCKET= 1.0
      NOW= 1
      READ (5,80)  A, FLOW(1), B, C, PLOW, HIPRES, CM
      IF (CM.GT.0.0)  BUCKET= CM
      OLD FLO= FLOW(1)
      RPM(1)=  SPEED*B
      N=1
      IF (C.GT.0.0)  EPISON= C
    3 CONTINUE
      DO 12 I=2,NX
   12 FLOW(I)= FLOW(I-1)*DFLOW(I)
C ----- ESTIMATE THE VELOCITIES, TEMPERATURES, PRESSURES ETC
   15 CALL  IN EST
C ----- ESTIMATE THE DEVIATION
   20 CALL  PREIT 2
      IST=  2*((NX-6)/2)
      IST=  NX -IST
      NSTA= NX
```

```
      DO 20 NX= IST, NSTA, 2
      ROW= NX -IST +1
      NX1= NX -1
      LSTAGE= MIN0(ILS,NX)
   10 CALL  C AXIAL
      ROW= 1
C ----- CALCULATE THE AXIAL VELOCITY DISTRIBUTION
   30 CALL  C AXIAL
C ----- CHECK THE LOSS
      CALL  LOSS
      IF (.NOT.OK)  GO TO 60
C ----- CHECK THE DEVIATION
      CALL  PRFIT 2
      IF (.NOT.OK)  GO TO 60
C ----- PRINT THE OUTPUT
C ----- CHECK FOR CHOKED FLOW
      CALL  CHOKE
      IF (OK)  GO TO 75
      WRITE (6,65)
   65 FORMAT ( 37H1 THE FOLLOWING DATA POINT IS CHOKED. )
      CALL  OUT PUT
C ----- CALCULATE NEW FLOW
      DELFLO= (FLOW(1) - OLDFLO)*0.5
      FLOW(1)= OLD FLO +DELFLO
      DO 70 I=2,NX
      FLOW(I)= FLOW(I-1)*DFLOW(I)
   70 CALL  STREAM
      IF (ABS(DELFLO).GE.EPISON)  GO TO 30
      GO TO 76
   75 CALL  OUT PUT
   76 READ (5,80)  A, B, C, D, BB, CC, CM
      IF (A.EQ.ANEW)  GO TO 10
      IF  (A.NE.FLO)  GO TO 75
   80 FORMAT (A4,6X 7F10.4)
      IF (D.GT.0.0)  EPISON= D
      IF (C.NE.0.0)  RPM(N)= SPEED*C
      FLOW(1)= B
      OLD FLO= B
      IF (BB.GT.0.0)  PLOW= BB
      IF (CC.GT.0.0)  HIPRES= CC
      IF (CM.GT.0.0)  BUCKET= CM
      IF (.NOT.OK)  GO TO 8
      DO 90 I=2,NX
      FLOW(I)= FLOW(I-1)*DFLOW(I)
   90 CALL  STREAM
      IF (FLOW(1).GT.0.0)  GO TO 30
      RETURN
      ENTRY  SUPER
      ENTRY  STALL
      NX= NSTA
      LSTAGE= ILS
      NX1= NX -1
      OK= .FALSE.
      GO TO 75
      END
```

```
      FUNCTION CAMBER(ANG,SOLID)

C -----   REFERENCE MINIMUM-LOSS INCIDENCE ANGLE FOR ZERO CAMBER
C        DEDUCED FROM LOW-SPEED-CASCADE OF 10-PERCENT-THICK NACA
C        65-(A10)-SERIES BLADES.
C          FIGURE 137  NASA  SP-36

      DIMENSION DEG(7), P(7,9), SO(8)
      COMMON /SCALAR/ QQ(81),  RADIAN,   QQQ(21)
      DATA  DEG, P, SO /
     X 50.0, 55.0, 60.0, 62.5, 65.0, 67.5, 70.0,
     X 1.55, 1.68, 1.79, 1.83, 1.89, 1.92, 1.99,
     X 2.34, 2.52, 2.71, 2.79, 2.87, 2.93, 3.01,
     X 3.13, 3.39, 3.62, 3.74, 3.83, 3.93, 4.02,
     X 3.92, 4.24, 4.58, 4.72, 4.86, 4.99, 5.08,
     X 4.71, 5.11, 5.50, 5.69, 5.83, 5.97, 6.07,
     X 5.50, 6.0,  6.43, 6.64, 6.82, 6.98, 7.10,
     X 6.29, 6.86, 7.42, 7.67, 7.87, 8.02, 8.10,
     X 7.08, 7.73, 8.35, 8.64, 8.85, 9.01, 9.11,
     X 7.87, 8.61, 9.34, 9.66, 9.91, 10.07,10.1,
     X 0.4,  0.6,  0.8,  1.0,  1.2,  1.4,  1.6,
     X 1.8/
      A=ANG*RADIAN
      S=SOLID
      IF (A.GT.DEG(1)) GO TO 50
      CAMBER= (0.079*S-0.0006)*ANG
      GO TO 100
   50 K=MAX0(MIN0(INT(5.0*S)-1,8),1)
      L=0
   60 L=L+1
      IF (A.GT.DEG(L).AND.L.LT.6) GO TO 60
      DEL=(A-DEG(L))/(DEG(L-1)-DEG(L))
      P1= (P(L-1,K)-P(L,K))*DEL +P(L,K)
      P2= (P(L-1,K+1)-P(L,K+1))*DEL +P(L,K+1)
      CAMBER=((P2-P1)*(S-SO(K))*5.0 +P1)/RADIAN
  100 RETURN
      END
```

```
      SUBROUTINE CAXIAL                                                 OFFD2079
                                                                        OFFD2080
C        *** CALCULATES AXIAL VELOCITIES WHICH SATISFY THE              OFFD2081
C            AXIAL-VELOCITY EQUATION                                    OFFD2082
                                                                        OFFD2083
      DIMENSION  BETA(32,11)                                            OFFD2084
      EQUIVALENCE  (BETA,RCURVE)                                        OFFD2085
      LOGICAL  FIT                                                      OFFD2086
      LOGICAL YES                                                       OFFD2087
      REAL  LIMIT                                                       OFFD2088
      COMMON /FULL/  BUCKET, NOW                                        OFFD2089
      LOGICAL  CIRCLS,  SIXTY5                                          OFFD2090
      REAL           IREF,           JOULE,          MACH,              OFFD2091
     X METAL,        MIN,            MINR,           MOUT,              OFFD2092
     X MOUTR                                                            OFFD2093
      INTEGER BLADE,                 COUNT                              OFFD2094
      LOGICAL        OFF,            OK,             ROFLO,             OFFD2095
     X RESTAR,       TONE                                               OFFD2096
      INTEGER  RULE                                                     OFFD2097
      REAL KDEL,KDEL2                                                   OFFD2098
      COMMON  /VECTOR/                                                  OFFD2099
     .ALPHA(29,11),ATAR(25,11),BET (29,11),BH(32),BLADE(25),BT(32),CIRCLOFFD2100
     .E(25),CU(32,11),CPCU(6),CR(32,11),CSLOPE(32,11),CU(32,11),CX(32,11OFFD2101
     .),CXM(11),CXNEW(11),DA(10),DELM(11),DEPV(32,11),DF(20),DFLOW(32),FOFFD2102
     .LOW(32),FORF(25),FOUND(20,3,10),IREF(25,11),ITYPE(25),METAL(2),METOFFD2103
     .HOD(25),MIN(8,25),MINR(8,25),MOUT(8,25),MOUTR(8,25),NIN(25),NRAD(2OFFD2104
     .5),NS(25),NSS(25),NTC(25),NTH(25),NXIT(25),OBAR(25,11),OFFD(25),POFFD2105
     .(32,11),R(32,11),RAD(8,25),RADR(8,25),RCURVE(32,11),RH(32),RINT(11OFFD2106
     .),RPM(1),RS(32),RSLOPE(32,11),RULE(25),SHAPE(25),SIXTY5(25),SO(8,2OFFD2107
     .5),SOR(8,25),SS(8,25),SSR(8,25),TERMC(11),TH(8,25),THC(8,25),THCR(OFFD2108
     .8,25),THR(8,25),TITLE(36),TO(32,11),TSTAT(11),X(32)               OFFD2109
      COMMON  /SCALAR/                                                  OFFD2110
     .A,AA,A1OAC,A202AC,A303A0,A404A0,A505AC,ANG,B,BB,CC,CENT,CM,CMEAN,COFFD2111
     .MEANP,CM1,CORRC,COUNT,CP,CPI2,CPI3,CPI4,CPI5,CPI6,CPO2,CPO3,CPO4,COFFD2112
     .PO5,DAMP,DCP,DELFLO,DFACT,DMACH,EPISON,FACTM,G,GAMMER,GASK,GJ,GR2,OFFD2113
     .H,HIGH,HIPRES,I,IG,IGO,IOUTTR,IPASS,J,JJ,JM,JM1,JOULE,K,KDEL,KK,L,OFFD2114
     .LAST,LC1,LEVEL,LST,LSTAGE,M,MACH,MAXPT,MINPT,N,NBLADE,NDATA,NLINESOFFD2115
     .,NSETS,NSPEED,NTUBES,NX,NX1,OFF,OK,PHI,PLOW,Q,RA,RADIAN,RDFLO,REF,OFFD2116
     .RESTAR,RMACH,S,SOLID,SPEED,STOP,T,TERMD,THICK,TIME,TOLAT,TOLCX,TOLOFFD2117
     .MIN,TOLR,TONE,V,VM1,YES                                           OFFD2118
      DIMENSION TERM3(11),TERM1(11)                                     OFFD2119
      DIMENSION TERMA(11)                                               OFFD2120
                                                                        OFFD2121
    5 CONTINUE                                                          OFFD2122
      DAMP= 10.0                                                        OFFD2123
      LIMIT= 1.6                                                        OFFD2124
      TEST= 1.56                                                        OFFD2125
      BOTTOM= -0.99                                                     OFFD2126
      PUTS= 0.1                                                         OFFD2127
                                                                        OFFD2128
C        *** INITIALIZE THE ITERATION COUNTERS                          OFFD2129
                                                                        OFFD2130
      LOOPY= 0                                                          OFFD2131
      DO 1 I=1,NX                                                       OFFD2132
      DO 1 J=1,NLINES                                                   OFFD2133
```

```
[illegible] TA(I,J)= CX(I,J)
[illegible] YES= .FALSE.
      HIT= .FALSE.
      LOOPY= LOOPY +1
      IF (LOOPY.GT.250) CALL ERROR(5)

C           *** FIND AXIAL VELOCITY-INDEPENDENT TERMS IN
C               AXIAL-VELOCITY EQUATION

      DO 75 J=2,NTUBES

C -----   GET STREAMLINE SLOPE.

   75 CALL  XDERIV(R,RSLOPE)
  210 DO 220 J=1,NLINES

C           *** OBTAIN THE FIRST DERIVATIVE OF AXIAL VELOCITY WITH RESPECT
C               TO AXIAL LENGTH, RESULT IS IN CSLOPE

  220 CALL  XDERIV(CR,CSLOPE)



C           *** BEGINNING OF CX ITERATION WITHIN CAXIAL. STREAMLINE
C               POSITION IS FIXED

  230 DO 490 I=NOW,NX


      HELP= 1.0
      ILL= 0
      CM=CX(I,JM)
      CM2= CM*CM
  235 DO 240 J=1,NLINES
C -----   GET AN ENTROPY TERM.
      CD(I,J)= THERM3(TO(I,J))/DCP -ALOG(PO(I,J))
C -----   SQUARE THE TANGENTIAL VELOCITY.
      CXM(J)= CU(I,J)**2
      DEPV(I,J)= CXM(J)/R(I,J)
C -----   CALCULATE THE ENTHALPY DUE TO THE VELOCITY.
      H= -(CX(I,J)**2 +CR(I,J)**2 +CU(I,J)**2)/GJ
      T= TO(I,J)
C -----   GET THE STATIC TEMPERATURE.
      CALL  ENTALP
C -----   CALCULATE THE RADIAL VELOCITY.
  240 CR(I,J)= CX(I,J)*RSLOPE(I,J)
C -----   INTEGRATE THE TANGENTIAL VELOCITY SQUARED DIVIDED BY THE
C         RADIUS.  THE RESULT IS IN RINT.
      CALL INTEG (DEPV,2)
      TERMC(1)= 0.0

      A= THERM1(TO(I,JM))
      AA= CR(I,JM)**2
      DO 250 J=1,NLINES
C -----   INTEGRATE THE ENTROPY.
      IF (J.NE.1)  TERMC(J)= TERMC(J-1) +GR2*(TSTAT(J)+TSTAT(J-1))*
```

```
      X (CO(I,J) -CO(I,J-1))
C -----   CALCULATE THE ENTHALPY TERM MINUS THE RADIAL VELOCITY TERM.
      TERM1(J)= (GJ*(THERM1(TO(I,J)) -A)
     X +AA -CR(I,J)**2
     X  -(CXM(J) -CXM(JM)) -2.0*RINT(J))
  2[illegible]0 DEPV(I,J)= CX(I,J)*CSLOPE(I,J)
C -----   INTEGRATE THE VELOCITY TERM.
      CALL INTEG (DEPV,2)
  365 ILL= ILL+1
  370 DO 400 J=1,NLINES

C         *** FIND NEW VALUES OF CXM

C -----   COMBINE THE AXIAL VELOCITY TERMS.
      TERMD= (TERM1(J) +2.0*RINT(J) -TERMC(J) +TERMC(JM))/CM2/HELP
      IF (TERMD) 383,381,385
  381 CXNEW(J)= CM
      GO TO 400

C         *** TEST THE VELOCITY RATIO TERM FOR REASONABLE VALUE

  383 IF (TERMD.GE.BOTTOM)  GO TO 390
      HIT= .TRUE.

C ----- SET THIS TERM TO ITS LIMIT AND EFFECTIVELY INCREASE
C        THE MEAN LINE VELOCITY

      HELP= 1.0001*TERMD/BOTTOM
      IF (ILL.LT.5)  GO TO 365
      TERMD= POTS
      GO TO 395
  385 IF (TERMD.LT.TEST)  GO TO 390
      HELP= HELP*1.1
      HIT= .TRUE.
      IF (ILL.LT.10) GO TO 365
      TERMD= LIMIT
      GO TO 395
  390 TERMD= SQRT(1.0+TERMD)
  395 CXNEW(J)= TERMD*CM
  400 CONTINUE
  410 CONTINUE

C         *** UNSUCCESSFUL CONVERGENCE ON CX

      IF (YES)  GO TO 450
      DO 440 J=1,NLINES
C         *** COMPARE AXIAL VELOCITY FROM CURVATURE EQUATION TO AXIAL
C             VELOCITY FROM THE CONTINUITY EQUATION

  440 IF (ABS((CX(I,J) -CXNEW(J))/CX(I,J)).GT.TOLCX)  GO TO 445
      GO TO 450
  445 YES= .TRUE.
  450 DO 460 J=1,NLINES
  460 CX(I,J)= (CX(I,J) +CXNEW(J))*0.5
      CALL STREAM
      A= CMEANP/CM/(DAMP +1.0)
```

```
          C.X.        -  EFN    SOURCE STATEMENT  -  IFN(S)  -

         ... 460 J=1,NLINES                                              OFFD2246
          .TA(I,J)= (BETA(I,J)*DAMP +CXNEW(J))*A                         OFFD2247
         ..(I,J)= BETA(I,J)                                              OFFD2248
    . 0 CONTINUE                                                         OFFD2249
    . .0 CONTINUE                                                        OFFD2250
                                                                         OFFD2251
                                                                         OFFD2252
         IF (MOD(ICOPY,10).EQ.7)  CALL  PRFIT2                           OFFD2253
  C -----    GET THE LOSSES.                                             OFFD2254
         .LL  LOSS                                                       OFFD2255
  C -----    RESET THE WORK.                                             OFFD2256
         CALL  PRFIT.                                                    OFFD2257
     . CALL  TIME. (A)                                                   OFFD2258
  C          *** CHECK EXECUTION TIME                                    OFFD2259
         .  (A.LT.TIME.) .= A+.1E.00.                                    OFFD2260
         IF (A.GT.STOP) CALL HALT                                        OFFD2261
    ... CONTINUE                                                         OFFD2262
         IF (HI.)  GO TO 10                                              OFFD2263
         IF (YES) GO TO .0                                               OFFD2264
   1000 CONTINUE                                                         OFFD2265
         .ETURN                                                          OFFD2266
          ND                                                             OFFD2267
```

```
      SUBROUTINE CHOKE

C     *** THIS SUBROUTINE CHECKS FOR CHOKED FLOW CONDITIONS

      COMMON /CET IT/ ROTOR(29)
      LOGICAL  CIRCLE,  SIXTY5
      REAL            IREF,          JOULE,         MACH,
     X METAL,         MIN,           MINR,          MOUT,
     X MOUTR
      INTEGER BLADE,                 COUNT
      LOGICAL         OFF,           OK,            RDFLO,
     X RESTAR,        TONE
      INTEGER  RULE
      REAL KDEL,KDEL2
      COMMON  /VECTOR/
     .ALPHA(29,11),ATAR(25,11),BETA(29,11),BH(32),BLADE(25),BT(32),CIRCL
     .E(25),CO(32,11),CPCO(6),CR(32,11),CSLOPE(32,11),CU(32,11),CX(32,11
     .),CXM(11),CXNEW(11),DA(10),DELM(11),DEPV(32,11),DF(20),DFLOW(32),F
     .LOW(32),FORM(25),FOUND(20,3,10),IREF(25,11),ITYPE(25),METAL(?),MET
     .HOD(25),MIN(8,25),MINR(8,25),MOUT(8,25),MOUTR(8,25),NIN(25),NRAD(2
     .5),NS(25),NSS(25),NTC(25),NTH(25),NXIT(25),OBAR(25,11),OFFO(25),PO
     .(32,11),R(32,11),RAD(8,25),RADR(8,25),RCURVE(32,11),RH(32),RINT(11
     .),RPM(1),RS(32),RSLOPE(32,11),RULE(25),SHAPE(25),SIXTY5(25),SO(8,2
     .5),SOR(8,25),SS(8,25),SSR(8,25),TERMC(11),TH(8,25),THC(8,25),THCR(
     .8,25),THR(8,25),TITLE(36),TO(32,11),TSTAT(11),X(32)
      COMMON  /SCALAR/
     .A,AA,A10A0,A202A0,A303A0,A404A0,A505AC,ANG,B,BB,CC,CENT,CM,CMEAN,C
     .MEANP,CM2,COREC,COUNT,CP,CPI2,CPI3,CPI4,CPI5,CPI6,CPO2,CPO3,CPO4,C
     .PO5,DAMP,DCP,DELFLO,DFACT,EMACH,EPISON,FACTM,G,GAMMER,GASK,GJ,GR2,
     .H,HIGH,HIPRES,I,IG,IGO,ICUTTR,IPASS,J,JJ,JM,JM1,JOULE,K,KDEL,KK,L,
     .LAST,LC1,LEVEL,LST,LSTAGE,M,MACH,MAXPT,MINPT,N,NBLADE,NDATA,NLINES
     .,NSETS,NSPEED,NTUBES,NX,NX1,OFF,OK,PHI,PLOW,Q,RA,RADIAN,RDFLO,REF,
     .RESTAR,RMACH,S,SOLID,SPEED,STOP,T,TERMD,THICK,TIME,TOLAT,TOLCX,TOL
     .MIN,TOLR,TONE,V,VMI,YES

      OK=.FALSE.
      DO 50 I=5,LSTAGE
      DO 50 J=1,NLINES

C     *** CALCULATE THROAT

      CXM(J)= SLINE(R(I-1,J),THR(1,I-4),TH(1,I-4),NTH(I-4))
      AA= CX(I-1,J)**2 +CR(I-1,J)**2 +CU(I-1,J)**2
      H= -AA/GJ
      T= TO(I-1,J)
      CALL  ENTALP
      IF (ROTOR(I-4).GT.0.0)  AA= AA +RPM(N)*R(I-1,J)*(
     X    RPM(N)*R(I-1,J) -2.0*CU(I-1,J))
      CALL  GAM
      AA= SQRT(AA/(GR2*GAMMER*TSTAT(J)))
      AA= ((GAMMER +1.0)*0.5)**(0.5*(GAMMER +1.0)/(1.0 -GAMMER))
     X  *(1.0 +0.5*(GAMMER -1.0)*AA**2)**(0.5*(GAMMER +1.0)
     X  /(GAMMER -1.0)) /AA

C     *** CALCULATE INLET METAL ANGLE
```

```
      METAL(I)= SLINE(R(I-1,J),MINR(1,I-4),MIN(1,I-4),NIN(I-4))         0FFD3066
      IF (ROTOR(I-4)) 15,50,30                                          0FFD3067
   15 CONTINUE                                                          0FFD3068
      CO(I,J)= COS(ALPHA(I-1,J))/CXM(J)                                 0FFD3069
      IF (AA.LE.CO(I,J)) GO TO 100                                      0FFD3070
      CO(I,J)= COS(METAL(I) +IREF(I-4,J))/CXM(J)                        0FFD3071
      IF (AA.LE.CO(I,J)) GO TO 100                                      0FFD3072
      GO TO 50                                                          0FFD3073
   30 CO(I,J)= COS(BETA(I-1,J))/CXM(J)                                  0FFD3074
      IF (AA.LE.CO(I,J)) GO TO 100                                      0FFD3075
      CO(I,J)= COS(METAL(I) +IREF(I-4,J))/CXM(J)                        0FFD3076
      IF (AA.LE.CO(I,J)) GO TO 100                                      0FFD3077
   50 CONTINUE                                                          0FFD3078
      OK=.TRUE.                                                         0FFD3079
  100 RETURN                                                            0FFD3080
      END                                                               0FFD3081
                                                                        0FFD3082
```

```
      FUNCTION CORREC2(ANG)
C
C     *** THICKNESS CORRECTION FOR ZERO-CAMBER REFERENCE ANGLE FOR
C         65-(A10)-SERIES AIRFOILS AS A FUNCTION OF THE BLADE
C         MAXIMUM-THICKNESS RATIO. REFERENCE FIGURE6
C
      DIMENSION COEF(6)
      DATA  COEF /0.1357869E-1, 16.86372,
     X -33.20523,  -1081.117, 9359.921,  -22184.5  /
      A=ANG
      CORREC2=COEF(1)+(COEF(2)+(COEF(3)+(COEF(4)+(COEF(5)+COEF(6)*A)*A)
     X *A)*A)*A
      RETURN
      END
```

```
 BLOCK DATA                                                          OFFD0154
 LOGICAL  CIRCLE,  SIXTY5                                            OFFD0155
 REAL            IREF,           JOULE,          MACH,               OFFD0156
X METAL,         MIN,            MINR,           MOUT,               OFFD0157
X MOUTR                                                              OFFD0158
 INTEGER BLADE,                  COUNT                               OFFD0159
 LOGICAL         OFF,            OK,             RDFLO,              OFFD0160
X RESTAR,        TONE                                                OFFD0161
 INTEGER  RULE                                                       OFFD0162
 REAL KDEL,KDEL2                                                     OFFD0163
 COMMON  /VECTOR/                                                    OFFD0164
.ALPHA(29,11),ATAN(25,11),BETA(29,11),BH(32),BLADE(25),BT(32),CIRCL OFFD0165
.E(25),CL(32,11),CPCO(6),CR(32,11),CSLOPE(32,11),CU(32,11),CX(32,11OFFD0166
.),CXM(11),CXNEW(11),DA(10),DELM(11),DEPV(32,11),DF(20),DFLOW(32),FOFFD0167
.LOW(32),FORM(25),FOUND(20,3,10),IREF(25,11),ITYPE(25),METAL(2),METOFFD0168
.MOD(25),MIN(8,25),MINR(8,25),MOUT(8,25),MOUTR(8,25),NIN(25),NRAD(2OFFD0169
.5),NS(25),NSS(25),NTC(25),NTH(25),NXIT(25),OBAR(25,11),OFFD(25),POOFFD0170
.(32,11),R(32,11),RAD(8,25),RADR(8,25),RCURVE(32,11),RH(32),RINT(11OFFD0171
.),RPM(11),RS(32),RSLOPE(32,11),RULE(25),SHAPE(25),SIXTY5(25),SO(8,2OFFD0172
.5),SOR(8,25),SS(8,25),SSR(8,25),TERMC(11),TH(8,25),THC(8,25),THCR(OFFD0173
.8,25),THP(8,25),TITLE(36),TU(32,11),TSTAT(11),X(32)                OFFD0174
 COMMON  /SCALAR/                                                    OFFD0175
.A,AA,A1CA0,A2O2A0,A3O3A0,A4O4A0,A5O5A0,ANG,B,BB,CC,CENT,CM,CMEAN,COOFFD0176
.MLANP,CM2,COREC,COUNT,CP,CPI2,CPI3,CPI4,CPI5,CPI6,CPO2,CPO3,CPO4,COFFD0177
.PO5,DAMP,DCP,DELFLO,DFACT,EMACH,EPISON,FACTM,G,GAMMER,GASK,GJ,GR2,OFFD0178
.F,HIGH,HIPRES,I,IG,IGO,IOUTTR,IPASS,J,JJ,JM,JM1,JOULE,K,KDEL,KK,L,OFFD0179
.LAST,LC1,LEVEL,LST,LSTAGE,M,MACH,MAXPT,MINPT,N,NBLADE,NDATA,NLINESOFFD0180
.,NSETS,NSPEED,NTUBES,NX,NX1,OFF,OK,PHI,PLOW,Q,RA,RADIAN,RDFLO,REF,OFFD0181
.RESTAR,RMACH,S,SOLID,SPEED,STOP,T,TERMD,THICK,TIME,TOLAT,TOLCX,TOLOFFD0182
.MIN,TOLR,TONE,V,VMI,YES                                             OFFD0183
 DATA   DFLOW(1),DFLOW(2),DFLOW(3),DFLOW(4),DFLOW(5) /5*1.0/         OFFD0184
 DATA   G, GJ, JOULE /1545.44, 50070.47, 778.12 /                    OFFD0185
 DATA   DF /0.0,.1,.15,.2,.25,.3,.35,.4,.45,.5,.55,.6,.65,           OFFD0186
X.7,.75,.8,.85,.9,.95,1.0/                                           OFFD0187
 DATA   RADIAN /57.29578/                                            OFFD0188
 END                                                                 OFFD0189
```

```
      FUNCTION DERUL1(RMACH,HIGH)                                        OFFD1742
C ----- DEDUCE VARIATION OF AVERAGE ROTOR DEVIATION ANGLE MINUS         OFFD1743
C      LOW-SPEED TWO DIMENSIONAL-CASCADE-RULE DEVIATION ANGLE AT         OFFD1744
C       COMPRESSOR REFERENCE INCIDENCE ANGLE WITH RELATIVE INLET MACH    OFFD1745
C      NUMBER FOR DOUBLE-CIRCULAR-ARC BLADES.                            OFFD1746
C        FIGURE 202B  NASA  SP-36                                        OFFD1747
      DIMENSION HTAB(5),RMNTAB(6),CDATAB(6,5)                            OFFD1748
      COMMON /SCALAR/ QQ(81),  RADIAN,   QQQ(21)                         OFFD1749
      DATA  HTAB /.1,.3,.5,.7,.9/, RMNTAB/.2,.5,.7,.8,.9,1.0/,CDATAB/    OFFD1750
     X 3*-1.5,                                                           OFFD1751
     &-1.5,-1.,-1.,-1.,-1.,-.9,-.8,-.5,-.5,-.45,-.38,-.2,0.,.1,.1,.18,   OFFD1752
     &0.,.28,.5,.84,1.,1.,1.1,1.3,1.7,2.2/                               OFFD1753
      A=RMACH                                                            OFFD1754
      B=HIGH                                                             OFFD1755
      K= (INT(10.*B)+1)/2                                                OFFD1756
      K= MAX0(MIN0(K,4),1)                                               OFFD1757
      ANS1= SLINE(A,RMNTAB,CDATAB(1,K),6)                                OFFD1758
      ANS2= SLINE(A,RMNTAB,CDATAB(1,K+1),6)                              OFFD1759
   10 DERUL1= (ANS1+(ANS2-ANS1)/(HTAB(K+1)-HTAB(K))*(B-HTAB(K)))/RADIAN OFFD1760
      RETURN                                                             OFFD1761
      END                                                                OFFD1762
```

```
      FUNCTION DERUL2(RMACH,HIGH)                                       0FFD1716
C -----   DEDUCED VARIATION OF AVERAGE ROTOR DEVIATION ANGLE MINUS      0FFD1717
C       LOW-SPEED TWO-DIMENSIONAL-CASCADE-RULE DEVIATION ANGLE AT       0FFD1718
C       COMPRESSOR REFERENCE INCIDENCE ANGLE WITH RELATIVE INLET MACH   0FFD1719
C       NUMBER FOR NACA 65-(A10)-SERIES BLADE.                          0FFD1720
C         FIGURE 202A  NASA  SP-36                                      0FFD1721
      COMMON /SCALAR/ Q1(81),  RADIAN,   QCQ(21)                        0FFD1722
      A=RMACH                                                           0FFD1723
      B=HIGH                                                            0FFD1724
      IF (B.LE.0.5) GO TO 20                                            0FFD1725
      IF (B.LT.0.7) GO TO 10                                            0FFD1726
      X1=.7                                                             0FFD1727
      X2=.9                                                             0FFD1728
      Y1=-.1                                                            0FFD17 9
      Y2=0.0                                                            0FFD1730
      GO TO 15                                                          0FFD1731
   10 X1=.5                                                             0FFD1732
      X2=.7                                                             0FFD1733
      Y1=-.5                                                            0FFD1734
      Y2=-.1                                                            0FFD1735
   15 DERUL2=(Y1+(Y2-Y1)/(X2-X1)*(B-X1))/RADIAN                         0FFD1736
      GO TO 30                                                          0FFD1737
   20 DERUL2= -.008727                                                  0FFD1738
   30 RETURN                                                            0FFD1739
      END                                                               0FFD1740
```

```
 FUNCTION  DEVI (OFFDD)
 COMMON /OUT IT/ ROTOR(29)
 LOGICAL  CIRCLE,  SIXTY5
 REAL            IREF,             JOULE,           MACH,
X METAL,         MIN,              MINR,            MOUT,
X MOUTR
 INTEGER BLADE,                    COUNT
 LOGICAL         OFF,              OK,              RDFLO,
X RESTAR,        TONE
 INTEGER  RULE
 REAL KDEL,KDEL2
 COMMON  /VECTOR/
.ALPHA(32,11),ATAR(25,11),BETA(29,11),BH(32),BLADE(25),BT(32),CIRCL
.E(25),CL(32,11),CPCO(6),CR(32,11),CSLOPE(32,11),CU(32,11),CX(32,11
.),CXM(11),CXNEW(11),DA(10),DELM(11),DEPV(32,11),DF(20),DFLOW(32),F
.LOW(32),FORM(25),FOUND(20,3,10),IREF(25,11),ITYPE(25),METAL(2),MET
.HOD(25),MIN(8,25),MINR(8,25),MOUT(8,25),MOUTR(8,25),NIN(25),NRAD(2
.5),NS(25),NSS(25),NTC(25),NTH(25),NXIT(25),OBAR(25,11),OFFD(25),PO
.(32,11),R(32,11),RAD(8,25),RADR(8,25),RCURVE(32,11),RH(32),RINT(11
.),RPM(1),RS(32),RSLOPE(32,11),RULE(25),SHAPE(25),SIXTY5(25),SO(8,2
.5),SOR(8,25),SS(8,25),SSR(8,25),TERMC(11),TH(8,25),THC(8,25),THCR(
.8,25),THR(8,25),TITLE(36),TO(32,11),TSTAT(11),X(32)
 COMMON  /SCALAR/
.A,AA,A1OAC,A2O2AO,A3O3AO,A4O4AO,A5C5AC,ANG,B,BB,CC,CENT,CM,CMEAN,C
.MEANP,CM2,COREC,COUNT,CP,CPI2,CPI3,CPI4,CPI5,CPI6,CPO2,CPO3,CPO4,C
.PO5,DAMP,DCP,DELFLC,DFACT,EMACH,EPISON,FACTM,G,GAMMER,GASK,GJ,GR2,
.H,HIGH,HIPRES,I,IG,IGO,IOUTTR,IPASS,J,JJ,JM,JM1,JOULE,K,KDEL,KK,L,
.LAST,LC1,LEVEL,LST,LSTAGE,M,MACH,MAXPT,MINPT,N,NBLADE,NDATA,NLINES
.,NSETS,NSPEED,NTUBES,NX,NX1,OFF,OK,PHI,PLOW,Q,RA,RADIAN,RDFLO,REF,
.RESTAR,RMACH,S,SOLID,SPEED,STOP,T,TERMO,THICK,TIME,TOLAT,TOLCX,TOL
.MIN,TOLR,TONE,V,VMI,YES

 DIMENSION  UP(2), TAB(17,2,3)
 DATA  TAB /
X .347, .28, .211, .145, .077, .009, -0.032, -0.034, 0.0, .052,
X .1, .141,.178, .206, .225, .238, .242,
X -.8, -.7, -.6, -.5, -.4, -.3, -.2, -.1, 0., .1, .2, .3, .4, .5,
X .6, .7, .8,
X .347, .28, .211, .145, .077, .009, -0.032, -0.034, 0.0, .052,
X .1, .141,.178, .206, .225, .238, .242,
X -.8, -.7, -.6, -.5, -.4, -.3, -.2, -.1, 0., .1, .2, .3, .4, .5,
X .6, .7, .8,
X .347, .28, .211, .145, .077, .009, -0.032, -0.034, 0.0, .052,
X .1, .141,.178, .206, .225, .238, .242,
X -.8, -.7, -.6, -.5, -.4, -.3, -.2, -.1, 0., .1, .2, .3, .4, .5,
X .6, .7, .8/
 L= 2
 IF (HIGH.GT.0.5)  L= 3
 UP(1)= SLINE(OFFDD, TAB(1,2,2), TAB(1,1,2), 17 )
 UP(2)= SLINE(OFFDD, TAB(1,2,L), TAB(1,1,L), 17 )
 DEVI=  (ABS(HIGH -0.5)*(UP(2) -UP(1))*2.5) +UP(1)
 RETURN
 END
```

```
      FUNCTION DEVI6(ANGLE,SOLID)                                        OFFD0197
C ----- ZERO-CAMBER DEVIATION ANGLE AT REFERENCE MINIMUM-LOSS             OFFD0198
C       INCIDENCE ANGLE DEDUCED FROM LOW-SPEED-CASCADE DATA FOR          OFFD0199
C       10-PERCENT-THICK NACA 65-(A10)-SERIES BLADES.                    OFFD0200
C         FIGURE 161  NASA  SP-36                                        OFFD0201
      DIMENSION ZERO(6,9),D(2),SODITY(9)                                 OFFD0202
      DATA  ZERO / 0.1163438E-1, 0.1042048E-1,                           OFFD0203
     X -0.2357149E-3, 0.1393758E-4,-0.2187326E-6,   0.1030741E-8,        OFFD0204
     X -0.2379782E-2, 0.1138221E-1,  0.5835683E-4,  0.1210531E-5,        OFFD0205
     X -0.3104238E-7, 0.4912501E-9,                                      OFFD0206
     X -0.2422225E-2, 0.9617408E-2,  0.3394261E-3, -0.3245611E-5,        OFFD0207
     X -0.1521519E-7, 0.7470425E-9,                                      OFFD0208
     X -0.2308945E-2, 0.7704409E-2,  0.6286594E-5, -0.1304805E-4,        OFFD0209
     X  0.1527598E-6, -0.1427643E-9,                                     OFFD0210
     X  0.1254558E-2,  0.4640114E-2,  0.1140354E-2, -0.3527895E-4,       OFFD0211
     X  0.5881120E-6,  -0.2864518E-8,                                    OFFD0212
     X  0.142741E-2,   0.1133045E-1,  0.3779976E-5, -0.1485940E-5,       OFFD0213
     X -0.7734151E-8,  0.9486864E-9,                                     OFFD0214
     X  0.3152415E-2,  0.3404205E-2,  0.8033776E-3, -0.2062771E-4,       OFFD0215
     X  0.3634500E-5,  -0.1375512E-8,                                    OFFD0216
     X  0.4984319E-2,  0.1482529E-1,  0.2540287E-5,  0.7250227E-5,       OFFD0217
     X  0.1335551E-7,  0.8991799E-9,                                     OFFD0218
     X  0.5406452E-2,  0.2085425E-1, -0.2622876E-3, 0.2088415E-4,        OFFD0219
     X -0.3263101E-6, 0.2288596E-8/, SODITY / 0.4, 0.6, 0.8,             OFFD0220
     X 1.0,1.2,1.4,1.6,1.8,2.0 /                                         OFFD0221
      A= ANGLE*57.29578                                                  OFFD0222
      S=SOLID                                                            OFFD0223
      I=1                                                                OFFD0224
      IF (S.LT.SODITY(1)) GO TO 5                                        OFFD0225
    1 I=I+1                                                              OFFD0226
      IF (S.GE.SODITY(I).AND.I.LT.9) GO TO 1                             OFFD0227
    5 DO 10 J=1,2                                                        OFFD0228
      D(J)= ZERO(1,I) +(ZERO(2,I) +(ZERO(3,I) +(ZERO(4,I) +(ZERO(5,I)    OFFD0229
     X +ZERO(6,I)*A)*A)*A)*A)*A                                          OFFD0230
   10 I=I-1                                                              OFFD0231
      DEVI6= 5.0*(S-SODITY(I+1))*(D(1)-D(2)) + D(2)                      OFFD0232
      RETURN                                                             OFFD0233
      END                                                                OFFD0234
```

```
      SUBROUTINE ENTALP
C
C      *** CALCULATES THE TEMPERATURE RISE CORRESPONDING TO AN
C          ENTHALPY CHANGE
C
      LOGICAL  CIRCLE,  SIXTY5
      REAL              IREF,            JOULE,           MACH,
     X METAL,           MIN,             MINR,            MOUT,
     X MOUTR
      INTEGER BLADE,                     COUNT
      LOGICAL           OFF,             OK,              RDFLO,
     X RESTAR,          TONE
      INTEGER  RULE
      REAL KDEL,KDEL2
      COMMON  /VECTOR/
     .ALPHA(29,11),ATAR(25,11),BETA(29,11),BH(32),BLADE(25),BT(32),CIRCL
     .E(25),CO(32,11),CPCO(8),CR(32,11),CSLOPE(32,11),CU(32,11),CX(32,11
     .),CXM(11),CXNEW(11),DA(10),DELM(11),DEPV(32,11),DF(20),DFLOW(32),F
     .LOW(32),FORM(25),FOUND(20,3,10),IREF(25,11),ITYPE(25),METAL(2),MET
     .HOD(25),MIN(8,25),MINR(8,25),MOUT(8,25),MOUTR(8,25),NIN(25),NRAD(2
     .5),NS(25),NSS(25),NTC(25),NTH(25),NXIT(25),OBAR(25,11),OFFD(25),P
     .(32,11),R(32,11),RAD(6,25),RADR(8,25),RCURVE(32,11),RH(32),RINT(11
     .),RPM(1),RS(32),RSLOPE(32,11),RULE(25),SHAPE(25),SIXTY5(25),SO(8,2
     .5),SOR(8,25),SS(8,25),SSR(8,25),TERMC(11),TH(8,25),THC(8,25),THCR(
     .8,25),THR(8,25),TITLE(36),TO(32,11),TSTAT(11),X(32)
      COMMON  /SCALAR/
     .A,AA,A10A0,A202A0,A303A0,A404A0,A505A0,ANG,B,BB,CC,CENT,CM,CMEAN,C
     .MEANP,CM2,COREC,COUNT,CP,CPI2,CPI3,CPI4,CPI5,CPI6,CPO2,CPO3,CPO4,C
     .PO5,DAMP,DCP,DELFLO,DFACT,EMACH,EPISON,FACTM,G,GAMMER,GASK,GJ,GR2,
     .H,HIGH,HIPRES,I,IG,IGO,IOUTTR,IPASS,J,JJ,JM,JM1,JOULE,K,KDEL,KK,L,
     .LAST,LC1,LEVEL,LST,LSTAGE,M,MACH,MAXPT,MINPT,N,NBLADE,NDATA,NLINES
     .,NSETS,NSPEED,NTUBES,NX,NX1,OFF,OK,PHI,PLOW,Q,RA,RADIAN,RDFLO,REF,
     .RESTAR,RMACH,S,SOLID,SPEED,STOP,T,TERMO,THICK,TIME,TOLAT,TOLCX,TOL
     .MIN,TOLR,TONE,V,VM1,YES
      HOT= THERM1(T)
      TSTAT(J)= H/CP +T
      DO 10 ITER=1,25
      HIT= THERM1(TSTAT(J))
      E=H-HIT +HOT
      TSTAT(J)= E/CP +TSTAT(J)
   10 IF (ABS(E).LE.TOLMIN)  GO TO 20
      CALL ERROR (35)
   20 RETURN
      END
```

```
      SUBROUTINE ERROR(IAX)
      LOGICAL  CIRCLE,  SIXTY5
      REAL            IREF,           JOULE,          MACH,
     X METAL,         MIN,            MINR,           MOUT,
     X MOUTR
      INTEGER BLADE,                  COUNT
      LOGICAL         OFF,            OK,             RDFLO,
     X RESTAR,        TONE
      INTEGER  RULE
      REAL KDEL,KDEL2
      COMMON  /VECTOR/
     .ALPHA(29,11),ATAR(25,11),BETA(29,11),BH(32),BLADE(25),BT(32),CIRCL
     .E(25),CO(32,11),CPCO(6),CR(32,11),CSLOPE(32,11),CU(32,11),CX(32,11
     .),CXM(11),CXNEW(11),DA(10),DELM(11),DERV(32,11),DF(20),DFLOW(32),F
     .LOW(32),FORM(25),FOUND(20,5,10),IREF(25,11),ITYPE(25),METAL(2),MET
     .HOD(25),MIN(8,25),MINR(8,25),MOUT(8,25),MOUTR(8,25),NIN(25),NRAD(2
     .5),NS(25),NSS(25),NTC(25),NTH(25),NXIT(25),OBAR(25,11),OFFD(25),PO
     .(32,11),R(32,11),RAD(8,25),RADR(8,25),RCURVE(32,11),RH(32),RINT(11
     .),RPM(11),RS(32),RSLOPE(32,11),RULE(25),SHAPE(25),SIXTY5(25),SO(8,2
     .5),SOR(8,25),SS(8,25),SSR(8,25),TERMC(11),TH(8,25),THC(8,25),THCR(
     .8,25),THR(8,25),TITLE(36),TO(32,11),TSTAT(11),X(32)
      COMMON  /SCALAR/
     .A,AA,A10A0,A202AC,A303A0,A404A0,A505A0,ANG,B,BB,CC,CENT,CM,CMEAN,CO
     .MEANP,CM2,CUREC,COUNT,CP,CP12,CP13,CP14,CP15,CP16,CP02,CP03,CP04,CO
     .P05,DAMP,DCP,DELFLO,DFACT,EMACH,EPISON,FACTM,G,GAMMER,GASK,GJ,GR2,
     .H,HIGH,HIPRES,I,IG,IGO,IOUTTR,IPASS,J,JJ,JM,JM1,JOULE,K,KDEL,KK,L,
     .LAST,LC1,LEVEL,LST,LSTAGE,M,MACH,MAXPT,MINPT,N,NBLADE,NDATA,NLINES
     .,NSETS,NSPEED,NTUBES,NX,NX1,OFF,OK,PHI,PLOW,Q,RA,RADIAN,RDFLO,REF,
     .RESTAR,RMACH,S,SOLID,SPEED,STOP,T,TERMO,THICK,TIME,TOLAT,TOLCX,TOL
     .MIN,TOLR,TONE,V,VMI,YES

      WRITE (6,5) IAX
    5 FORMAT (1H145X23H***** ERROR MESSAGE NO. I3 ///)
      GO TO (11,22,33,44,55,66,77,88,99,100,11,120,11,140,150,160,11,
     1 180,190,200),IAX
   11 WRITE (6,12)
   12 FORMAT (1H020X67HTHE ITERATION ON THE INITIAL ESTIMATE OF AXIAL VE
     1LOCITY HAS FAILED. / 21X55HCHECK YOUR INPUT DATA -- THIS ITERATION
     2 JUST DOES NOT FAIL. // )

C         *** RETURN TO NEW DATA SET

      GO TO 1030
   22 WRITE (6,23) I,FLOW(I)
   23 FORMAT (1H020X28HTHE MEAN VELOCITY AT STATION I3,39H HAS EXCEEDED
     1THE SONIC VELOCITY ON TWO /21X53HSUCCESSIVE ITERATIONS ON CONTINUI
     2TY. PERHAPS THE MASS FLOW E15.7 /21X54HIS TOO HIGH. THIS ERROR OCC
     3URRED IN SUBROUTINE STREAM. //)

      CALL  SUPER
C         *** PRINT THE OUTPUT

      GO TO 1000
   33 WRITE (6,34)
   34 FORMAT (1H020X95HTHE ITERATION ON CONTINUITY HAS UNFORTUNATELY FAI
```

```
 LED. THIS ERROR OCCURRED IN SUBROUTINE STREAM. //)

      CALL  SUPER
C         *** PRINT THE OUTPUT

      GO TO 1000
   45 WRITE (6,45)
   45 FORMAT (1HO20X65HTHE ITERATION ON THE CURVATURE EQUATION HAS FAILE
     1D. THIS ERROR OCCURRED IN SUBROUTINE CAXIAL. //)

C         *** PRINT THE OUTPUT

      CALL  STALL
      GO TO 1000
   55 WRITE (6,56)
   56 FORMAT (1HO20X85HTHE ITERATION ON AXIAL VELOCITY HAS FAILED. THIS
     1ERROR OCCURRED IN SUBROUTINE CAXIAL. //)

C         *** PRINT THE OUTPUT

      GO TO 1000
   66 WRITE (6,67) NLINES
   67 FORMAT (1HO20X50HTHE NUMBER OF STREAMLINES MUST BE 5,7,9 OR 11, NO
     1T I3,23H, EXECUTION TERMINATED. /21X39HTHIS ERROR OCCURRED IN SUBR
     2OUTINE BOSS. //)

C         *** CALL EXIT SUBROUTINE

      GO TO 1010
   77 WRITE (6,78)
   78 FORMAT (1HO20X80HTHE NUMBER OF STAGES IS GREATER THAN 12, NUMBER R
     1ESET TO 12. NEXT DATA SET COULD /21X52HBE IN ERROR. THIS ERROR OCC
     2URRED IN SUBROUTINE BOSS. //)
      NSTAGE=12

C         *** CONTINUE ON THIS DATA SET

      GO TO 1020
   88 WRITE (6,89)
   89 FORMAT (1HO20X82HA NEGATIVE STATIC TEMPERATURE HAS BEEN ENCOUNTERE
     1D. THIS ERROR OCCURRED IN CAXIAL. //)

C         *** PRINT THE OUTPUT

      GO TO 1000
   95 WRITE (6,98)
   98 FORMAT (1HO20X79HTHE ITERATION ON REFERENCE INCIDENCE HAS FAILED.
     1THIS ERROR OCCURRED IN PRFIT2. //)

C         *** PRINT THE OUTPUT

      GO TO 1000
  100 WRITE (6,101)
  101 FORMAT (1HO20X35HA NON-POSITIVE INLET TEMPERATURE OR PRESSURE HAS
     1BEEN ENCOUNTERED. THIS ERROR OCCURRED IN BOSS. /21X49HEXECUTION WI
     2LL CONTINUE WITH STANDARD CONDITIONS. //)
```

```
      T0C0=518.688                                                      OFFD0444
      P0C0=2116.312                                                     OFFD0445
                                                                        OFFD0446
C        *** CONTINUE ON THIS DATA SET                                  OFFD0447
                                                                        OFFD0448
      GO TO 1020                                                        OFFD0449
  120 WRITE (6,121)                                                     OFFD0450
  121 FORMAT (1H020X53HTHE ITERATION ON EFFICIENCY HAS FAILED. THIS ERROFFD0451
     1R OCCURRED IN BOSS. //)                                           OFFD0452
                                                                        OFFD0453
C        *** PRINT THE OUTPUT                                           OFFD0454
                                                                        OFFD0455
      GO TO 1000                                                        OFFD0456
  140 WRITE (6,141) I                                                   OFFD0457
  141 FORMAT (1H020X75HA NEGATIVE BLOCKAGE FACTOR AT THE TIP HAS BEEN ENOFFD0458
     1COUNTERED AT AXIAL STATION I3,1H. /21X47HTHE DATA WILL BE CHANGED OFFD0459
     2TO A REASONABLE VALUE. //)                                        OFFD0460
      BT(I)=1.0                                                         OFFD0461
                                                                        OFFD0462
C        *** CONTINUE ON THIS DATA SET                                  OFFD0463
                                                                        OFFD0464
      GO TO 1020                                                        OFFD0465
  150 WRITE (6,151)                                                     OFFD0466
  151 FORMAT (1H020X70HAN IMPROPER FRACTIONAL MASS FLOW (AN INPUT ITEM) OFFD0467
     1HAS BEEN ENCOUNTERED. /21X30HTHIS ERROR OCCURRED IN RSTART. //)   OFFD0468
                                                                        OFFD0469
C        *** RETURN TO NEW DATA SET                                     OFFD0470
                                                                        OFFD0471
      GO TO 1030                                                        OFFD0472
  160 WRITE (6,161)                                                     OFFD0473
  161 FORMAT (1H020X86HEITHER GAMMA OR THE STATIC TEMPERATURE HAS BEE FOOFFD0474
     1UND NEGATIVE. CHECK THE SPECIFIC HEAT /21X42HPOLYNOMIAL. THIS ERROOFFD0475
     2R OCCURRED IN STREAM. //)                                         OFFD0476
                                                                        OFFD0477
C        *** PRINT THE OUTPUT                                           OFFD0478
                                                                        OFFD0479
      GO TO 1000                                                        OFFD0480
  180 WRITE (6,181)                                                     OFFD0481
  181 FORMAT (1H020X68HTHE CONTINUITY ITERATION HAS FAILED (PERHAPS DUE OFFD0482
     1TO OTHER FAILURES) AND THE VELOCITY HAS /21X73HEXCEEDED THE EQUIVAOFFD0483
     2LENT TOTAL TEMPERATURE. THIS ERROR OCCURRED IN STREAM. //)        OFFD0484
                                                                        OFFD0485
C        *** PRINT THE OUTPUT                                           OFFD0486
                                                                        OFFD0487
      GO TO 1000                                                        OFFD0488
  190 WRITE (6,191)                                                     OFFD0489
  191 FORMAT (1H020X91HTHE ITERATION ON THE THEORETICAL TEMPERATURE RISEOFFD0490
     1HAS FAILED. THIS ERROR OCCURRED IN THERM2. //)                    OFFD0491
                                                                        OFFD0492
C        *** PRINT THE OUTPUT                                           OFFD0493
                                                                        OFFD0494
      GO TO 1000                                                        OFFD0495
  200 WRITE (6,201) I                                                   OFFD0496
  201 FORMAT (1H020X75HA NEGATIVE BLOCKAGE FACTOR AT THE HUB HAS BEEN ENOFFD0497
     1COUNTERED AT AXIAL STATION I3,1H. /21X47HTHE DATA WILL BE CHANGED OFFD0498
     2TO A REASONABLE VALUE. //)                                        OFFD0499
```

```
                                                                      05/02/6?
        ERROR.    -  EFN   SOURCE STATEMENT  -  IFN(S)  -

       ?H(I)=1.0                                                      OFF00500
                                                                      OFF00501
C           *** CONTINUE ON THIS DATA SET                             OFF00502
                                                                      OFF00503
       GO TO 10?0                                                     OFF00504
  ?000 CALL OUTPUT                                                    OFF00505
  ???? CALL BOSS                                                      OFF00506
  ???? CALL EXIT                                                      OFF00507
  10?? RETURN                                                         OFF00508
       END                                                            OFF00509
```

```
      FUNCTION EXPB(ANG)                                                 0FFD1684
C -----   VALUE OF SOLIDITY EXPONENT B IN DEVIATION-ANGLE RULE DEDUCED   0FFD1685
C        FROM DATA FOR 65-(A10)-SERIES BLADES.                           0FFD1686
C          FIGURE 164  NASA  SP-36                                       0FFD1687
                                                                         0FFD1688
C          *** SOLIDITY EXPONENT B IN DEVIATION-ANGLE RULE AS A          0FFD1689
C              FUNCTION OF THE INLET AIR ANGLE. REFERENCE FIGURE 16      0FFD1690
                                                                         0FFD1691
      DIMENSION COEF(4)                                                  0FFD1692
      COMMON /SCALAR/ QQ(81),  RADIAN,   QQQ(21)                         0FFD1693
      DATA  COEF /0.9570973, -0.2610395E-02,                             0FFD1694
     X 0.4193[illegible]693E-4,    -0.12909[illegible]4E-5/              0FFD1695
      A=ANG*RADIAN                                                       0FFD1696
      EXPB=  COEF(1) +(COEF(2) +(COEF(3) +COEF(4)*A)*A)*A                0FFD1697
      RETURN                                                             0FFD1698
      END                                                                0FFD1699
```

```
      FUNCTION FACTM1(ANG)                                              OFFD1764
C -----   FACTOR M IN DEVIATION-ANGLE RULE FOR CIRCULAR-ARC MEAN LINE   OFFD1765
C      BLADES.                                                          OFFD1766
C        FIGURE 195  (TOP CURVE) NASA  SP-36                            OFFD1767
      DIMENSION COEF(6)                                                 OFFD1768
      COMMON /SCALAR/ CQ(31),  RADIAN,   QCC(21)                        OFFD1769
      DATA  COEF /0.25011137,  0.5814584E-3,                            OFFD1770
     X -0.5093281256E-5,       0.17153075E-6, 0.36251376E-9,            OFFD1771
     X  0.51825372E-11/                                                 OFFD1772
      A=ANG*RADIAN                                                      OFFD1773
      FACTM1=COEF(1)+(COEF(2)+(COEF(3)+(COEF(4)+(COEF(5)+COEF(6)*A)*A)  OFFD1774
     X *A)*A)*A                                                         OFFD1775
      RETURN                                                            OFFD1776
      END                                                               OFFD1777
```

```
                                                                     05/02/68
       FACTM2.      -  EFN   SOURCE STATEMENT  -  IFN(S)  -

      FUNCTION FACTM2(ANG)                                           OFFD1701
      DIMENSION COEF(6)                                              OFFD1702
C -----    FACTOR M IN DEVIATION-ANGLE RULE FOR 65-(A10)-SERIES MEAN  OFFD1703
C      LINE.                                                         OFFD1704
C        FIGURE 155  NASA  SP-36                                     OFFD1705
      COMMON /SCALAR/ CQ(31),  RADIAN,   QQQ(21)                     OFFD1706
      DATA  COEF /0.170128,  -0.86649545E-4,                         OFFD1707
     X 0.32150557E-4,   -0.15519066E-5,   0.42658713E-7,             OFFD1708
     X -0.27621569E-9/                                               OFFD1709
      A=ANG*RADIAN                                                   OFFD1710
      FACTM2=COEF(1)+(COEF(2)+(COEF(3)+(COEF(4)+(COEF(5)+COEF(6)*A)*A) OFFD1711
     X *A)*A)*A                                                      OFFD1712
      RETURN                                                         OFFD1713
      END                                                            OFFD1714
```

```
 SUBROUTINE  GAM                                                        OFFD0556
 LOGICAL  CIRCLE,  SIXTY5                                               OFFD0557
 REAL             IREF,           JOULE,          MACH,                 OFFD0558
X METAL,          MIN,            MINR,           MOUT,                 OFFD0559
X MOUTR                                                                 OFFD0560
 INTEGER BLADE,                   COUNT                                 OFFD0561
 LOGICAL          OFF,            OK,             RDFLO,                OFFD0562
X RESTAR,         TONE                                                  OFFD0563
 INTEGER  RULE                                                          OFFD0564
 REAL KDEL,KDEL2                                                        OFFD0565
 COMMON  /VECTOR/                                                       OFFD0566
.ALPHA(29,11),ATAR(25,11),BETA(29,11),BH(32),BLADE(25),BT(32),CIRCLOFFD0567
.E(25),CO(32,11),CPCO(6),CR(32,11),CSLOPE(32,11),CU(32,11),CX(32,11OFFD0568
.),CXM(11),CXNEW(11),DA(10),DELM(11),DEPV(32,11),DF(20),DFLOW(32),FOFFD0569
.LOW(32),FORM(25),FOUND(20,3,10),IREF(25,11),ITYPE(25),METAL(2),METOFFD0570
.HOD(25),MIN(8,25),MINR(8,25),MOUT(8,25),MOUTR(8,25),NIN(25),NRAD(2OFFD0571
.5),NS(25),NSS(25),NTC(25),NTH(25),NXIT(25),OBAR(25,11),OFFD(25),PDOFFD0572
.(32,11),R(32,11),RAD(8,25),RADR(8,25),RCURVE(32,11),RH(32),RINT(11OFFD0573
.),RPM(1),RS(32),RSLOPE(32,11),RULE(25),SHAPE(25),SIXTY5(25),SO(8,2OFFD0574
.5),SOR(8,25),SS(8,25),SSR(8,25),TERMC(11),TH(8,25),THC(8,25),THCR(OFFD0575
.8,25),THR(8,25),TITLE(36),TO(32,11),TSTAT(11),X(32)                   OFFD0576
 COMMON  /SCALAR/                                                       OFFD0577
.A,AA,A10A0,A20A0,A30A0,A40A0,A50A0,ANG,B,BB,CC,CENT,CM,CMEAN,COFFD0578
.MEANP,CM2,COREC,COUNT,CP,CPI2,CPI3,CPI4,CPI5,CPI6,CPO2,CPO3,CPO4,COFFD0579
.PO5,DAMP,DCP,DELFLO,DFACT,EMACH,EPISON,FACTM,G,GAMMER,GASK,GJ,GR2,OFFD0580
.H,HIGH,HIPRES,I,IG,IGO,IOUTTR,IPASS,J,JJ,JM,JM1,JOULE,K,KDEL,KK,L,OFFD0581
.LAST,LC1,LEVEL,LST,LSTAGE,M,MACH,MAXPT,MINPT,N,NBLADE,NDATA,NLINESOFFD0582
.,NSETS,NSPEED,NTUBES,NX,NX1,OFF,OK,PHI,PLOW,Q,RA,RADIAN,RDFLO,REF,OFFD0583
.RESTAR,RMACH,S,SOLID,SPEED,STOP,T,TERMD,THICK,TIME,TOLAT,TOLCX,TOLOFFD0584
.MIN,TOLR,TONE,V,VMI,YES                                                OFFD0585
                                                                        OFFD0586
 CP= CPCO(1) +(CPCO(2) +(CPCO(3) +(CPCO(4) +(CPCO(5) +CPCO(6)           OFFD0587
X     *TSTAT(J) )*TSTAT(J) )*TSTAT(J) )                                 OFFD0588
X     *TSTAT(J) )*TSTAT(J)                                              OFFD0589
 GAMMER= CP/(CP -DCP)                                                   OFFD0590
 RETURN                                                                 OFFD0591
 END                                                                    OFFD0592
```

```
     HALT.        -  EFN    SOURCE STATEMENT  -  IFN(S)  -

      SUBROUTINE HALT                                                   OFFD0594
                                                                        OFFD0595
                                                                        OFFD0596
      LOGICAL   CIRCLE,   SIXTY5                                        OFFD0597
      REAL            IPFF,           JOULE,          MACH,             OFFD0598
     X METAL,         MIN,            MINR,           MOUT,             OFFD0599
     X MOUTR                                                            OFFD0600
      INTEGER BLADE,                  COUNT                             OFFD0601
      LOGICAL         OFF,            OK,             RDFLO,            OFFD0602
     X RESTAR,        TONE                                              OFFD0603
      INTEGER   RULE                                                    OFFD0604
      REAL KDEL,KDEL2                                                   OFFD0605
      COMMON   /VECTOR/                                                 OFFD0606
     .ALPHA(29,11),ATAR(25,11),BETA(29,11),BF(32),BLADE(25),BT(32),CIRCLOFFD0607
     .E(25),CC(32,11),CPCO(6),CR(32,11),CSLOPE(32,11),CU(32,11),CX(32,11OFFD0608
     .),CXM(11),CXNEW(11),DA(10),DELM(11),DEPV(32,11),DF(20),DFLOW(32),FOFFD0609
     .LOW(32),FORM(25),FOUND(20,3,10),IREF(25,11),ITYPE(25),METAL(2),METOFFD0610
     .HOD(25),MIN(8,25),MINR(8,25),MOUT(8,25),MOUTR(8,25),NIN(25),NRAD(2OFFD0611
     .5),NS(25),NSS(25),NTC(25),NTH(25),NXIT(25),OBAR(25,11),OFFD(25),PCOFFD0612
     .(32,11),R(32,11),RAD(8,25),RADR(8,25),RCURVE(32,11),RH(22),RINT(11OFFD0613
     .),RPM(1),RS(32),RSLOPE(32,11),RULE(25),SHAPE(25),SIXTY5(25),SO(8,2OFFD0614
     .5),SOR(8,25),SS(8,25),SSR(8,25),TERMC(11),TH(8,25),THC(8,25),THCR(OFFD0615
     .8,25),THR(8,25),TITLE(36),TO(32,11),TSTAT(11),X(32)               OFFD0616
      COMMON   /SCALAR/                                                 OFFD0617
     .A,AA,A1O1A0,A2O2A0,A3O3A0,A4O4A0,A5O5A0,ANG,B,BB,CC,CENT,CM,CMEAN,COFFD0618
     .MEANP,CM2,COREC,COUNT,CP,CPI2,CPI3,CPI4,CPI5,CPI6,CPO2,CPO3,CPO4,COFFD0619
     .PO5,DAMP,DCP,DELFLO,DFACT,EMACH,EPISON,FACTM,G,GAMMER,GASK,GJ,GR2,OFFD0620
     .H,HIGH,HIPRES,I,IG,IGO,IOUTTR,IPASS,J,JJ,JM,JMI,JOULE,K,KDEL,KK,L,OFFD0621
     .LAST,LC1,LEVEL,LST,LSTAGE,M,MACH,MAXPT,MINPT,N,NBLADE,NDATA,NLINESOFFD0622
     .,NSETS,NSPEED,NTUBES,NX,NX1,OFF,OK,PHI,PLOW,Q,RA,RADIAN,RDFLO,REF,OFFD0623
     .RESTAR,RMACH,S,SOLID,SPEED,STOP,T,TERMD,THICK,TIME,TOLAT,TOLCX,TOLOFFD0624
     .MIN,TOLR,TONE,V,VMI,YES                                           OFFD0625
                                                                        OFFD0626
      WRITE (6,20)                                                      OFFD0627
   20 FORMAT(1H13(1X119(1H*)/),1H035X49HEXECUTION TERMINATED AT THE END OFFD0628
     XOF TIME INTERVAL.//3(1X119(1H*)/))                                OFFD0629
C         *** REMOVE THIS PRINT AFTER INITIAL CHECK OUT                 OFFD0630
      ENTRY  MUCH                                                       OFFD0631
      CALL OUTPUT                                                       OFFD0632
      CALL   BOSS                                                       OFFD0633
      CALL EXIT                                                         OFFD0634
      RETURN                                                            OFFD0635
      END                                                               OFFD0636
```

```
      SUBROUTINE INEST
C
C     *** ESTIMATE THE VELOCITIES ALONG THE MEAN LINE
C
      COMMON /GET 11/ FOTOR(25)
      LOGICAL   CIRCLE,   SIXTY5
      REAL            IREF,           JOULE,          MACH,
     X METAL,         MIN,            MINR,           MOUT,
     X MOUTR
      INTEGER BLADE,                  COUNT
      LOGICAL         OFF,            OK,             RDFLO,
     X RESTAR,        TONE
      INTEGER   RULE
      REAL KDEL,KDEL2
      COMMON   /VECTOR/
     .ALPHA(29,11),ATAR(25,11),BETA(29,11),BH(32),BLADE(25),BT(32),CIRCL
     .E(25),CC(32,11),CPCO(6),CR(32,11),CSLOPE(32,11),CU(32,11),CX(32,11
     .),CXM(11),CXNEW(11),DA(10),DELM(11),DEPV(32,11),DF(20),DFLOW(32),FO
     .LOW(32),FORM(25),FOUND(20,3,10),IREF(25,11),ITYPE(25),METAL(?),MET
     .HOD(25),MIN(8,25),MINR(8,25),MOUT(8,25),MOUTR(8,25),NIN(25),NRAD(2
     .5),NS(25),NSS(25),NTC(25),NTH(25),NXIT(25),UBAR(25,11),OFFD(25),PO
     .(32,11),R(32,11),RAD(8,25),RADR(8,25),RCURVE(32,11),RH(32),RINT(11
     .),RPM(11),RS(32),RSLOPE(32,11),RULE(25),SHAPE(25),SIXTY5(25),SO(8,2
     .5),SCR(8,25),SS(8,25),SSR(8,25),TERMC(11),TH(8,25),THC(8,25),THCR(
     .8,25),THR(8,25),TITLE(36),TO(32,11),TSTAT(11),X(32)
      COMMON   /SCALAR/
     .A,AA,A1OAC,A2O2AO,A3O3AO,A4O4AO,A5O5AO,ANG,B,BB,CC,CENT,CM,CMEAN,C
     .MEANP,CM1,COREC,COUNT,CP,CPI2,CPI3,CPI4,CPI5,CPI6,CPO2,CPO3,CPO4,C
     .PO5,DAMP,DCP,DELFLO,DFACT,EMACH,EPISON,FACTM,G,GAMMER,GASK,GJ,GK2,
     .H,HIGH,HIPRES,I,IG,IGO,IGUTTR,IPASS,J,JJ,JM,JM1,JOULE,K,KDEL,KK,L,
     .LAST,LC1,LEVEL,LST,LSTAGE,M,MACH,MAXPT,MINPT,N,NBLADE,NDATA,NLINES
     .,NSETS,NSPEED,NTUBES,NX,NX1,OFF,OK,PHI,PLOW,Q,RA,RADIAN,RDFLO,REF,
     .RESTAR,RMACH,S,SOLID,SPEED,STOP,T,TERMD,THICK,TIME,TOLAT,TOLCX,TOL
     .MIN,TOLR,TONE,V,VMI,YES
      PI= 3.141593
      LOGICAL   DONE
      DONE= .FALSE.
      ROSTAG= PO(1,1)/GASK/TO(1,1)
      TSTAT(JM)= TO(1,1)
      VX= 500.0
      J=JM
      CALL   GAM
      MACH= SQRT(GK2*GAMMER*TSTAT(JM))
      GA= (GAMMER -1.0)*0.5
      GAR= GAMMER/(GAMMER -1.0)
C
C     *** CALCULATE AN ESTIMATE OF THE MEAN AXIAL VELOCITY
C         IN THE MACHINE ENTRANCE
C
      DO 50 I=1,5
      A= PI*(RS(I)**2 -RH(I)**2)
      DO 40 K=1,25
      CX(I,JM)= FLOW(I)/A/ROSTAG/(1.0 -GA*(VX/MACH)**2)**(0.5/GA)
      IF (ABS((VX-CX(I,JM))/VX).LT.TOLCX) GO TO 50
      VX= CX(I,JM)
```

```
   60 CONTINUE
      CALL ERROR(1)
   70 CONTINUE

C         *** SET THE MEAN LINE INDEX TO THE WORKING STREAMLINE INDEX

      J= JM

C         *** ESTIMATE THE MEAN AXIAL VELOCITY THROUGH THE BLADE ROWS

      DO 80 I=3,LSTAGE
      IF (ROTOR(I-4).EQ.0.0) GO TO 70
      L= I+1
      CX(I,JM)= VX
      METAL(1)= SLINE(R(I-1,JM),MINR(1,I-4),MIN(1,I-4),NIN(I-4))
      METAL(2)= SLINE(R(I,JM),MOUTR(1,I-4),MOUT(1,I-4),NXIT(I-4))
      SOLID=    SLINE(R(I-1,JM),SOR(1,I-4),SO(1,I-4),NS(I-4))

C         *** ADD THE DEVIATION TO THE EXIT METAL ANGLE AND
C             DETERMINE THE TANGENT OF THE FLOW ANGLE

      DEV= TAN(.25*(METAL(1)-METAL(2))/SQRT(SOLID)+ METAL(2))
      A= PI*(R(I,NLINES)**2 -R(I,1)**2)
      IF (ROTOR(I-4)) 66, 70, 51
   51 CONTINUE
      DO 60 K=1,25

C         *** CALCULATE THE TANGENTIAL VELOCITY

      CU(I,JM)= -VX*DEV +RPM(N)*R(I,JM)

C         *** COMPUTE THE TOTAL TEMPERATURE

      TO(I,JM)= TO(I-1,JM) +2.0*RPM(N)*(CU(I,JM)*R(I,JM) -CU(I-1,JM)*
     X R(I-1,JM))/GJ/CP

C         *** EVALUATE THE SPECIFIC HEAT AT THIS TEMPERATURE


C         *** COMPUTE THE TOTAL TEMPERATURE

      PO(I,JM)= PO(I-1,J)*(0.9*(TO(I,JM) -TO(I-1,JM))/TO(I-1,JM) +1.0)
     X  **GAR
C -----   SET THE FIRST ROTOR EXIT AXIAL VELOCITY DOWNSTREAM.
      IF (DONE)  GO TO 80

C         *** CALCULATE THE DENSITY

C         *** ESTIMATE DENSITY
      ROSTAG= PO(I,JM)/GASK/TO(I,JM)
      V= SQRT(VX**2 + CU(I,JM)**2)
      H= -V*V/GJ
      T= TO(I,JM)
      CALL ENTALP
C         *** ESTIMATE MACH NUMBER
      MACH= SQRT( GR2*GAMMER*TSTAT(JM))
```

```
C        *** ESTIMATE THE AXIAL VELOCITY

      ROSTAG= ROSTAG/(1.0+ 0.5*(GAMMER -1.0)*(V/MACH)**2)**(1.0
     X  /(GAMMER -1.0))
      CX(I,JM)= FLOW(I)/A/ROSTAG
      IF (ABS((VX -CX(I,JM))/VX).LT.TOLCX)  GO TO 51
      VX= CX(I,JM)
   49 CONTINUE
      CALL ERROR(11)
   51 DONE= .TRUE.
      GO TO 80

   56 CONTINUE
      TO(I,JM)= TO(I-1,JM)

C        *** ESTIMATE PRESSURE

      PO(I,JM)= PO(I-1,JM)
      DO 68 K=1,25

C        *** ESTIMATE WHIRL VELOCITY

      CU(I,JM)= VX*DEV
      IF (DONE)  GO TO 80

C        *** ESTIMATE TOTAL VELOCITY

      V= SQRT(VX**2 +CU(I,JM))


C        *** ESTIMATE AXIAL VELOCITY

      CX(I,JM)= FLOW(I)/A/ROSTAG/(1.0 -GA*(V/MACH)**2)**(0.5/GA)
      IF (ABS((VX -CX(I,JM))/VX).LT.TOLCX)  GO TO 80
      VX= CX(I,JM)
   68 CONTINUE
      CALL ERROR(17)
   70 CX(I,JM)= CX(I-1,JM)
      CU(I,JM)= CU(I-1,JM)*R(I-1,JM)/R(I,JM)
      TO(I,JM)= TO(I-1,JM)
      PO(I,JM)= PO(I-1,JM)
   80 CONTINUE

C        *** ESTIMATE EXIT PROPERTIES

      K=LSTAGE+1
      DO 90 I=K,NX
      TO(I,JM)=TO(I-1,JM)
      PO(I,JM)=PO(I-1,JM)
      CU(I,JM)= CU(I-1,JM)*R(I-1,JM)/R(I,JM)
      CX(I,JM)= VX
   89 CONTINUE
   90 CONTINUE

C        *** SET THE VELOCITIES AND OTHER FLOW PARAMETERS AT ALL
```

05/02/65

```
   ISN.ST.      -  EFN   SOURCE STATEMENT  -  IFN(S)  -

C             POSITIONS                                              0FFD1477
                                                                     0FFD1478
      DO 100 I=1,NX                                                  0FFD1479
      DO 100 J=1,NLINES                                              0FFD1480
      CX(I,J)= CX(I,JM)                                              0FFD1481
      CU(I,J)=CU(I,JM)*R(I,JM)/R(I,J)                                0FFD1482
      TO(I,J)= TO(I,JM)                                              0FFD1483
      PO(I,J)= PO(I,JM)                                              0FFD1484
  100 CONTINUE                                                       0FFD1485
                                                                     0FFD1486
C        *** SET INDICATOR SO THAT THIS ROUTINE WILL NOT BE USED     0FFD1487
C            AGAIN FOR THIS DATA SET                                 0FFD1488
                                                                     0FFD1489
  110 RETURN                                                         0FFD1490
      END                                                            0FFD1491
```

```
      SUBROUTINE INPUT
      COMMON /GET IT/ ROTOR(20)
      LOGICAL  CIRCLE,  SIXTY5
      REAL            IREF,            JOULE,          MACH,
     X METAL,         MIN,             MINR,           MOUT,
     X MOUTR
      INTEGER BLADE,                   COUNT
      LOGICAL         OFF,             OK,             RDFLO,
     X RESTAR,        TONE
      INTEGER  RULE
      REAL KDEL,KDEL2
      COMMON  /VECTOR/
     .ALPHA(29,11),ATAR(25,11),BETA(29,11),BH(32),BLADE(25),BI(32),CIRCL
     .E(25),CO(32,11),CPCO(5),CR(32,11),CSLOPE(32,11),CU(32,11),CX(32,11
     .),CXM(11),CXNEW(11),DA(10),DELH(11),DEPV(32,11),DF(20),DFLOW(32),F
     .LOW(32),FORM(25),FOUND(20,3,10),IREF(25,11),ITYPE(25),METAL(2),MET
     .COD(25),MIN(8,25),MINR(8,25),MOUT(8,25),MOUTR(8,25),NIN(25),NRAD(2
     .0),NS(25),NSS(25),NTC(25),NTH(25),NXIT(25),OBAR(25,11),OFFD(25),PO
     .(32,11),R(32,11),RAD(8,25),RADR(8,25),RCURVE(32,11),RH(32),RINT(11
     .),RPM(1),RS(32),RSLOPE(32,11),RULE(25),SHAPE(25),SIXTY5(25),SO(8,2
     .5),SOR(3,25),SS(8,25),SSF(8,25),TERMC(11),TH(8,25),THC(8,25),THCP(
     .8,25),THR(8,25),TITLE(26),TO(32,11),TSTAT(11),X(32)
      COMMON  /SCALAR/
     .A,AA,A1OAC,A2O2AC,A3O3AC,A4O4AC,A5O5AC,ANG,B,BB,CC,CENT,CM,CMEAN,C
     .MEANP,CMS,COREC,COUNT,CP,CPI2,CPI3,CPI4,CPI5,CPI6,CPO2,CPO3,CPO4,C
     .PO5,DAMP,DCP,DELFLO,DFACT,EMACH,EPISON,FACTM,G,GAMMER,GASK,GJ,GR2,
     .H,HIGH,HIPRES,I,IG,IGO,IOUTTR,IPASS,J,JJ,JM,JM1,JOULE,K,KDEL,KK,L,
     .LAST,LC1,LEVEL,LST,LSTAGE,M,MACH,MAXPT,MINPT,N,NBLADE,NDATA,NLINES
     .,NSETS,NSPEED,NTUBES,NX,NX1,OFF,OK,PHI,PLOW,Q,RA,RADIAN,RDFLO,REF,
     .RESTAR,RMACH,S,SOLID,SPEED,STOP,T,TERMC,THICK,TIME,TOLAT,TOLCX,TOL
     .MIN,TOLR,TONE,V,VMI,YES

      DIMENSION CHECK(5)
      DATA CHECK / 4H65-S, 4HCIRC, 4HINCI, 4HDEVI, 4HBOTH /
      INTEGER   DA
      INTEGER   TERMC
      REAL   MOLEWT
      DIMENSION   WORD(7), NOTE(5,3)
      DATA WORD / 4HSTAT, 4HANNU, 4HROTO, 4H2-D , 4H3-D , 4HSUCT,
     X 4HTABL  /
      DATA   NOTE /
     X 4HN IN, 4HLET , 4HGUID, 4HE VA, 4HNE   ,
     X 4H ROT, 4HOR. , 4H    , 4H    , 4H    ,
     X 4H STA, 4HTOR., 4H    , 4H    , 4H    /
      NAMELIST /DSTART/ DATAIN
   10 READ (5,DSTART)
C
C        *** READ THE JOB TITLE, NECESSARY FOR JOB DESCRIPTION
C
      READ (5,1001) TITLE
C ----   READ THE SPECIFIC HEAT COEFFICIENTS.
      READ (5,1000) CPCO
 1000 FORMAT(3E20.8)
C
C        *** CALCULATE THE COEFFICIENTS NEEDED IN THE VARIOUS
```

```
C              OPERATIONS INVOLVING CP
C
      CPO2=CPCO(3)/2.
      CPO3=CPCO(4)/3.
      CPO4=CPCO(5)/4.
      CPO5=CPCO(6)/5.
      A1CAO=CPCO(2)/CPCO(1)
      A2C2AO=CPO2/CPCO(1)
      A3C3AO=CPC3/CPCO(1)
      A4C4AO=CPO4/CPCO(1)
      A5C5AO=CPC5/CPCO(1)
      CPINTG= THERM3(518.688)
      CPI2=CPCO(2)/2.
      CPI3=CPCO(3)/3.
      CPI4=CPCO(4)/4.
      CPI5=CPCO(5)/5.
      CPI6=CPCO(6)/6.
 1001 FORMAT (12A5)
      KK=1
   20 REWIND 4
C
C         *** READ THE SCALER INFORMATION
C
      READ (5,1003) NX, NLINES, NSPEED, MAXPT, MINPT, RESTAR, ICUTTR,
     X   IDUMP, LEVEL, ROFLD
      LSTAGE= NX-3
      NBLADE= LSTAGE-4
      READ (5,1014) SPEED, STOP,TOCO,POCO,TOLCX,EPISCN,TOLR,TOLCP,TOLAT,
     1   TOLMIN,MOLEWT,DAMP
      KK=KK-1
C
C         *** CALCULATE FLUID CONSTANTS
C
      GASK= G/MOLEWT
      GR= 64.348*GASK
      GR2= GR**.5
 1003 FORMAT (5I5,L5,3I5,L5)
C
C         *** TEST THE INPUT DATA FOR REASONABLE NUMBERS
C
      IF (POCO.LE.0.0.OR.TOCO.LE.0.0) CALL ERROR(10)
C
C         *** THE NUMBER OF STREAMLINES MUST BE 5,7,9 OR 11, ERROR
C              WILL TERMINATE EXECUTION
C
      IF (NLINES.LT.5.OR.NLINES.GT.11.OR.MOD(NLINES,2).EQ.0)
     X  CALL  ERROR (6)
C
C         *** CALCULATE INTEGER CONSTANTS
C
      JM1= NLINES/2
      JM= JM1+1
      NTUBES= NLINES-1
      LAST=LSTAGE-1
      NX1 = NX-1
C
```

```
C        *** SET DERIVATIVES AT ENTRANCE AND EXIT
C
      DO 50 J=1,11
      CSLOPE(1,J)= 0.
      FSLOPE(NX,J)=0.
      CSLOPE(NX,J)=0.
      FSLOPE(1, J)=0.
      FCURVE(1, J)=0.
   50 FCURVE(NX,J)=0.
C        *** READ THE FRACTION MASS FLOW BETWEEN THE HUB AND THE J-TH
C            STREAMLINE. THESE NUMBERS MUST INCREASE MONOTONICALLY
      READ (5,1014) (DELM(J),J=1,NLINES)
C
      K=ISTAGE + 1
      DO 40 I=1,NX
      DFLOW(I)= 1.0
C
C        *** READ THE MACHINE GEOMETRY AND BOUNDARY LAYER
C            BLOCKAGE FACTORS
C
      READ (5,1014) X(I), RH(I), BH(I), RS(I), BT(I)
C        *** CHECK ON THE BLOCKAGE FACTORS AT TIP AND HUB
      IF (BT(I).LT.0.0) CALL ERROR(14)
      IF (BH(I).LT.0.0) CALL ERROR(20)
   40 CONTINUE
C
C        *** PRINT THE INPUT AND CONVERT TO THE PROPER UNITS
C
      CALL DATE(DA)
      WRITE (6,1004) (DA(I),I=1,2)
 1004 FORMAT (1H1111X2A4)
      WRITE (6,1005) TITLE,  NX,      NLINES,
     X        SPEED,  TOCO,   POCO,   MOLEWT, DAMP,    TOLCX,  EPISON,
     X        TOLR,   TOLCP,  TOLAT,  STOP,   TOLMIN, CPCO,
     X        (DELM(J),J=1,NLINES)
 1005 FORMAT(1H0/////20X5(1H-),74H P E R F O R M A N C E   A N A L Y S I
     XS   O F   M U L T I S T A G E -----18X3H036//20X14(1H-),31H A X I
     XA L - F L O W   C O M P R E S S O R S   A T 14(1H-)//20X18(1H-),40
     X3H O F F - D E S I G N   C O N D I T I O N S 18(1H-)//3(20X4H--- 1
     X2A6,3H---//),10X9HTHERE ARE13,14H STATIONS.    28X35HCALCULATIONS
     XARE TO BE PERFORMED AT13,12H STREAMLINES//
     X                                      10X19HTHE DESIGN SPE
     XED ISF8.1,7H R.P.M.//10X29HTHE INLET TOTAL TEMPERATURE =F7.2,9H DE
     XG.S.R. 9X26HTHE INLET TOTAL PRESSURE =F7.4,12H (LB/SQ IN.)//10X
     X23HTHE MOLECULAR WEIGHT ISF7.2,24X29HTHE ITERATION WEIGHT FACTOR =
     XF5.1//10X30HTHE AXIAL VELOCITY TOLERANCE =F6.3,18X35HTHE MINIMUM W
     XEIGHT FLOW INCREMENT =F6.3,10H (LB/SEC.)//10X26HTHE CONTINUITY TOL
     XERANCE =F7.4,21X32HTHE TEMPERATURE RISE TOLERANCE =F7.4//10X
     X32HTHE TOLERANCE ON EFFICIENCY IS  F6.3,16X23HA HALT WILL OCCUR AF
     XTERF6.1, 8H MINUTES//10X24HTHE ENTHALPY TOLERANCE = F7.4 /
     X//33X53HTHE SPECIFIC HEAT POLYNOMIAL IS IN THE FOLLOWING FORM//3X4
     XHCP =E12.5,3H + E12.5,5H*T + E12.5,8H*T**2 + E12.5,8H*T**3 + E12.5
     X,8H*T**4 + E12.5,5H*T**5///10X79HTHE FRACTION OF THE TOTAL MASS FL
     XOW BETWEEN THE HUB AND THE J-TH STREAMLINE IS. //10X11F7.3)
      WRITE (6,1006) (I,X(I),RH(I),RS(I),BH(I),BT(I),I=1,NX)
 1006 FORMAT (1H1////43X33(1H*)/43X1H*31X1H*/43X33H* A N N U L U S   P RO
```

```
     X ' F I L E */43X1H*31X1H*/43X33(1H*)///8X7HSTATION6X5HAXIAL14X
     X 4HHUB  14X  4HTIP
     X     ,10X12HHUB BLOCKAGE6X12HTIP BLOCKAGE/19X10HCOORDINATE2(10X8HR
     XADIUS  ),2(10X8HFACTOR  )//(I12,F16.5,2F18.5,F17.4,F18.4 //))
      KI= 0
      KK= 0
C -----   READ AND DECODE THE INPUT DATA.
      DO 220 I=1,NBLADE
 1007 FORMAT (16I5)
      READ (5,1008) ROTOR(I), BLADE(I), OFFD(I), AA, BB, CC, DD,
     X    FORM(I), SHAPE(I), DFLOW(I+4)
      IF (FORM(I).LE.0.0)  FORM(I)= 1.0
      IF (SHAPE(I).LE.0.0) SHAPE(I)=1.0
 1008 FORMAT (A4, 6X 2I5, 4(A4, 6X), 2F10.4 / F10.4 )
      IF (ROTOR(I).EQ.WORD(1))  ROTOR(I)= -1.0
      IF (ROTOR(I).EQ.WORD(2))  ROTOR(I)=  0.0
      IF (ROTOR(I).EQ.0.0)  GO TO 220
      IF (ROTOR(I).EQ.WORD(3))  ROTOR(I)=  1.0
      L= 3
      IF (ROTOR(I).GT.0.0)  L= 2
      WRITE (6,1018) I,(NOTE(J,L),J=1,5)
      SIXTY5(I)= .FALSE.
C -----   CHECK FOR A 65-SERIES BLADE.
      IF (BB.NE.CHECK(1))  GO TO 60
      WRITE (6,1009)
 1009 FORMAT (/ 5X 26HTHESE ARE 65-SERIES BLADES )
      SIXTY5(I)= .TRUE.
   60 CIRCLE(I)= .FALSE.
C -----   CHECK FOR A CIRCULAR ARC MEAN LINE.
      IF (CC.NE.CHECK(2))  GO TO 70
      WRITE (6,1010)
 1010 FORMAT (/ 5X 36HTHESE BLADES ARE DOUBLE-CIRCULAR-ARC )
      CIRCLE(I)= .TRUE.
C -----   INITIALIZE THE 3-D CORRECTION TRIGGER TO NO CORRECTION.
   70 RULE(I)= 1
C -----   CHECK FOR AN INCIDENCE CORRECTION.
      IF (DD.NE.CHECK(3))  GO TO 80
      RULE(I)= 2
      WRITE (6,1011)
 1011 FORMAT (/ 5X 58HAN INCIDENCE CORRECTION WILL BE MADE IN THE DEVIAT
     XION RULE )
C -----   CHECK FOR A DEVIATION CORRECTION.
      GO TO 100
   80 IF (DD.NE.CHECK(4))  GO TO 90
      RULE(I)= 3
      WRITE (6,1012)
 1012 FORMAT (/ 5X 52HTHE DEVIATION RULE WILL BE CORRECTED FOR 3-D EFFEC
     XTS )
      GO TO 100
C -----   CHECK FOR BOTH A DEVIATION AND AN INCIDENCE CORRECTION.
   90 IF (DD.NE.CHECK(5))  GO TO 100
      RULE(I)= 4
      WRITE (6,1011)
      WRITE (6,1012)
  100 CONTINUE
      IF (BLADE(I).LE.0.OR.BLADE(I).GT.IG)  BLADE(I)= 1
```

```
C -----   PICK UP THE APPROPRIATE LOSS DATA SET.  IF NO CORRESPONDING
C         DATA SET CAN BE FOUND USE THE FIRST ONE.
      IF (KK.EQ.0)  GO TO 120
      DO 110 J=1,KK
      IF (TERMC(J).EQ.BLADE(I))  GO TO 150
  110 CONTINUE
      IF (KK.NE.10)  GO TO 120
      BLADE(I)= 1
      JJ= TERMC(1)
      GO TO 150
  120 KK= KK+1
      TERMC(KK)= BLADE(I)
      JJ=        BLADE(I)
      BLADE(I)=  KK
  130 KI= KI +1
      IF (KI.LE.IG)  GO TO 140
      REWIND 4
      KI= 0
      GO TO 130
C
C        *** READ LOSS DATA FROM MASTER TAPE
C
  140 READ (4)  ((FOUND(K,J,KK),K=1,20),J=1,3)
      IF (KI.NE.TERMC(KK))  GO TO 130
      GO TO 160
  150 BLADE(I)= J
  160 CONTINUE
      WRITE (6,1019) DFLOW(I+4)
      WRITE (6,1020) BLADE(I)
      WRITE (6,1013) SHAPE(I)
 1013 FORMAT (/ 5X 28HTHE DEVIATION SHAPE FACTOR = F5.2 )
      READ (5,1007)  NIN(I)
      N= NIN(I)
      JJ= BLADE(I)
 1014 FORMAT (8F10.4)
C -----   READ THE INLET METAL ANGLE TABLE.
      READ (5,1014)  (MIN(J,I),J=1,N)
      WRITE (6,1022) (MIN(J,I),J=1,N)
      READ (5,1014)  (MINR(J,I),J=1,N)
      WRITE (6,1023) (MINR(J,I),J=1,N)
C -----   READ THE EXIT METAL ANGLE TABLE.
      READ (5,1007)  NXIT(I)
      N= NXIT(I)
      READ (5,1014)  (MOUT(J,I),J=1,N)
      WRITE (6,1024) (MOUT(J,I),J=1,N)
      READ (5,1014)  (MOUTR(J,I),J=1,N)
      WRITE (6,1023) (MOUTR(J,I),J=1,N)
C -----   READ THE THICKNESS TO CHORD TABLE.
      READ (5,1007)  NTC(I)
      N= NTC(I)
      READ (5,1014)  (THC(J,I),J=1,N)
      WRITE (6,1025) (THC(J,I),J=1,N)
      READ (5,1014)  (THCR(J,I),J=1,N)
      WRITE (6,1023) (THCR(J,I),J=1,N)
C -----   READ THE THROAT TO SPACING TABLE.
      READ (5,1007)  NTH(I)
```

```
      N= NTH(I)
      READ (5,1014)  (TH(J,I),J=1,N)
      WRITE (6,1025) (TH(J,I),J=1,N)
      READ (5,1014)  (THR(J,I),J=1,N)
      WRITE (6,1023) (THR(J,I),J=1,N)
C -----    READ THE SOLIDITY TABLE.
      READ (5,1007)  NS(I)
      N= NS(I)
      READ (5,1014)  (SO(J,I),J=1,N)
      WRITE (6,1027) (SO(J,I),J=1,N)
      READ (5,1014)  (SOR(J,I),J=1,N)
      WRITE (6,1023) (SOR(J,I),J=1,N)
      READ (5,1007)  NSS(I)
      N= NSS(I)
      READ (5,1014)  (SS(J,I),J=1,N)
      READ (5,1014)  (SSR(J,I),J=1,N)
      WRITE (6,1028) (SS(J,I),J=1,N)
      WRITE (6,1023) (SSR(J,I),J=1,N)
      IF (AA.EQ.WORD(4))  METHOD(I)= 1
      IF (AA.EQ.WORD(5))  METHOD(I)= 2
      IF (AA.EQ.WORD(6))  METHOD(I)= 3
      IF (AA.EQ.WORD(7))  METHOD(I)= 4
C -----    READ THE RADIUS TO THICKNESS OR REFERENCE INCIDENCE TABLE.
      IF (METHOD(I).LE.2)  GO TO 200
      READ (5,1007)  NRAD(I)
      N= NRAD(I)
      READ (5,1014)  (RAD(J,I),J=1,N)
      READ (5,1014)  (RADR(J,I),J=1,N)
      IF (METHOD(I).EQ.4)  GO TO 170
      WRITE (6,1016) (RAD(J,I),J=1,N)
      GO TO 190
  170 WRITE (6,1015) (RAD(J,I),J=1,N)
 1015 FORMAT (// 5X 18HREF. INCIDENCE      8F10.2)
      DO 180 J=1,N
  180 RAD(J,I)= RAD(J,I)/RADIAN
 1016 FORMAT (// 5X 18HRADIUS/THICKNESS  8F10.3)
  190 CONTINUE
      WRITE (6,1023) (RADR(J,I),J=1,N)
      GO TO 205
  200 LK= METHOD(I) +3
      WRITE (6,1029) WORD(LK)
 1029 FORMAT (// 5X 41HREFERENCE INCIDENCE DETERMINED FROM NASA  A4,
     X 11HCORRELATION )
  205 DO 210 J=1,8
      MIN(J,I)= MIN(J,I)/RADIAN
      MOUT(J,I)= MOUT(J,I)/RADIAN
  210 CONTINUE
  220 CONTINUE
C
C         *** SET INLET PARAMETERS
C
      DO 230 I=1,NX
      DO 230J=1,NLINES
      CR(I,J)=0.0
      CU(I,J)= 0.0
      TO(I,J)= TOCO
```

```
      PO(I,J)= POCO                                                     OFFD1208
  230 CONTINUE                                                          OFFD1209
      DO 240 I=1,KK                                                     OFFD1210
  240 WRITE (6,1017)(FRMC(I),(DF(J),(FOUND(J,K,I),K=1,3),J=1,20)        OFFD1211
 1017 FORMAT (1H1///////43X 25H.... LOSS DATA SET NUMBERI3,5H ..../////  OFFD1212
     X  9X  8HD-FACTOR 10X 13HAT 10 PERCENT 10X 13HAT 50 PERCENT 10X    OFFD1213
     X 13HAT 90 PERCENT 5X 21H(OF BLADE HEIGHT FROM / 92X 18HTHE GEOMETROFFD1214
     XIC HUB)/ 20(F17.3,F18.4,2F23.4/))                                 OFFD1215
C                                                                       OFFD1216
C        *** DETERMINE THE TIME AT WHICH EXECUTION SHOULD CEASE         OFFD1217
C                                                                       OFFD1218
      CALL TIMEI(TIME)                                                  OFFD1219
      STOP=STOP*3600. + TIME                                            OFFD1220
C -----   CALCULATE BLADE SPACING.                                      OFFD1221
      DO 250 I=1,NX1                                                    OFFD1222
  250 X(I)= X(I+1) -X(I)                                                OFFD1223
      DONE=.TRUE.                                                       OFFD1224
C                                                                       OFFD1225
C        *** CONVERT SPEED TO PROGRAM UNITS                             OFFD1226
C                                                                       OFFD1227
      SPEED= SPEED*.10471976                                            OFFD1228
      SPEED= SPEED/12.0                                                 OFFD1229
      N=1                                                               OFFD1230
C                                                                       OFFD1231
C        *** ESTIMATE STREAMLINE POSITION                               OFFD1232
C                                                                       OFFD1233
      CALL RSTART                                                       OFFD1234
      DCP= GASK/JOULE                                                   OFFD1235
      J=1                                                               OFFD1236
      TSTAT(1)= TOCO                                                    OFFD1237
      CALL  GAM                                                         OFFD1238
      NDATA= 0                                                          OFFD1239
      IF (LEVEL.EQ.1)  CALL  READ                                       OFFD1240
      RETURN                                                            OFFD1241
 1018 FORMAT (1H1////// 5X 16HBLADE ROW NUMBER I3, 5H IS A 5A4)         OFFD1242
 1019 FORMAT(/5X59HTHE RATIO OF THE MASS FLOW RATE OUT OF THE BLADE ROW OFFD1243
     XTO THE /  5X 35HMASS FLOW RATE INTO THE BLADE ROW = F5.3)         OFFD1244
 1020 FORMAT (/ 5X 20HLOSS DATA SET NUMBER I3, 29H WILL BE USED FOR THISOFFD1245
     X BLADE.)                                                          OFFD1246
 1022 FORMAT (// 5X 18HBLADE INLET ANGLE  8F10.2 )                      OFFD1247
 1023 FORMAT (/ 5X 15HRADIUS (INCHES) 3X  8F10.3 )                      OFFD1248
 1024 FORMAT (// 5X 18HBLADE EXIT ANGLE   8F10.2 )                      OFFD1249
 1025 FORMAT (// 5X17HMAXIMUM THICKNESS/ 5X 12HTO THE CHORD 6X 8F10.4)  OFFD1250
 1026 FORMAT (// 5X 14HPASSAGE THROAT 4X  8F10.3 )                      OFFD1251
 1027 FORMAT (// 5X 14HBLADE SOLIDITY 4X  8F10.4 )                      OFFD1252
 1028 FORMAT (// 5X 18HSUPERSONIC TURNING  8F10.3 )                     OFFD1253
      END                                                               OFFD1254
```

```
      SUBROUTINE INTEG (VDEP,IFCON)

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

      LOGICAL  CIRCLE,  SIXTY5
      REAL            IREF,            JOULE,           MACH,
     X METAL,         MIN,             MINR,            MOUT,
     X MOUTR
      INTEGER BLADE,                   COUNT
      LOGICAL         OFF,             OK,              ROFLO,
     X RESTAR,        TONE
      INTEGER  RULE
      REAL KDEL,KDEL2
      COMMON   /VECTOR/
     .ALPHA(29,11),ATAR(25,11),BETA(29,11),BH(32),BLADE(25),BT(32),CIRCL
     .E(25),CO(32,11),CPCO(6),CR(32,11),CSLOPE(32,11),CU(32,11),CX(32,11
     .),CXM(11),CXNEW(11),DA(10),DELM(11),DEPV(32,11),DF(20),DFLOW(32),F
     .LOW(32),FORM(25),FOUND(20,3,10),IREF(25,11),ITYPE(25),METAL(2),MET
     .HOD(25),MIN(8,25),MINR(8,25),MOUT(8,25),MOUTR(8,25),NIN(25),NRAD(2
     .5),NS(25),NSS(25),NTC(25),NTH(25),NXIT(25),OBAR(25,11),OFFD(25),PU
     .(32,11),R(32,11),RAD(8,25),RADR(8,25),RCURVE(32,11),RH(32),RINT(11
     .),RPM(1),RS(32),RSLOPE(32,11),RULE(25),SHAPE(25),SIXTY5(25),SO(8,2
     .5),SOR(8,25),SS(8,25),SSR(8,25),TERMC(11),TH(8,25),THC(8,25),THCR(
     .8,25),THR(8,25),TITLE(36),TO(32,11),TSTAT(11),X(32)
      COMMON   /SCALAR/
     .A,AA,A10A0,A202A0,A303A0,A404A0,A505A0,ANG,B,BB,CC,CENT,CM,CMEAN,C
     .MEANP,CM2,COREC,COUNT,CP,CPI2,CPI3,CPI4,CPI5,CPI6,CPO2,CPO3,CPO4,C
     .PO5,DAMP,CCP,DELFLO,DFACT,EMACH,EPISON,FACTM,G,GAMMER,GASK,GJ,GR2,
     .H,HIGH,HIPRES,I,IG,IGO,ICUTTR,IPASS,J,JJ,JM,JM1,JOULE,K,KDEL,KK,L,
     .LAST,LC1,LEVEL,LST,LSTAGE,M,MACH,MAXPT,MINPT,N,NBLADE,NDATA,NLINES
     .,NSETS,NSPEED,NTUBES,NX,NX1,OFF,OK,PHI,PLOW,Q,RA,RADIAN,RDFLO,REF,
     .RESTAR,RMACH,S,SOLID,SPEED,STOP,T,TERMD,THICK,TIME,TOLAT,TOLCX,TOL
     .MIN,TOLR,TONE,V,VMI,YES
      DIMENSION  VDEP(32,11)
      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(I,J)*R(I,J)+VDEP(I,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(I,J)+VDEP(I,J+1))*(R(I,J+1)-R(I,J))*.5
  115 RINT(J+1)= RINT(J) +DA(J)
  150 B= RINT(JM)
      DO 200 J=1,NLINES
  200 RINT(J)= RINT(J)-B
      RETURN
```

```
END                                                         OFF00818
```

```
                                                                        05/02/68
      K[illegible]EL2.      -  EFN    SOURCE STATEMENT   -   IFN(S)   -

   [illegible]L FUNCTION KOEL2(ANG)                                      0FFD02269
   [illegible]NSION COEF(6)                                              0FFD02270
  [illegible]ATA  C[illegible]EF /-0.22513.9E-[illegible], 8.432497,     0FFD02271
 [illegible]1[illegible]33,        1[illegible]23.7[illegible]49,      -13802.383,  0FFD02272
 [illegible]51[illegible],10[illegible]/                                 0FFD02273
  [illegible]=[illegible]G                                               0FFD02274
  K[illegible]L[illegible] =[illegible]EF(1)+(C[illegible]EF(2)+(C[illegible]EF(3)+(COEF(4)+(COEF(5)+COEF(6)*A)*A)  0FFD02275
 [illegible]A)*A)*A                                                      0FFD02276
 [illegible]URN                                                          0FFD02277
  [illegible]                                                            0FFD02278
```

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

C -----   OBTAINS LOSS PARAMETERS FROM THE INPUT MAPS AS A FUNCTION OF
C      D-FACTOR AND PERCENT BLADE HEIGHT FROM THE ROOT.
      LOGICAL  CIRCLE,  SIXTY5
      REAL            IREF,            JOULE,           MACH,
     X METAL,         MIN,             MINR,            MOUT,
     X MOUTR
      INTEGER BLADE,                   COUNT
      LOGICAL         OFF,             OK,              RDFLO,
     X RESTAR,        TONE
      INTEGER  RULE
      REAL KDEL,KDEL2
      COMMON  /VECTOR/
     .ALPHA(29,11),ATAK(25,11),BETA(29,11),BH(32),BLADE(25),BT(32),CIRCL
     .E(25),CO(32,11),CPCO(6),CR(32,11),CSLOPE(32,11),CU(32,11),CX(32,11
     .),CXM(11),CXNEW(11),DA(10),DELM(11),DEPV(32,11),DF(20),DFLOW(32),F
     .LOW(32),FORM(25),FOUND(20,3,10),IREF(25,11),ITYPE(25),METAL(2),MET
     .HOD(25),MIN(8,25),MINR(8,25),MOUT(8,25),MOUTR(8,25),NIN(25),NRAD(2
     .5),NS(25),NSS(25),NTC(25),NTH(25),NXIT(25),OBAR(25,11),OFFD(25),PO
     .(32,11),R(32,11),RAD(8,25),RADR(8,25),RCURVE(32,11),RH(32),RINT(11
     .),RPM(1),RS(32),RSLOPE(32,11),RULE(25),SHAPE(25),SIXTY5(25),SO(8,2
     .5),SOR(8,25),SS(8,25),SSR(8,25),TERMC(11),TH(8,25),THC(8,25),THCR(
     .8,25),THR(8,25),TITLE(36),TO(32,11),TSTAT(11),X(32)
      COMMON  /SCALAR/
     .A,AA,A1OA0,A2O2A0,A3O3A0,A4O4A0,A5O5A0,ANG,B,BB,CC,CENT,CM,CMEAN,C
     .MEANP,CM2,COREC,COUNT,CP,CPI2,CPI3,CPI4,CPI5,CPI6,CPO2,CPO3,CPO4,C
     .PO5,DAMP,DCP,DELFLO,DFACT,EMACH,EPISON,FACTM,G,GAMMER,GASK,GJ,GR2,
     .H,HIGH,HIPRES,I,IG,IGO,IOUTTR,IPASS,J,JJ,JM,JM1,JOULE,K,KDEL,KK,L,
     .LAST,LC1,LEVEL,LST,LSTAGE,M,MACH,MAXPT,MINPT,N,NBLADE,NDATA,NLINES
     .,NSETS,NSPEED,NTUBES,NX,NX1,OFF,OK,PHI,PLOW,Q,RA,RADIAN,RDFLO,REF,
     .RESTAR,RMACH,S,SOLID,SPEED,STOP,T,TERMD,THICK,TIME,TOLAT,TOLCX,TOL
     .MIN,TOLR,TONE,V,VMI,YES

      INTEGER TYPE, FIRST
      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
      LOSE= FCT1 +6.25*DEL*(PERHT -0.5)**2
      RETURN
      END
```

```
      SUBROUTINE LOSS
C ----- ESTIMATE THE BLADE ROW LOSSES
      COMMON /GET IT/ ROTOR(29)
      COMMON /FULL/  BUCKET, NOW
      LOGICAL  CIRCLE,  SIXTY5
      REAL             IREF,            JOULE,           MACH,
     X METAL,          MIN,             MINR,            MOUT,
     X MOUTR
      INTEGER BLADE,                    COUNT
      LOGICAL          OFF,             OK,              RDFLO,
     X RESTAR,         TONE
      INTEGER  RULE
      REAL KDEL,KDEL2
      COMMON  /VECTOR/
     .ALPHA(29,11),ATAR(25,11),BETA(29,11),BH(32),BLADE(25),BT(32),CIRCL
     .E(25),CO(32,11),CPCO(6),CR(32,11),CSLOPE(32,11),CU(32,11),CX(32,11
     .),CXM(11),CXNEW(11),DA(10),DELM(11),DEPV(32,11),DF(20),DFLOW(32),F
     .LOW(32),FORM(25),FOUND(20,3,10),IREF(25,11),ITYPE(25),METAL(2),MET
     .HOD(25),MIN(8,25),MINR(8,25),MOUT(8,25),MOUTR(8,25),NIN(25),NRAD(2
     .5),NS(25),NSS(25),NTC(25),NTH(25),NXIT(25),OBAR(25,11),OFFD(25),PO
     .(32,11),R(32,11),RAD(8,25),RADR(8,25),RCURVE(32,11),RH(32),RINT(11
     .),RPM(1),RS(32),RSLOPE(32,11),RULE(25),SHAPE(25),SIXTY5(25),SO(8,2
     .5),SOR(8,25),SS(8,25),SSR(8,25),TERMC(11),TH(8,25),THC(8,25),THCR(
     .8,25),THR(8,25),TITLE(36),TO(32,11),TSTAT(11),X(32)
      COMMON  /SCALAR/
     .A,AA,A1OA0,A2O2A0,A3O3A0,A4O4A0,A5C5A0,ANG,B,BB,CC,CENT,CM,CMEAN,C
     .MEANP,CM2,COREC,COUNT,CP,CPI2,CPI3,CPI4,CPI5,CPI6,CPO2,CPO3,CPO4,C
     .PO5,DAMP,DCP,DELFLO,DFACT,EMACH,EPISON,FACTM,G,GAMMER,GASK,GJ,GR2,
     .H,HIGH,HIPRES,I,IG,IGO,IOUTTR,IPASS,J,JJ,JM,JM1,JOULE,K,KDEL,KK,L,
     .LAST,LC1,LEVEL,LST,LSTAGE,M,MACH,MAXPT,MINPT,N,NBLADE,NDATA,NLINES
     .,NSETS,NSPEED,NTUBES,NX,NX1,OFF,OK,PHI,PLOW,Q,RA,RADIAN,RDFLO,REF,
     .RESTAR,RMACH,S,SOLID,SPEED,STOP,T,TERMD,THICK,TIME,TOLAT,TOLCX,TOL
     .MIN,TOLR,TONE,V,VMI,YES
      REAL  LOSE
      REAL  MSIDE
C        *** OBAR CONTAINS THE LOSS FUNCTION

      SHOCK(X)= Q -V*ATAN(SQRT((X -1.0)*(X +1.0))/V) +ATAN(SQRT(
     X     (X -1.0)*(X +1.0)))
      OK= .TRUE.
      ISTA= MAXO(5,NOW)
      DO 500 I=ISTA,LSTAGE

C        *** BY-PASS THIS CALCULATION FOR AN ANNULAR PASSAGE

      IF (ROTOR(I-4)) 10,495,10
   10 DO 490 J=1,NLINES
      OBAR(I-4,J)= 0.0
      AA= CX(I-1,J)**2 +CU(I-1,J)**2 +CR(I-1,J)**2
      H= -AA/GJ
      T= TO(I-1,J)

C        *** CALCULATE THE INLET STATIC TEMPERATURE

      CALL  ENTALP
```

```
      CALL GAM

C      *** ADD THE WHEEL SPEED TERM FOR A ROTOR

      IF (ROTOR(I-4).LT.0.0)  AA= AA +RPM(N)*R(I-1,J)*(RPM(N)*R(I-1,J)
     X                          -2.0*CU(I-1,J))

C      *** COMPUTE THE RELATIVE (ABSOLUTE FOR A STATOR) VELOCITY
C          AND MACH NUMBER

      CM= SQRT(AA)
      MACH= SQRT(AA/(GR2*GAMMER*TSTAT(J)))
      V= SQRT((GAMMER +1.0)/(GAMMER -1.0))

C      *** GET SHOCK ANGLE PARAMETER

      Q= SLINE (R(I-1,J),SSR(1,I-4),SS(1,I-4),NSS(I-4))
      METAL(1)= SLINE(R(I-1,J),MINR(1,I-4),MIN(1,I-4),NIN(I-4))
      METAL(1)= ATAN(TAN(METAL(1))/SQRT( 1.0 +RSLOPE(I-1,J)**2))
      A= METAL(1) +IREF(I-4,J)
      Q= A -Q/RADIAN

C      *** CALCULATE THE SHOCK LOSS

   60 IF (MACH.LT.1.0)  GO TO 70
      Q=Q+Q -SHOCK(MACH)
   70 OBAR(I-4,J)= 0.0
      EMACH= 1.0
      BB= 0.1
      IF (Q.LT.0.0)  GO TO 90
      EMACH= Q*2.2 +1.0
      DO 80 K=1,500
      VMI= SHOCK(EMACH)
      IF (ABS(VMI).LE.0.001)  GO TO 90
      EMACH= VMI*2.04 +EMACH
   80 CONTINUE
      CALL ERROR(12)
   90 IF (MACH.GE.1.0)  GO TO 100
      EMACH= MACH*(1.0 +EMACH)*0.5
      IF (EMACH.LE.1.0)  GO TO 120
      GO TO 110
  100 EMACH= (EMACH +MACH)*0.5
  110 A= 0.5*(GAMMER +1.0)
      B= 0.5*(GAMMER -1.0)
      CC= GAMMER/(GAMMER -1.0)
      OBAR(I-4,J)= (1.0 -((A*EMACH**2) /
     1 (1.0 +B*EMACH**2))
     2 **CC *(2.0*GAMMER
     3 / (GAMMER +1.0)*EMACH**2 -B/A)**
     4   (1.0/(1.0 -GAMMER)))
     5   / (1.0 -1.0/(1.0 +B* MACH**2)
     6   **CC )
  120 CONTINUE
      A=RS(I)-RH(I)
      CC=((R(I-1,J) +R(I,J))*0.5)
```

```
C       *** GET THE SOLIDITY

        SOLID= SLINE(CC,SOR(1,I-4),SO(1,I-4),NS(I-4))
        IF (ROTOR(I-4).LT.0.0)  GO TO 122

C       *** COMPUTE THE DIFFUSION FACTOR

        DFACT= 1.0 -SQRT((CX(I,J)**2 +CR(I,J)**2 +(RPM(N)*R(I,J) -CU(I,J))
       X **2))/CM +(RPM(N)*(R(I-1,J) -R(I,J)) +CU(I,J) -CU(I-1,J))*0.5
       X /SOLID/CM
        BB= BETA(I,J)
        GO TO 124
  122   DFACT= 1.0 -SQRT(CX(I,J)**2 +CR(I,J)**2 +CU(I,J)**2)/CM
       X -0.5*(CU(I,J) -CU(I-1,J))/CM/SOLID
        BB= ALPHA(I,J)
  124   CONTINUE
C       DFACT= AMIN1(DFACT, 0.60)
        CENT=(R(I,J)-RH(I))/A

C       *** ADD THE PROFILE LOSS

        OBAR(I-4,J)= OBAR(I-4,J) +LOSE(DFACT, CENT,BLADE(I-4))
       X *2.0*SOLID/COS(AMIN1(BB,1.22))
        DEPV(I,J) = OBAR(I-4,J)
        IF (ROTOR(I-4))  130,500,140
  130   REF= ALPHA(I-1,J)
        CENT= 0.5
        GO TO 150
  140   REF= BETA(I-1,J)
  150   REF= REF -METAL(1) -IREF(I-4,J)
        REF= REF*RADIAN
        IF (REF.GT.0.0)  GO TO 160

C       *** ADD THE OFF-DESIGN LOSS

        AA= MSIDE(MACH)*REF**2
        GO TO 165
  160   AA= PSIDE(MACH)*REF**2
  165   IF (AA.GT.OBAR(I-4,J))  AA= -2.0*OBAR(I-4,J)
        OBAR(I-4,J)= OBAR(I-4,J) +AA

C          *** CALCULATE ROTOR EFFICIENCY BASED ON LOSS


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)
  170 IF (ROTOR(I-4)) 200,500,180
  180 CONTINUE
      H= RPM(N)*R(I-1,J)*(RPM(N)*R(I-1,J) -2.0*CU(I-1,J))/GJ
      CALL  ENTALP

C        *** COMPUTE THE TOTAL RELATIVE PRESSURE

      PREL= PO(I-1,J)*EXP((THERM3(TSTAT(J)) -B)/DCP)
      H= RPM(N)**2*(R(I,J) -R(I-1,J))*(R(I,J) +R(I-1,J))/GJ
      T= TSTAT(J)
      B= THERM3(T)
      CALL ENTALP

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 -ABS(CBAR(I-4,J))*(P REL -P STAT)
      H= RPM(N)*R(I,J)*(RPM(N)*R(I,J) -2.0*CU(I,J))/GJ
      T= TO(I,J)
      CALL  ENTALP

C        *** COMPUTE NEW TOTAL PRESSURE AT ROTOR EXIT

      P= P*EXP((THERM3(T) -THERM3(TSTAT(J)))/DCP)
      GO TO 210
  200 P= PO(I-1,J) -ABS(CBAR(I-4,J))*(PO(I-1,J) -P STAT)
  210 CONTINUE
      IF (ABS((P-PO(I,J))/P).GT.TOLAT)  OK= .FALSE.

  490 PO(I,J)=P
      GO TO 500
  495 DO 496 J=1,NLINES
  496 PO(I,J)= PO(I-1,J)
  500 CONTINUE

C        *** CHECK STAGE EFFICIENCY FOR CONVERGENCE

      NN=LSTAGE+1
      DO 966 I=NN,NX
      DO 966 J=1,NLINES
  966 PO(I,J)=PO(I-1,J)
      RETURN
      END
```

```
C -----   LOAD THE LOSS DATA ONTO THE FILE.
      LOGICAL  CIRCLE,  SIXTY5
      REAL             IREF,            JOULE,           MACH,
     X METAL,          MIN,             MINR,            MOUT,
     X MOUTR
      INTEGER BLADE,                    COUNT
      LOGICAL          OFF,             OK,              RDFLO,
     X RESTAR,         TONE
      INTEGER  RULE
      REAL KDEL,KDEL2
      COMMON  /VECTOR/
     .ALPHA(29,11),ATAR(25,11),BETA(29,11),BH(32),BLADE(25),BT(32),CIRCL
     .E(25),CO(32,11),CPCO(6),CP(32,11),CSLOPE(32,11),CU(32,11),CX(32,11
     .),CXM(11),CXNEW(11),DA(10),DELM(11),DEPV(32,11),DF(20),DFLOW(32),FOF
     .LOW(32),FORM(25),FOUND(20,2,10),IREF(25,11),ITYPE(25),METAL(2),MET
     .MOD(25),MIN(8,25),MINR(8,25),MOUT(8,25),MOUTR(8,25),NIN(25),NRAD(2
     .5),NS(25),NSS(25),NTC(25),NTH(25),NXIT(25),OBAR(25,11),OFFD(25),PO
     .(32,11),R(32,11),RAD(8,25),RADR(8,25),RCURVE(32,11),RH(32),RINT(11
     .),RPM(11),RS(32),RSLOPE(32,11),RULE(25),SHAPE(25),SIXTY5(25),SO(6,2
     .5),SOR(8,25),SS(8,25),SSR(8,25),TERMC(11),TH(8,25),THC(8,25),THCR(
     .8,25),THR(8,25),TITLE(26),TO(32,11),TSTAT(11),X(32)
      COMMON  /SCALAR/
     .A,AA,A1LA0,A2O2A0,A3O3A0,A4O4A0,A5O5A0,ANG,B,BB,CC,CENT,CM,CMEAN,C
     .MEANP,CMR,CORREC,COUNT,CP,CPI2,CPI3,CPI4,CPI5,CPI6,CPO2,CPO3,CPO4,C
     .PO5,DAMP,DCP,DELFLO,DFACT,EMACH,EPISON,FACTM,G,GAMMER,GASK,GJ,GR2,
     .H,HIGH,HIPRES,I,IG,IGO,IOUTTR,IPASS,J,JJ,JM,JM1,JOULE,K,KDEL,KK,L,
     .LAST,LCI,LEVEL,LST,LSTAGE,M,MACH,MAXPT,MINPT,N,NBLADE,NDATA,NLINES
     .,NSETS,NSPEED,NTUBES,NX,NX1,OFF,OK,PHI,PLOW,Q,RA,RADIAN,RDFLO,REF,
     .RESTAR,RMACH,S,SOLID,SPEED,STOP,T,TERMD,THICK,TIME,TOLAT,TOLCX,TOL
     .MIN,TOLR,TONE,V,VHI,YES
      READ (5,910)IG
  910 FORMAT (I5)
      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)
  930 END FILE 4
      REWIND 4
  925 FORMAT (12F6.0)
      CALL BOSS
      RETURN
      END
```

```
      SUBROUTINE OUT1
      COMMON /GET 11/ ROTOR(29)
      LOGICAL   CIRCLE,   SIXTY5
      REAL              IREF,             JOULE,            MACH,
     X METAL,           MIN,              MINR,             MOUT,
     X MOUTR
      INTEGER BLADE,                      COUNT
      LOGICAL           OFF,              OK,               RDFLO,
     X RESTAR,          TUNE
      INTEGER   RULE
      REAL KDEL,KDEL2
      COMMON   /VECTOR/
     .ALPHA(29,11),ATAR(25,11),BETA(29,11),BH(32),BLADE(25),BT(32),CIRCL
     .E(25),CO(32,11),CPCO(6),CR(32,11),CSLOPE(32,11),CU(32,11),CX(32,11
     .),CXM(11),CXNEW(11),DA(10),DELM(11),DEPV(32,11),DF(20),DFLOW(32),F
     .LOW(32),FORM(25),FOUND(20,3,10),IREF(25,11),ITYPE(25),METAL(2),MET
     .HOD(25),MIN(8,25),MINR(8,25),MOUT(8,25),MOUTR(8,25),NIN(25),NRAD(2
     .5),NS(25),NSS(25),NTC(25),NTH(25),NXIT(25),OBAR(25,11),OFFD(25),PO
     .(32,11),R(32,11),RAD(8,25),RADR(8,25),RCURVE(32,11),RH(32),RINT(11
     .),RPM(1),RS(32),RSLOPE(32,11),RULE(25),SHAPE(25),SIXTY5(25),SO(8,2
     .5),SOR(8,25),SS(8,25),SSR(8,25),TERMC(11),TH(8,25),THC(8,25),THCR(
     .8,25),THR(8,25),TITLE(36),TO(32,11),TSTAT(11),X(32)
      COMMON   /SCALAR/
     .A,AA,A10A0,A202A0,A303A0,A404A0,A505A0,ANG,B,BB,CC,CENT,CM,CMEAN,C
     .MEANP,CM2,COREC,COUNT,CP,CPI2,CPI3,CPI4,CPI5,CPI6,CPO2,CPO3,CPO4,C
     .POS,DAMP,DCP,DELFLO,DFACT,EMACH,EPISON,FACTM,G,GAMMER,GASK,GJ,GR2,
     .H,HIGH,HIPRES,I,IG,IGO,IOUTTR,IPASS,J,JJ,JM,JM1,JOULE,K,KDEL,KK,L,
     .LAST,LC1,LEVEL,LST,LSTAGE,M,MACH,MAXPT,MINPT,N,NBLADE,NDATA,NLINES
     .,NSETS,NSPEED,NTUBES,NX,NX1,OFF,OK,PHI,PLOW,Q,RA,RADIAN,RDFLO,REF,
     .RESTAR,RMACH,S,SOLID,SPEED,STOP,T,TERMD,THICK,TIME,TOLAT,TOLCX,TOL
     .MIN,TOLR,TONE,V,VM1,YES

      DIMENSION DAY(2)
      MACH= 100.0*RPM(N)/SPEED
      IF (LEVEL.EQ.1)  GO TO 10
      GO TO 50
   10 WRITE (6,20) MACH, FLOW(LSTAGE), A, AA, CC
   20 FORMAT (F14.1,F16.3,F11.3,F17.3,F20.3)
      GO TO 50
      ENTRY  HEAD
      CALL  DATE(DAY)
      WRITE (6,40)  TITLE, DAY
   40 FORMAT (1H1 /// 3(24X12A6/) //102X2A4 //
     X 7X 10HPERCENT OF 5X 9HMASS FLOW 4X 10HEFFICIENCY 4X
     X 14HTOTAL PRESSURE 4X 17HTOTAL TEMPERATURE /
     X 6X 12HDESIGN SPEED 6X 4HRATE 25X 5HRATIO 15X 5HRATIO /
     X 22X  3H(LB/SEC) /////)
   50 RETURN
      END
```

```
      SUBROUTINE OUT2                                                   OFFD2726
      COMMON /GET IT/ ROTOR(29)                                         OFFD2727
      LOGICAL   CIRCLE,   SIXTY5                                        OFFD2728
      REAL              IREF,          JOULE,         MACH,             OFFD2729
     X METAL,           MIN,           MINR,          MOUT,             OFFD2730
     X MOUTR                                                            OFFD2731
      INTEGER BLADE,                   COUNT                            OFFD2732
      LOGICAL           OFF,           OK,            RDFLO,            OFFD2733
     X RESTAR,          TONE                                            OFFD2734
      INTEGER   RULE                                                    OFFD2735
      REAL KDEL,KDEL2                                                   OFFD2736
      COMMON   /VECTOR/                                                 OFFD2737
     .ALPHA(29,11),ATAR(25,11),BETA(29,11),BH(32),BLADE(25),BT(32),CIRCLOFFD2738
     .E(25),CO(32,11),CPCO(6),CR(32,11),CSLOPE(32,11),CU(32,11),CX(32,11OFFD2739
     .),CXM(11),CXNEW(11),DA(10),DELM(11),DEPV(32,11),DF(20),DFLOW(32),FOFFD2740
     .LOW(32),FORM(25),FOUND(20,3,10),IREF(25,11),ITYPE(25),METAL(2),METOFFD2741
     .HOD(25),MIN(8,25),MINR(8,25),MOUT(8,25),MOUTR(8,25),NIN(25),NRAD(2OFFD2742
     .5),NS(25),NSS(25),NTC(25),NTH(25),NXIT(25),OBAR(25,11),OFFD(25),POOFFD2743
     .(32,11),R(32,11),RAD(8,25),RADR(8,25),RCURVE(32,11),RH(32),RINT(11OFFD2744
     .),RPM(1),RS(32),RSLOPE(32,11),RULE(25),SHAPE(25),SIXTY5(25),SO(8,2OFFD2745
     .5),SUR(8,25),SS(8,25),SSR(8,25),TERMC(11),TH(8,25),THC(8,25),THCR(OFFD2746
     .8,25),THR(8,25),TITLE(36),TO(32,11),TSTAT(11),X(32)               OFFD2747
      COMMON   /SCALAR/                                                 OFFD2748
     .A,AA,A1OA0,A2O2A0,A3O3A0,A4O4A0,A5O5A0,ANG,B,BB,CC,CENT,CM,CMEAN,COFFD2749
     .MEANP,CM2,COREC,COUNT,CP,CPI2,CPI3,CPI4,CPI5,CPI6,CPO2,CPO3,CPO4,COFFD2750
     .PO5,DAMP,DCP,DELFLO,DFACT,EMACH,EPISON,FACTM,G,GAMMER,GASK,GJ,GR2,OFFD2751
     .H,HIGH,HIPRES,I,IG,IGO,IOUTTR,IPASS,J,JJ,JM,JM1,JOULE,K,KDEL,KK,L,OFFD2752
     .LAST,LC1,LEVEL,LST,LSTAGE,M,MACH,MAXPT,MINPT,N,NBLADE,NDATA,NLINESOFFD2753
     .,NSETS,NSPEED,NTUBES,NX,NX1,OFF,OK,PHI,PLOW,Q,RA,RADIAN,RDFLO,REF,OFFD2754
     .RESTAR,RMACH,S,SOLID,SPEED,STOP,T,TERMD,THICK,TIME,TOLAT,TOLCX,TOLOFFD2755
     .MIN,TOLR,TONE,V,VM1,YES                                           OFFD2756
      DIMENSION TERMB(11),TERM1(11)                                     OFFD2757
      WRITE (6,5)  TITLE                                                OFFD2758
    5 FORMAT (1H1//////3(24X12A6/),/// 3X 3(24X 10HCUMULATIVE),6X4HMASS/OFFD2759
     X 6H  STA-  6( 3X 14HMASS AVERAGED ),7H   FLOW  /                  OFFD2760
     X 6H  TION 2(3X 14HPRESSURE RATIO),2( 4X 13HTEMPERATURE   ),       OFFD2761
     X 2( 4X 13HEFFICIENCY    ), 7H    RATE /                           OFFD2762
     X 35X 2( 12X 5HRATIO ),/// )                                       OFFD2763
      P IN= PO(1,1)                                                     OFFD2764
      T IN= TO(1,1)                                                     OFFD2765
      P LAST= PO(1,1)                                                   OFFD2766
      T LAST= TO(1,1)                                                   OFFD2767
      CM2= THERM1(TO)                                                   OFFD2768
      DO 100 I=5,LSTAGE                                                 OFFD2769
      IF (ROTOR(I-4).EQ.0.0)  GO TO 100                                 OFFD2770
      DO 10 J=1,NLINES                                                  OFFD2771
      H= -(CX(I,J)**2 +CR(I,J)**2 +CU(I,J)**2)/GJ                       OFFD2772
      T= TO(I,J)                                                        OFFD2773
      CALL ENTALP                                                       OFFD2774
      DEPV(I,J)= CX(I,J)*PO(I,J)*EXP((THERM3(TSTAT(J)) -THERM3(T))/DCP) OFFD2775
     X            /TSTAT(J)/GASK                                        OFFD2776
      CU(I,J)= DEPV(I,J)*PO(I,J)                                        OFFD2777
      RCURVE(I,J)= DEPV(I,J)*TO(I,J)                                    OFFD2778
   10 CONTINUE                                                          OFFD2779
      CALL  INTEG (DEPV,1)                                              OFFD2780
```

```
      TOTAL = RINT(NLINES) -RINT(1)                              OFF02781
      CALL  INTEG (CO,1)                                         OFF02782
      P OUT= (RINT(NLINES) -RINT(1))/TOTAL                       OFF02783
      CALL  INTEG (RCURVE,1)                                     OFF02784
      T OUT= (RINT(NLINES) -RINT(1))/TOTAL                       OFF02785
      AA= P OUT/PO(1,1)                                          OFF02786
      CC= T OUT/TO(1,1)                                          OFF02787
      IF (ROTOR(I-4).LT.0.0) GO TO 20                            OFF02788
      P LAST= P IN                                               OFF02789
      T LAST= T IN                                               OFF02790
   20 BB= P OUT/P LAST                                           OFF02791
      CM= T OUT/T LAST                                           OFF02792
      P IN= P OUT                                                OFF02793
      T IN= T OUT                                                OFF02794
      CALL  THERM2(BB,T OUT,T LAST)                              OFF02795
      EFF= 0.0                                                   OFF02796
      IF (TIN.EQ.TLAST)  GO TO 24                                OFF02797
      EFF = (THERM1(T OUT) -THERM1(T LAST))                      OFF02798
     X      /(THERM1(T IN ) -THERM1(T LAST))                     OFF02799
   24 CONTINUE                                                   OFF02800
      CALL  THERM2(AA, T OUT, TO)                                OFF02801
      A= 0.0                                                     OFF02802
      IF (TIN.EQ.TO(1,1))  GO TO 28                              OFF02803
      A= (THERM1(T OUT) -CM2)                                    OFF02804
     X /(THERM1(T IN ) -CM2)                                     OFF02805
   28 CONTINUE                                                   OFF02806
      WRITE (6,30) I, BB, AA, CM, CC, EFF, A, FLOW(I)            OFF02807
   30 FORMAT (I5, F12.3, 5F17.3, F14.3 )                         OFF02808
  100 CONTINUE                                                   OFF02809
      H= RPM(N)/SPEED                                            OFF02810
      WRITE (6,40) H                                             OFF02811
   40 FORMAT (///9X31HTHE FRACTION OF DESIGN SPEED IS F5.2 )     OFF02812
      RETURN                                                     OFF02813
      END                                                        OFF02814
```

```
      SUBROUTINE OUT3                                                   OFFD2816
      COMMON /GET IT/ ROTOR(29)                                         OFFD2817
      LOGICAL  CIRCLE,  SIXTY5                                          OFFD2818
      REAL           IREF,          JOULE,         MACH,                OFFD2819
     X METAL,        MIN,           MINR,          MOUT,                OFFD2820
     X MOUTR                                                            OFFD2821
      INTEGER BLADE,                COUNT                               OFFD2822
      LOGICAL        OFF,           OK,            ROFLO,               OFFD2823
     X RESTAR,       TONE                                               OFFD2824
      INTEGER  RULE                                                     OFFD2825
      REAL KDEL,KDEL2                                                   OFFD2826
      COMMON  /VECTOR/                                                  OFFD2827
     .ALPHA(29,11),ATAR(25,11),BETA(29,11),BH(32),BLADE(25),BT(32),CIRCLOFFD2828
     .E(29),CO(32,11),CPCO(6),CR(32,11),CSLOPE(32,11),CU(32,11),CX(32,11OFFD2829
     .),CXM(11),CXNEW(11),DA(10),DELM(11),DEPV(32,11),DF(20),DFLOW(32),FOFFD2830
     .LOW(32),FORM(25),FOUND(20,3,10),IREF(25,11),ITYPE(25),METAL(2),MFIOFFD2831
     .HOE(25),MIN(8,25),MINR(8,25),MOUT(8,25),MOUTR(8,25),NIN(25),NRAD(2OFFD2832
     .5),NS(25),NSS(25),NTC(25),NTH(25),NXIT(25),OBAR(25,11),OFFD(25),POOFFD2833
     .(32,11),R(32,11),RAD(8,25),RADR(8,25),RCURVE(32,11),RH(32),RINT(11OFFD2834
     .),RPM(1),RS(32),RSLOPE(32,11),RULE(25),SHAPE(25),SIXTY5(25),SO(8,2OFFD2835
     .5),SOR(8,25),SS(8,25),SSP(8,25),TERMC(11),TH(8,25),THC(8,25),THCR(OFFD2836
     .8,25),THR(8,25),TITLE(36),TO(32,11),TSTAT(11),X(32)               OFFD2837
      COMMON  /SCALAR/                                                  OFFD2838
     .A,AA,A1OA0,A2O2A0,A3O3A0,A4O4A0,A5O5A0,ANG,B,BB,CC,CENT,CM,CMEAN,COFFD2839
     .MEANP,CM2,COREC,COUNT,CP,CPI2,CPI3,CPI4,CPI5,CPI6,CPO2,CPO3,CPO4,COFFD2840
     .PO5,DAMP,DCP,DELFLO,DFACT,EMACH,EPISON,FACTM,G,GAMMER,GASK,GJ,GR2,OFFD2841
     .H,HIGH,HIPRES,I,IG,IGO,ICUTIR,IPASS,J,JJ,JM,JM1,JOULE,K,KDEL,KK,L,OFFD2842
     .LAST,LC1,LEVEL,LST,LSTAGE,M,MACH,MAXPT,MINPT,N,NBLADE,NDATA,NLINESOFFD2843
     .,NSETS,NSPEED,NTUBES,NX,NX1,OFF,OK,PHI,PLOW,Q,RA,RADIAN,ROFLO,REF,OFFD2844
     .RESTAR,RMACH,S,SOLID,SPEED,STOP,T,TERMO,THICK,TIME,TOLAT,TOLCX,TOLOFFD2845
     .MIN,TOLR,TONE,V,VMI,YES                                           OFFD2846
      DIMENSION  DAY(2)                                                 OFFD2847
      DIMENSION  STALL(2), STAL(2)                                      OFFD2848
      DIMENSION TERM1(11)                                               OFFD2849
      DATA  BLANK, STAL / 4H    , 4H STA, 4HLLED  /                     OFFD2850
      DO 5 J=1,NLINES                                                   OFFD2851
    5 RINT(J)= 0.0                                                      OFFD2852
      DO 40 I=5,LSTAGE                                                  OFFD2853
      IF (ROTOR(I-4)) 30,40,10                                          OFFD2854
   10 CONTINUE                                                          OFFD2855
      DO 20 J=1,NLINES                                                  OFFD2856
      CXM(J)= TO(I-1,J)                                                 OFFD2857
      TERM1(J)= PO(I-1,J)                                               OFFD2858
      CALL  THERM2(PO(I,J)/PO(I-1,J),T,TO(I-1,J))                       OFFD2859
      RINT(J)= THERM1(TO(I,J)) -THERM1(TO(I-1,J))                       OFFD2860
   20 ATAR(I-4,J)= (THERM1(T) -THERM1(TO(I-1,J)))/RINT(J)               OFFD2861
      GO TO 40                                                          OFFD2862
   30 DO 38 J=1,NLINES                                                  OFFD2863
      IF (RINT(J).EQ.0.0)  GO TO 35                                     OFFD2864
      CALL  THERM2(PO(I,J)/TERM1(J),T,CXM(J))                           OFFD2865
      ATAR(I-4,J)= (THERM1(T) -THERM1(CXM(J)))/RINT(J)                  OFFD2866
      GO TO 38                                                          OFFD2867
   35 ATAR(I-4,J)= (PO(I-1,J) -PO(I,J))/PO(I,J)                         OFFD2868
   38 CONTINUE                                                          OFFD2869
   40 CONTINUE                                                          OFFD2870
```

```
      CALL   DATE (DAY)                                             OFFD2871
      IR= 0                                                         OFFD2872
      IS= 0                                                         OFFD2873
      DO 500 I=1,NX                                                 OFFD2874
      WRITE (6 ,50)  DAY,TITLE                                      OFFD2875
      IF (I.LT.5.OR.I.GT.LSTAGE)  GO TO 110                         OFFD2876
      IF (ROTOR(I-4)) 100,110,120                                   OFFD2877
  100 IS= IS +1                                                     OFFD2878
      WRITE (6 ,52)  IS                                             OFFD2879
      GO TO 125                                                     OFFD2880
  110 WRITE (6 ,54)  I                                              OFFD2881
      GO TO 125                                                     OFFD2882
  120 IR= IR +1                                                     OFFD2883
      WRITE (6 ,57)  IR                                             OFFD2884
  125 WRITE (6 ,55)                                                 OFFD2885
      WRITE (6 ,56)                                                 OFFD2886
  126 DO 150 J=1,NLINES,IOUTTR                                      OFFD2887
      A= CX(I,J)**2 +CR(I,J)**2 +CU(I,J)**2                         OFFD2888
      H= -A/GJ                                                      OFFD2889
      T= T0(I,J)                                                    OFFD2890
      CALL   ENTALP                                                 OFFD2891
      CALL   GAM                                                    OFFD2892
      AA= SQRT(GR2*GAMMER*TSTAT(J))                                 OFFD2893
      A= SQRT(A)                                                    OFFD2894
      B= RPM(N)*R(I,J)                                              OFFD2895
      V= SQRT(CX(I,J)**2 +CR(I,J)**2 +(CU(I,J) -B)**2)              OFFD2896
      MACH= A/AA                                                    OFFD2897
      EMACH= V/AA                                                   OFFD2898
      CXM(J)= MACH                                                  OFFD2899
      IF (ROTOR(I-4).GT.0.0)  CXM(J)= EMACH                         OFFD2900
  150 WRITE (6 ,58)  J,R(I,J), CX(I,J), CU(I,J), CR(I,J), A, MACH,  OFFD2901
     X  V, EMACH, B                                                 OFFD2902
      WRITE (6 ,60)                                                 OFFD2903
      WRITE (6 ,55)                                                 OFFD2904
      IF (I.LT.5.OR.I.GT.LSTAGE)  GO TO 153                         OFFD2905
      IF (ROTOR(I-4).NE.0.0)  GO TO 155                             OFFD2906
  153 WRITE (6 ,66)                                                 OFFD2907
      GO TO 210                                                     OFFD2908
  155 WRITE (6 ,62)                                                 OFFD2909
      DO 180 J=1,NLINES,IOUTTR                                      OFFD2910
      ARG= (R(I,J) +R(I-1,J))*0.5                                   OFFD2911
      RINT(J)= SLINE(ARG     ,SOR(1,I-4),SO(1,I-4),NS(I-4))         OFFD2912
      METAL(1)=SLINE(R(I-1,J),MINR(1,I-4),MIN(1,I-4),NIN(I-4))      OFFD2913
      METAL(1)= ATAN(TAN(METAL(1))/SQRT( 1.0 +RSLOPE(I-1,J)**2))    OFFD2914
      A= ALPHA(I-1,J)*RADIAN                                        OFFD2915
      B= BETA(I-1,J)*RADIAN                                         OFFD2916
      STALL(1)= BLANK                                               OFFD2917
      STALL(2)= BLANK                                               OFFD2918
      IF (DBAR(I-4,J).GE.0.0)  GO TO 157                            OFFD2919
      STALL(1)= STAL(1)                                             OFFD2920
      STALL(2)= STAL(2)                                             OFFD2921
  157 CONTINUE                                                      OFFD2922
      DBAR(I-4,J)= ABS(DBAR(I-4,J))                                 OFFD2923
      CM= DEPV(I,J)                                                 OFFD2924
      IF (ROTOR(I-4).GT.0.0)  GO TO 160                             OFFD2925
      AA= SQRT(CX(I-1,J)**2 +CR(I-1,J)**2 +CU(I-1,J)**2)            OFFD2926
```

```
      CM2=SQRT(CX(I,J)**2 +CR(I,J)**2 +CU(I,J)**2)                      OFFD2927
      BB= CU(I-1,J) -CU(I,J)                                            OFFD2928
      CC= (ALPHA(I-1,J) -METAL(1))                                      OFFD2929
      GO TO 165                                                         OFFD2930
  160 AA= SQRT(CX(I-1,J)**2 +CR(I-1,J)**2+(RPM(N)*R(I-1,J)-CU(I-1,J))**2OFFD2931
     X )                                                                OFFD2932
      CM2=SQRT(CX(I,J)**2 +CR(I,J)**2 +(RPM(N)*R(I,J) -CU(I,J))**2)     OFFD2933
      BB= RPM(N)*(R(I-1,J) -R(I,J)) +CU(I,J) -CU(I-1,J)                 OFFD2934
      CC= BETA(I-1,J) -METAL(1)                                         OFFD2935
  165 CC= CC*RADIAN                                                     OFFD2936
      METAL(1)= METAL(1)*RADIAN                                         OFFD2937
      IREF(I-4,J)= IREF(I-4,J)*RADIAN                                   OFFD2938
      DFACT= 1.0 - CM2/AA +0.5*BB/RINT(J)/AA                            OFFD2939
  190 WRITE (6 ,64)J,DFACT,OBAR(I-4,J),STALL,CM,ATAR(I-4,J),METAL(1),   OFFD2940
     X CC, IREF(I-4,J), A, B                                            OFFD2941
  200 WRITE (6 ,55)                                                     OFFD2942
      WRITE (6 ,68)                                                     OFFD2943
  210 CONTINUE                                                          OFFD2944
      DO 240 J=1,NLINES,IOUTTR                                          OFFD2945
      PSTAT= PO(I,J)*EXP((THERM3(TSTAT(J)) -THERM3(TO(I,J)))/DCP)       OFFD2946
      IF (I.LT.5.OR.I.GT.LSTAGE)  GO TO 215                             OFFD2947
      IF (ROTOR(I-4).NE.0.0)  GO TO 220                                 OFFD2948
  215 CONTINUE                                                          OFFD2949
      WRITE (6 ,70)  J, TO(I,J), PO(I,J), TSTAT(J), PSTAT               OFFD2950
      GO TO 240                                                         OFFD2951
  220 CONTINUE                                                          OFFD2952
      ARG=  (R(I,J) +R(I-1,J))*0.5                                      OFFD2953
      THICK= SLINE(ARG ,    THCR(1,I-4),THC(1,I-4),NTC(I-4))            OFFD2954
      Q= SLINE(R(I-1,J),THR(1,I-4),TH(1,I-4),NTH(I-4))                  OFFD2955
      METAL(2)= SLINE(R(I,J),MOUTR(1,I-4),MOUT(1,I-4),NXIT(I-4))        OFFD2956
      METAL(2)= ATAN(TAN(METAL(2))/SQRT( 1.0 +RSLOPE(I,  J)**2))        OFFD2957
      B= ALPHA(I,J)                                                     OFFD2958
      IF (ROTOR(I-4).GT.0.0)  B= BETA(I,J)                              OFFD2959
      B= (B -METAL(2))*RADIAN                                           OFFD2960
      METAL(2)= METAL(2)*RADIAN                                         OFFD2961
      WRITE (6 ,70)  J, TO(I,J), PO(I,J), TSTAT(J), PSTAT  ,RINT(J),    OFFD2962
     X THICK, Q, METAL(2), B                                            OFFD2963
  240 CONTINUE                                                          OFFD2964
      IF (I.LT.5.OR.I.GT.LSTAGE)  GO TO 245                             OFFD2965
      IF (ROTOR(I-4).NE.0.0)  GO TO 300                                 OFFD2966
  245 CONTINUE                                                          OFFD2967
      WRITE (6 ,72)                                                     OFFD2968
      GO TO 310                                                         OFFD2969
  300 WRITE (6 ,55)                                                     OFFD2970
  310 CONTINUE                                                          OFFD2971
  500 CONTINUE                                                          OFFD2972
   50 FORMAT (1H1 111X 2A4/(24X 12A6)//)                                OFFD2973
   52 FORMAT (6X 15HSTATOR EXIT NO. I3//)                               OFFD2974
   54 FORMAT (6X 11HSTATION NO. I3//)                                   OFFD2975
   55 FORMAT (1X 119(1H.))                                              OFFD2976
   56 FORMAT (18H .S.L.  STREAMLINE 4X  9HAXIAL VEL 4X  9HWHIRL VEL 4X  OFFD2977
     X 10HRADIAL VEL 4X  7HABS VEL 5X 8HABS MACH 4X 7HREL VEL 6X        OFFD2978
     X 8HREL MACH 5X 8HWHEEL  . /                                       OFFD2979
     X 5H .NO. 3X 10HRADIUS IN. 4X 8H(FT/SEC) 5X 8H(FT/SEC) 6X          OFFD2980
     X 8H(FT/SEC) 5X 8H(FT/SEC) 5X 6HNUMBER 4X 8H(FT/SEC) 7X 6HNUMBER   OFFD2981
     X 6X 8HSPEED   . / 2H . 117X 1H. )                                 OFFD2982
```

```
./ FURMAT (5X 9HROTOR NO. I3, 6H EXIT. //)                           0FFD2983
59 FJRMAT (2H . I2, F13.2, 4F13.1, F12.3, F12.1, F13.3, F11.1, 3H  .)0FFD2984
60 FORMAT (2H . 117X 1H.)                                             0FFD2985
62 FORMAT ( 17H .S.L.  DIFFUSION 6X 4HLOSS 9X 8HREF LOSS 5X          0FFD2986
  X 59HADIABATIC  . INLET BLADE   INCIDENCE   REFERENCE   ABS FLOW   0FFD2987
  X X  9HREL FLOW. /                                                 0FFD2988
  X 5H .NO. 4X 6HFACTOR 5X 11HCOEFFICIENT 4X 11HCOEFFICIENT 5X       0FFD2989
 62X 24HEFFICIENCY . ANGLE (DEG) 15X 9HINCIDENCE 3X  8HANGLE IN 3X   0FFD2990
  X 9HANGLE IN. / 2H . 58X 1H. 58X 1H.)                              0FFD2991
64 FORMAT (2H . I2, F10.3, F13.3, 2A4, F7.3,F14.3, 4X 1H. F8.2,      0FFD2992
  X F14.2, 2F12.2, F11.2, 2H . )                                     0FFD2993
66 FORMAT ( 61H .S.L.  TOTAL TEMP   TOTAL PRES   STATIC TEMP  STATIC 0FFD2994
  XPRES  . /                                                         0FFD2995
  X 2H . 6X 22HDEG RANKINE  LB/SQ IN. 4X 27HDEG RANKINE   LB/SQ IN.  0FFD2996
  X . / 2H . 58X 1H. )                                               0FFD2997
68 FORMAT ( 82H .S.L.  TOTAL TEMP   TOTAL PRES   STATIC TEMP  STATIC 0FFD2998
  XPRES  . SCLIDITY   THICKNESS 4X 34HTHROAT  . EXIT BLADE  DEVIATION0FFD2999
  X  . /                                                             0FF03000
  X 2H . 6X 22HDEG RANKINE  LB/SQ IN. 4X 27HDEG RANKINE   LB/SQ IN.  0FF03001
  X . 12X  8HTO CHORD 5X 34HSPACING . ANGLE DEG   AMGLE DEG  . /     0FF03002
  X 2H . 58X 1H. 33X 1H. 24X 1H. )                                   0FF03003
70 FORMAT (2H . I2, F12.1, F12.3, F14.1, F13.3, 5X 1H. F8.3, F11.3,  0FF03004
  X F12.2, 3H  . F9.2, F12.2, 4H   . )                               0FF03005
72 FORMAT (1X 50(1H.))                                               0FF03006
   RETURN                                                            0FF03007
   END                                                               0FF03008
```

```
      SUBROUTINE OUTPUT                                                 OFFD2637
      LOGICAL  CIRCLE,  SIXTY5                                          OFFD2638
      REAL            IREF,           JOULE,          MACH,             OFFD2639
     X METAL,         MIN,            MINR,           MOUT,             OFFD2640
     X MOUTR                                                            OFFD2641
      INTEGER BLADE,                  COUNT                             OFFD2642
      LOGICAL         OFF,            OK,             RDFLO,            OFFD2643
     X RESTAR,        TUNE                                              OFFD2644
      INTEGER  RULE                                                     OFFD2645
      REAL KDEL,KDEL2                                                   OFFD2646
      COMMON  /VECTOR/                                                  OFFD2647
     .ALPHA(29,11),ATAR(25,11),BETA(29,11),BH(32),BLADE(25),BT(32),CIRCLOFFD2648
     .E(25),CO(32,11),CPCO(6),CR(32,11),CSLOPE(32,11),CU(32,11),CX(32,11OFFD2649
     .),CXM(11),CXNEW(11),DA(10),DELM(11),DEPV(32,11),DF(20),DFLOW(32),FOFFD2650
     .LOW(32),FORM(25),FOUND(20,3,10),IREF(25,11),ITYPE(25),METAL(2),METOFFD2651
     .HOD(25),MIN(8,25),MINR(8,25),MOUT(8,25),MOUTR(8,25),NIN(25),NRAD(2OFFD2652
     .5),NS(25),NSS(25),NTC(25),NTH(25),NXIT(25),OBAR(25,11),OFFD(25),POOFFD2653
     .([illegible],11),R(32,11),RAD(8,25),RADR(8,25),RCURVE(32,11),RH(32),RINT(11OFFD2654
     .),RPM([illegible]),RS(32),RSLOPE(32,11),RULE(25),SHAPE(25),SIXTY5(25),SO(8,2OFFD2655
     .5),SOR(8,25),SS(8,25),SSR(8,25),TERMC(11),TH(8,25),THC(8,25),THCR(OFFD2656
     .8,25),THR(8,25),TITLE([illegible]),TO(32,11),TSTAT(11),X(32)                 OFFD2657
      COMMON  /SCALAR/                                                  OFFD2658
     .A,AA,A10AC,A202AC,A303A0,A404A0,A505A0,ANG,B,BB,CC,CENT,CM,CMEAN,COFFD2659
     .MEANP,CM2,COREC,COUNT,CP,CPI2,CPI3,CPI4,CPI5,CPI6,CPO2,CPO3,CPO4,COFFD2660
     .PO5,DAMP,DCP,DELFLO,DFACT,EMACH,EPISON,FACTM,G,GAMMER,GASK,GJ,GR2,OFFD2661
     .H,HIGH,HIPRES,I,IG,IGO,ICUTTR,IPASS,J,JJ,JM,JM1,JOULE,K,KDEL,KK,L,OFFD2662
     .LAST,LC1,LEVEL,LST,LSTAGE,M,MACH,MAXPT,MINPT,N,NBLADE,NDATA,NLINESOFFD2663
     ..NSETS,NSPEED,NTUBES,NX,NX1,OFF,OK,PHI,PLOW,Q,RA,RADIAN,RDFLO,REF,OFFD2664
     .RESTAR,RMACH,S,SOLID,SPEED,STOP,T,TERMO,THICK,TIME,TOLAT,TOLCX,TOLOFFD2665
     .MIN,TOLR,TUNE,V,VMI,YES                                           OFFD2666
                                                                        OFFD2667
      NDATA= NDATA +1                                                   OFFD2668
      GO TO (30,20,10), LEVEL                                           OFFD2669
   10 CALL  OUT 3                                                       OFFD2670
   20 CALL  OUT 2                                                       OFFD2671
   30 CALL  OUT 1                                                       OFFD2672
      RETURN                                                            OFFD2673
      END                                                               OFFD2674
```

```
      SUBROUTINE  PREFILL                                               OFFD2538
      COMMON /GET IT/ ROTOR(29)                                         OFFD2539
      COMMON /FULL/  BUCKET, NOW                                        OFFD2540
      LOGICAL  CIRCLE,  SIXTY5                                          OFFD2541
      REAL           IRLF,          JOULE,        MACH,                 OFFD2542
     X METAL,        MIN,           MINR,         MOUT,                 OFFD2543
     X MOUTR                                                            OFFD2544
      INTEGER BLADE,                COUNT                               OFFD2545
      LOGICAL        OFF,           OK,           RDFLO,                OFFD2546
     X RESTAR,       TONE                                               OFFD2547
      INTEGER  RULE                                                     OFFD2548
      REAL KDEL,KDEL2                                                   OFFD2549
      COMMON  /VECTOR/                                                  OFFD2550
     .ALPHA(29,11),ATAR(25,11),BETA(29,11),BH(32),BLADE(25),BT(32),CIRCLOFFD2551
     .E(25),CO(32,11),CPCO(6),CR(32,11),CSLOPE(32,11),CU(32,11),CX(32,11OFFD2552
     .),CXM(11),CXNEW(11),DA(10),DELM(11),DEPV(32,11),DF(20),DFLOW(32),FUOFFD2553
     .LOW(32),FORM(25),FOUND(20,3,10),IREF(25,11),ITYPE(25),METAL(2),MLTOFFD2554
     .MOD(25),MIN(8,25),MINR(8,25),MOUT(8,25),MOUTR(8,25),NIN(25),NRAD(2OFFD2555
     .5),NS(25),NSS(25),NTC(25),NTH(25),NXIT(25),OBAR(25,11),OFFD(25),POOFFD2556
     .(32,11),R(32,11),RAD(8,25),RADR(8,25),RCURVE(32,11),RH(32),RINT(11OFFD2557
     .),RPM(1),RS(32),RSLOPE(32,11),RULE(25),SHAPE(25),SIXTY5(25),SO(8,2OFFD2558
     .5),SCR(8,25),SS(8,25),SSR(8,25),TERMC(11),TH(8,25),THC(8,25),THCR(OFFD2559
     .8,25),THR(8,25),TITLE(36),TO(32,11),TSTAT(11),X(32)               OFFD2560
      COMMON  /SCALAR/                                                  OFFD2561
     .A,AA,A10AC,A202A0,A303A0,A404A0,A505A0,ANG,B,BB,CC,CENT,CM,CMEAN,COFFD2562
     .MEANP,CMI,COREC,COUNT,CP,CPI2,CPI3,CPI4,CPI5,CPI6,CPO2,CPO3,CPO4,COFFD2563
     .PO5,CAMP,CCP,DELFLO,DFACT,EMACH,EPISON,FACTM,G,GAMMER,GASK,GJ,GR2,OFFD2564
     .H,HIGH,HIPRES,I,IG,IGO,ICUTTR,IPASS,J,JJ,JM,JM1,JOULE,K,KDEL,KK,L,OFFD2565
     .LAST,LC1,LEVEL,LST,LSTAGE,M,MACH,MAXPT,MINPT,N,NBLADE,NDATA,NLINESOFFD2566
     .,NSETS,NSPEED,NTUBES,NX,NX1,OFF,OK,PHI,PLOW,Q,RA,RADIAN,RDFLO,REF,OFFD2567
     .RESTAR,RMACH,S,SOLID,SPEED,STOP,T,TERMD,THICK,TIME,TOLAT,TOLCX,TOLOFFD2568
     .MIN,TOLR,TONE,V,VMI,YES                                           OFFD2569
      ISTA= MAXO(5,NOW)                                                 OFFD2570
      DO 100 I=ISTA,NX                                                  OFFD2571
      IF (I.GT.LSTAGE)  GO TO 80                                        OFFD2572
      IF (ROTOR(I-4)) 50,80,10                                          OFFD2573
   10 DO 30 J=1,NLINES                                                  OFFD2574
C -----    CALCULATE THE TEMPERATURE AND TANGENTIAL VELOCITY FOR A      OFFD2575
C       ROTOR.                                                          OFFD2576
      CU(I,J)= RPM(1)*R(I,J) -SQRT( CX(I,J)**2 +CR(I,J)**2)*TAN(BETA    OFFD2577
     X (I,J))                                                           OFFD2578
      H=  RPM(N)*(R(I,J)*CU(I,J) -R(I-1,J)*CU(I-1,J))*2.0/GJ            OFFD2579
      T= TO(I-1,J)                                                      OFFD2580
      CALL  ENTALP                                                      OFFD2581
   30 TO(I,J)= TSTAT(J)                                                 OFFD2582
      GO TO 100                                                         OFFD2583
   50 DO 60 J=1,NLINES                                                  OFFD2584
C -----    CALCULATE THE TEMPERATURE AND TANGENTIAL VELOCITY FOR A      OFFD2585
C       STATOR.                                                         OFFD2586
      CU(I,J)= SQRT( CX(I,J)**2 +CR(I,J)**2)*TAN(ALPHA(I,J))            OFFD2587
   60 TO(I,J)= TO(I-1,J)                                                OFFD2588
      GO TO 100                                                         OFFD2589
   80 DO 90 J=1,NLINES                                                  OFFD2590
      TO(I,J)= TO(I-1,J)                                                OFFD2591
C -----    CONSERVATION OF MOMENTUM IS ASSUMED FOR AN ANNULUS.          OFFD2592
```

```
 90 CU(I,J)= R(I-1,J)*CU(I-1,J)/R(I,J)                          OFFD2593
100 CONTINUE                                                     OFFD2594
    RETURN                                                       OFFD2595
    END                                                          OFFD2596
```

```
      SUBROUTINE PREIT2
C
      COMMON /GET IT/ ROTOR(29)
      COMMON /FULL/  BUCKET, NOW
      LOGICAL   CIRCLE,   SIXTY5
      REAL      IREF,          JOULE,          MACH,
     X METAL,   MIN,           MINR,           MOUT,
     X MOUTR
      INTEGER BLADE,           COUNT
      LOGICAL         OFF,     OK,             ROFLO,
     X RESTAR,        TONE
      INTEGER   ROLE
      REAL KDEL,KDEL2
      COMMON  /VECTOR/
     .ALPHA(29,11),ATAR(25,11),BETA(29,11),BH(32),BLADE(25),BT(32),CIRCL
     .E(25),CO(32,11),CPCO(5),CR(32,11),CSLOPE(32,11),CU(32,11),CX(32,11
     .),CXM(11),CXNEW(11),DA(10),DELM(11),DEPV(32,11),DF(20),DFLOW(32),F
     .LOW(32),FORM(25),FOUND(20,5,10),IREF(25,11),ITYPE(25),METAL(2),MET
     .ODE(25),MIN(8,25),MINR(8,25),MOUT(8,25),MOUTR(8,25),NIN(25),NRAD(2
     .5),NS(25),NSS(25),NTC(25),NTH(25),NXIT(25),OBAR(25,11),OFFD(25),PO
     .(32,11),R(32,11),RAD(8,25),RADR(8,25),RCURVE(32,11),RH(32),RINT(11
     .),RPM(1),RS(32),RSLOPE(32,11),ROLE(25),SHAPE(25),SIXTY5(25),SO(8,2
     .5),SOR(8,25),SS(8,25),SSR(8,25),TERMC(11),TH(8,25),THC(8,25),THCR(
     .8,25),THR(8,25),TITLE(36),TO(32,11),TSTAT(11),X(32)
      COMMON  /SCALAR/
     .A,AA,A101AC,A202AC,A303AC,A404AC,A505AC,ANG,B,BB,CC,CENT,CM,CMEAN,C
     .MEANP,CM2,COREC,COUNT,CP,CPI2,CPI3,CPI4,CPI5,CPI6,CPO2,CPO3,CPO4,CO
     .PO5,DAMP,DCP,DELFLO,DFACT,EMACH,EPISON,FACTM,G,GAMMER,GASK,GJ,GR2,
     .H,HIGH,HIPRES,I,IG,IGG,ICUTTR,IPASS,J,JJ,JM,JM1,JOULE,K,KDEL,KK,L,
     .LAST,LCI,LEVEL,LST,LSTAGE,M,MACH,MAXPT,MINPT,N,NBLADE,NDATA,NLINES
     .NSETS,NSPEED,NTUBES,NX,NX1,OFF,OK,PHI,PLOW,Q,RA,RADIAN,ROFLO,REF,
     .RESTAR,RMACH,S,SOLID,SPEED,STOP,T,TERMP,THICK,TIME,TOLAT,TOLCX,TOL
     .MIN,TOLR,TONE,V,VMI,YES
C
C       1 - SP-36  2-D
C       2 - SP-36  3-D
C       3 - SUCTION SURFACE
C       4 - TABLE  INPUT
      OK= .TRUE.
      DO 10 J=1,NTUBES
   10 CALL XDERIV(R,RSLOPE)
      DO 1 J=1,NLINES
      ALPHA(4,J)= 0.0
    1 BETA(4,J)= ATAN(RPM(N)*R(4,J)/CX(4,J))
      ISTA= MAX0(5,NOW   )
      DO 50 I=ISTA,LSTAGE
      DO 50 J=1,NLINES
      CR(I,J)= CX(I,J)*RSLOPE(I,J)
C        *** CALCULATE BLADE PROPERTIES
      IF (ROTOR(I-4).EQ.0.0) GO TO 44
      METAL(1)= SLINE(R(I-1,J),MINR(1,I-4),MIN(1,I-4),NIN(I-4))
      METAL(1)= ATAN(TAN(METAL(1))/SQRT( 1.0 +RSLOPE(I-1,J)**2))
      METAL(2)= SLINE(R(I,J),MOUTR(1,I-4),MOUT(1,I-4),NXIT(I-4))
      METAL(2)= ATAN(TAN(METAL(2))/SQRT( 1.0 +RSLOPE(I,   J)**2))
      A= R(I,J) + R(I-1,J)
```

```
      HIGH= (RS(I) + RS(I-1) - A)/(RS(I)+RS(I-1)-RH(I)-RH(I-1))
      A= A*.5
      SOLID=    SLINE(A,SOR(1,I-4),SO(1,I-4),NS(I-4))
      THICK=    SLINE(A,THCR(1,I-4),THC(1,I-4),NTC(I-4))

C         *** CALCULATE ABSOLUTE VELOCITY

      V= CX(I- ,J)**2 + CU(I-1,J)**2 + CR(I-1,J)**2
      ANG= BETA(I-1,J)
      IF (ROTOR(I-4).GT.0.0)  GO TO 113
      ANG= ALPHA(I-1,J)
      S= V
      GO TO 114

C         *** CALCULATE RELATIVE VELOCITY

  113 S= CX(I-1,J)**2 +(RPM(N)*R(I-1,J) -CU(I-1,J))**2 +CR(I-1,J)**2

C         *** COMPUTE RELATIVE MACH NUMBER

  114 H= -V/GJ
      T= TO(I-1,J)
      CALL  ENTALP
      CALL  GAM
      RMACH= SQRT(S/(GR2*GAMMER*TSTAT(J)))
C        *** CALCULATE REFERENCE INCIDENCE
      PHI= METAL(1) - METAL(2)
      IGO= METHOD(I-4)
      COREC= COREC2(THICK)*FORM(I-4)
      KDEL= KDEL2(THICK)*SHAPE(I-4)
      KDEL = KDEL /RADIAN
      GO TO (200,300,220,220),IGO
  200 IREF(I-4,J)= SP36(COREC,PHI)
      IF (RULE(I-4).EQ.1.OR.RULE(I-4).EQ.3)  GO TO 250
      IF (SIXTYS(I-4))  GO TO 205
      REF= REF1(RMACH,HIGH)
      GO TO 210
  205 REF= REF2(RMACH,HIGH)
  210 IREF(I-4,J)= IREF(I-4,J) +REF
      GO TO 250
  220 CONTINUE
      RA= SLINE(A,RADR(1,I-4),RAD(1,I-4),NRAD(I-4))
      IF (IGO.EQ.4)  GO TO 240
      IREF(I-4,J)= 2.0*ATAN((TAN(PHI*0.25) -2.0*RA*THICK*COS(PHI*0.5)
     X  +THICK)/(1.0 +2.0*RA*THICK*SIN(PHI*0.5)))
     X  -PHI*0.5
      GO TO 250
  240 IREF(I-4,J)= RA
  250 CONTINUE
      ANG= METAL(1) +IREF(I-4,J)
      IF (SIXTYS(I-4))  GO TO 255
      FACTM= FACTM1(ANG)
      GO TO 257
  255 FACTM= FACTM2(ANG)
  257 CONTINUE
      AA= KDEL*DEVI8(ANG,SOLID)
```

```
     X +PHI*FACIM/SOLID**EXPB(ANG)
      JJ= RULE(I-4)
      GO TO (290,250,270,260),JJ
  250 AA= AA +(IREF(I-4,J) -SP36(COREC,PHI))*SLOPE(ANG,SOLID)
      IF (JJ.EQ.2) GO TO 290
  270 IF (CIRCLE(I-4)) GO TO 280
      AA= DERUL2(RMACH,HIGH) +AA
      GO TO 290
  280 AA= DERUL1(RMACH,HIGH) +AA
  290 CONTINUE
      A= PHI +IREF(I-4,J) -AA
      IF (ROTOR(I-4).GT.0.0) GO TO 116

C         *** CALCULATE ABSOLUTE GAS FLOW ANGLE

      ALPHA(I,J)= A*DEVI((ALPHA(I-1,J) -METAL(1) -IREF(I-4,J))/A)
     X +METAL(2) +AA

C         *** CALCULATE WHIRL(TANGENTIAL) VELOCITY (NEW + OLD)/2

      CU(I,J)= SQRT( CX(I,J)**2 +CR(I,J)**2)*TAN(ALPHA(I,J))

C         *** COMPUTE RELATIVE FLOW ANGLE

      BETA(I,J)= ATAN((RPM(1)*R(I,J) -CU(I,J))/SQRT( CX(I,J)**2
     X  +CR(I,J)**2))
      GO TO 50
  116 CONTINUE

C         *** COMPUTE RELATIVE GAS FLOW ANGLE

      BETA(I,J)= DEVI((BETA(I-1,J) -METAL(1) -IREF(I-4,J))/A)*A
     X +METAL(2) +AA

C         *** COMPUTE TANGENTIAL VELOCITY

      CU(I,J)= RPM(1)*R(I,J)  -SQRT( CX(I,J)**2 +CR(I,J)**2)*TAN(BETA
     X (I,J))

C         *** CALCULATE ABSOLUTE GAS FLOW ANGLE

      S= SQRT( CX(I,J)**2 +CR(I,J)**2)
      ALPHA(I,J)= ATAN(CU(I,J)/S)
      GO TO 50

C         *** SET ANGLES WHERE THERE IS NO BLADE

   44 IREF(I-4,J)=0.0
      CU(I,J)= CU(I-1,J)*R(I-1,J)/R(I,J)
      S= SQRT( CX(I,J)**2 +CR(I,J)**2)
      ALPHA(I,J)= ATAN(CU(I,J)/S)
      BETA(I,J)= ATAN((RPM(1)*R(I,J) -CU(I,J))/SQRT( CX(I,J)**2
     X  +CR(I,J)**2))
   50 CONTINUE
      DO 80 I=ISTA,LSTAGE
      DO 50 J=1,NLINES
```

```
                                                                   05/02/68
        PR2.        -  EFN    SOURCE STATEMENT   -   IFN(S)   -

      IF (ROTOR(I-4).GT.0.0)  GO TO 70                                 OFFD2061
   77 TO(I,J)= TO(I-1,J)                                               OFFD2062
      GO TO 80                                                         OFFD2063
                                                                       OFFD2064
C          *** CALCULATE ROTOR QUANTITIES                              OFFD2065
                                                                       OFFD2066
   70 RINT(J)=(RPM(N)*(R(I,J)*CU(I,J) -R(I-1,J)*CU(I-1,J))/GJ)*2.0     OFFD2067
      H= RINT(J)                                                       OFFD2068
      T= TO(I-1,J)                                                     OFFD2069
      CALL ENTALP                                                      OFFD2070
      IF (ABS((TSTAT(J) -TO(I,J))/TO(I,J)).GT.TOLR)  OK= .FALSE.       OFFD2071
      TO(I,J)= TSTAT(J)                                                OFFD2072
   80 CONTINUE                                                         OFFD2073
C          *** SET EXIT QUANTITIES                                     OFFD2074
                                                                       OFFD2075
      RETURN                                                           OFFD2076
      END                                                              OFFD2077
```

```
      FUNCTION  P SIDE( ACH)
      REAL MSIDE
      COMMON /FULL/  BUCKET
      LOGICAL  CIRCLE,  SIXTY5
      REAL               IREF,             JOULE,           MACH,
     X METAL,            MIN,              MINR,            MOUT,
     X MOUTR
      INTEGER BLADE,                       COUNT
      INTEGER  RULE
      REAL KDEL,KDEL2
      COMMON  /VECTOR/
     .ALPHA(29,11),ATAR(25,11),BETA(29,11),BH(32),BLADE(25),BT(32),CIRCL
     .E(25),CO(32,11),CPCO(6),CR(32,11),CSLOPE(32,11),CU(32,11),CX(32,11
     .),CXM(11),CXNEW(11),DA(10),DELM(11),DEPV(32,11),DF(20),DFLOW(32),F
     .LOW(32),FORM(25),FOUND(20,3,10),IREF(25,11),ITYPE(25),METAL(2),MET
     .HOD(25),MIN(8,25),MINR(8,25),MOUT(8,25),MOUTR(8,25),NIN(25),NRAD(2
     .5),NS(25),NSS(25),NTC(25),NTH(25),NXIT(25),OBAR(25,11),OFFD(25),PO
     .(32,11),R(32,11),RAD(8,25),RADR(8,25),RCURVE(32,11),RH(32),RINT(11
     .),RPM(1),RS(32),RSLOPE(32,11),RULE(25),SHAPE(25),SIXTY5(25),SO(8,2
     .5),SOR(8,25),SS(8,25),SSR(8,25),TERMC(11),TH(8,25),THC(8,25),THCR(
     .8,25),THR(8,25),TITLE(36),TO(32,11),TSTAT(11),X(32)
      COMMON  /SCALAR/
     .A,AA,A1O1A0,A202A0,A303A0,A404A0,A5C5A0,ANG,B,BB,CC,CENT,CM,CMEAN,C
     .MEANP,CM2,COREC,COUNT,CP,CPI2,CPI3,CPI4,CPI5,CPI6,CPO2,CPO3,CPO4,CO
     .POS,DAMP,DCP,DELFLO,DFACT,EMACH,EPISON,FACTM,G,GAMMER,GASK,GJ,GR2,
     .H,HIGH,HIPRES,I,IG,IGO,IOUTTR,IPASS,J,JJ,JM,JM1,JOULE,K,KDEL,KK,L,
     .LAST,LC1,LEVEL,LST,LSTAGE,M,MACH,MAXPT,MINPT,N,NBLADE,NDATA,NLINES
     .,NSETS,NSPEED,NTUBES,NX,NX1,OF ,OK,PHI,PLOW,Q,RA,RADIAN,RDFLO,REF,
     .RESTAR,RMACH,S,SCLID,SPEED,STOP,T,TERMD,THICK,TIME,TOLAT,TOLCX,TOL
     .MIN,TOLR,TONE,V,VMI,YES
      LOGICAL MID
      DIMENSION OFF(12,3,2), ANS(2), HM(2)
      DIMENSION  AC(12)
      DATA  AC/ 0.0, 0.6, 0.65, C.7, 0.75, 0.8, 0.85, 0.9, 0.95, 1.0,
     X 1.05, 1.1 /, HM / 0.1, 0.5 /, OFF /
     X 0.0   ,.0012 ,.0015 ,.0019 ,.0024 ,.0031 ,.0042 ,.00675,.0107 ,
     X 0.0196,.03    ,.05    ,
     X 0.0   ,.0006 ,.0007 ,.0009 ,.001   ,.00145,.0022 ,.0033 ,.00465,
     X .00638,.00875,.01345,
     X 0.0   ,.00065,.0008 ,.00105,.00125,.00145,.00185,.00285,.0051 ,
     X .00825,.0118 ,.0158 ,
     X 0.0   ,.0009 ,.00115,.0015 ,.0019 ,.00235,.0029 ,.00365,.00455,
     X .00585,.008  ,.0118 ,
     X 0.0   ,.0006 ,.0007 ,.00075,.00085,.00115,.00195,.00295,.00415,
     X .00555,.0074 ,.0099,
     X 0.0   ,.00065,.0008 ,.00105,.00125,.00145,.00185,.00285,.0051 ,
     X .00825,.0118 ,.0158 /
      JQ= 1
      GO TO 5
      ENTRY     M SIDE( ACH)
      JQ= 2
    5 KQ= 0
      MID= .FALSE.
      A=MACH
      IQ= 1
```

```
      IF (CENT.GT.HM(2))  IQ= 3                                         OFFD1549
   10 KQ= KQ +1                                                         OFFD1550
      IF (A.GT.AC(KQ+1).AND.KQ.LT.11)  GO TO 10                         OFFD1551
      L= 0                                                              OFFD1552
   20 MID= .NOT.MID                                                     OFFD1553
      L= L+1                                                            OFFD1554
      ANS(L)= (OFF(KQ+1,IQ,JQ) -OFF(KQ,IQ,JQ))*(A -AC(KQ))/(AC(KQ+1)   OFFD1555
     X  -AC(KQ))  +OFF(KQ,IQ,JQ)                                        OFFD1556
      IQ= IQ+1                                                          OFFD1557
      IF (MID)  GO TO 20                                                OFFD1558
      PSIDE= (2.5*(ANS(2) -ANS(1))*(CENT -HM(IQ -2)) +ANS(1))/BUCKET    OFFD1559
      MSIDE=PSIDE                                                       OFFD1560
      RETURN                                                            OFFD1561
      END                                                               OFFD1562
```

```
      FUNCTION REFL(RMACH,HIGH)                                        OFFD1660
      DIMENSION HTAB(5), RMNTAB(10),CRITAB(10,5)                       OFFD1661
C -----   DEDUCED VARIATION OF AVERAGE ROTOR REFERENCE INCIDENCE ANGLE OFFD1662
C        MINUS LOW-SPEED TWO-DIMENSIONAL-CASCADE-RULE REFERENCE        OFFD1663
C       INCIDENCE ANGLE WITH RELATIVE INLET MACH NUMBER FOR           OFFD1664
C       DOUBLE-CIRCULAR-ARC BLADES.                                    OFFD1665
C         FIGURE 201B  NASA  SP-36                                     OFFD1666
      COMMON /SCALAR/ QQ(81),  RADIAN,   QQQ(21)                       OFFD1667
      DATA  HTAB/.1,.3,.5,.7,.9/,RMNTAB/.2,.3,.4,.5,.6,.7,.8,.9,.95,1.0/OFFD1668
     X ,CRITAB / -2.5,-2.5                                             OFFD1669
     2,-2.4,-2.3,-1.7,-.6,1.2,2.6,3.1,3.4,-2.,-2.,-2.,-1.62,-.5,1.1,2.9,OFFD1670
     34.4,5.0,5.5,-1.58,-1.5,-1.42,-.85,.5,2.5,4.58,6.0,6.5,6.8,-1.,-1.,OFFD1671
     4-.9,0.,1.6,3.7,5.8,7.39,7.8,7.92,-.5,-.5,-.3,.8,2.52,4.9,7.2,8.5, OFFD1672
     58.9,9.0/                                                         OFFD1673
      A=RMACH                                                          OFFD1674
      B=HIGH                                                           OFFD1675
      K=(INT(10.*B)+1)/2                                               OFFD1676
      K=MAX0(MIN0(K,4),1)                                              OFFD1677
      ANS1= SLINE(A,RMNTAB,CRITAB(1,K),10)                             OFFD1678
      ANS2= SLINE(A,RMNTAB,CRITAB(1,K+1),10)                           OFFD1679
   10 REFL= (ANS1 + (ANS2-ANS1)/(HTAB(K+1)-HTAB(K))*(B-HTAB(K)))/RADIAN OFFD1680
      RETURN                                                           OFFD1681
      END                                                              OFFD1682
```

```
      FUNCTION REF2(FMACH,HIGH)                                        0FFD1779
C -----    DEDUCED VARIATION OF AVERAGE ROTOR REFERENCE INCIDENCE ANGLE  0FFD1780
C        MINUS LOW-SPEED TWO-DIMENSIONAL-CASCADE-RULE REFERENCE        0FFD1781
C         INCIDENCE ANGLE WITH RELATIVE INLET MACH NUMBER FOR NACA     0FFD1782
C         65-(A10)-SERIES BLADES.                                      0FFD1783
C            FIGURE 201A  NASA  SP-36                                  0FFD1784
      DIMENSION HTAB(5),C(5)                                           0FFD1785
      COMMON /SCALAR/ CQ(81),  RADIAN,   QCC(21)                       0FFD1786
      DATA HTAB, C /.1,.3,.5,.7,.9,-2.5,-1.8,-1.0,0.2,1.5 /            0FFD1787
      REF2= SLINE(HIGH,HTAB,C,5)/RADIAN                                0FFD1788
      RETURN                                                           0FFD1789
      END                                                              0FFD1790
```

```
      SUBROUTINE RSTART
C
C        *** CALCULATES EQUAL AREA ESTIMATE OF STREAMLINE POSITION
C
      LOGICAL  CIRCLE,  SIXTY5
      REAL             IREF,            JOULE,           MACH,
     X METAL,          MIN,             MINR,            MOUT,
     X MOUTR
      INTEGER BLADE,                    COUNT
      LOGICAL          OFF,             OK,              RDFLO,
     X RESTAR,         TONE
      INTEGER  RULE
      REAL KDEL,KDEL2
      COMMON  /VECTOR/
     .ALPHA(25,11),ATAR(25,11),BETA(29,11),BH(32),BLADE(25),BT(32),CIRCL
     .E(25),CO(32,11),CPCO(6),CR(32,11),CSLOPE(32,11),CU(32,11),CX(32,11
     .),CXM(11),CXNEW(11),DA(10),DELM(11),DEPV(32,11),DF(20),DFLOW(32),FO
     .LOW(32),FORM(25),FOUND(20,3,10),IREF(25,11),ITYPE(25),METAL(2),MET
     .HOD(25),MIN(8,25),MINR(8,25),MOUT(8,25),MOUTR(8,25),NIN(25),NRAD(2
     .5),NS(25),NSS(25),NTC(25),NTH(25),NXIT(25),OBAR(25,11),OFFD(25),PO
     .(32,11),R(32,11),RAD(8,25),RADR(8,25),RCURVE(32,11),RH(32),RINT(11
     .),RPM(1),RS(32),RSLOPE(32,11),RULE(25),SHAPE(25),SIXTY5(25),SO(8,2
     .5),SOR(8,25),SS(8,25),SSR(8,25),TERMC(11),TH(8,25),THC(8,25),THCR(
     .8,25),THR(8,25),TITLE(36),TO(32,11),TSTAT(11),X(32)
      COMMON  /SCALAR/
     .A,AA,A1O1A0,A2O2A0,A3O3A0,A4O4A0,A5O5A0,ANG,B,BB,CC,CENT,CM,CMEAN,CO
     .MEANP,CM2,COREC,COUNT,CP,CPI2,CPI3,CPI4,CPI5,CPI6,CPO2,CPO3,CPO4,CO
     .PO5,DAMP,DCP,DELFLO,DFACT,EMACH,EPISON,FACTM,G,GAMMER,GASK,GJ,GR2,
     .H,HIGH,HIPRES,I,IG,IGO,ICUTTR,IPASS,J,JJ,JM,JM1,JOULE,K,KDEL,KK,L,
     .LAST,LCL,LEVEL,LST,LSTAGE,M,MACH,MAXPT,MINPT,N,NBLADE,NDATA,NLINES
     .,NSETS,NSPEED,NTUBES,NX,NX1,OFF,OK,PHI,PLOW,Q,RA,RADIAN,RDFLO,REF,
     .RESTAR,RMACH,S,SOLID,SPEED,STOP,T,TERMO,THICK,TIME,TOLAT,TOLCX,TOL
     .MIN,TOLR,TONE,V,VM1,YES


      DO 10 I=1,NX
      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
      DO 10 J=1,NLINES
      ERAS1= AA +DELM(J)*CC

C        *** ERROR TRANSFER TO A NEW DATA SET
      IF (ERAS1.LT.0.) CALL ERROR(15)
   10 R(I,J)= SQRT(ERAS1)
      J= 1
      CALL  XDERIV(R,RSLOPE)
      J= NLINES
      CALL  XDERIV(R,RSLOPE)
      RETURN
      END
```

```
      FUNCTION    SLINE(X,XT,YT,N)
C -----    STRAIGHT LINE INTERPOLATION ROUTINE.
      DIMENSION XT(1),YT(1)
      IF (N-1) 3, 3, 11
    3 SLINE=YT(1)
      GO TO 2
   11 DO 8 I=2,N
      IF(X-XT(I)) 9, 10, 8
    8 CONTINUE
      I = N
    9 SLINE=(YT(I)-YT(I-1))*(X-XT(I-1))/(XT(I)-XT(I-1))+YT(I-1)
      GO TO 2
   10 SLINE=YT(I)
    2 RETURN
      END
```

```
      FUNCTION SLOPE(ANG,SOLID)                                    0FFD1630
      DIMENSION COEF(6,6),DEG(6)                                   0FFD1631
      COMMON /SCALAR/ QU(81),   RADIAN,    QQQ(21)                 0FFD1632
      DATA  COEF, DEG /                                            0FFD1633
     X 0.99099346,    -3.011759,    4.2921655,                     0FFD1634
     X -3.4509487,    1.4851443,    -0.25894861,                   0FFD1635
     X 0.99699544,    -2.7549694,   3.4863607,                     0FFD1636
     X -2.4634244,    0.93023323,   -0.14398689,                   0FFD1637
     X 0.99910585,    -2.5241725,   2.9249367,                     0FFD1638
     X -1.7215087,    0.56298301,   -0.077439575,                  0FFD1639
     X 0.99928508,    -2.170019,    1.9204703,                     0FFD1640
     X -0.61285781,   0.14920688,   -0.64582498E-2,                0FFD1641
     X 1.0009804,     -1.6830904,   0.70910027,                    0FFD1642
     X 0.36425018,    -0.270269,    0.090840853,                   0FFD1643
     X 0.99927569,    -1.1334851,   -0.24760659,                   0FFD1644
     X 0.8294628,     -0.35717499, 0.042019739,                    0FFD1645
     X 0.0, 30.0, 40.0, 50.0, 60.0, 70.0/                          0FFD1646
      A=ANG*RADIAN                                                 0FFD1647
      S=SOLID                                                      0FFD1648
      K=0                                                          0FFD1649
   10 K=K+1                                                        0FFD1650
      IF (DEG(K+1).LT.A.AND.K.LT.5) GU TO 10                       0FFD1651
      P1= COEF(1,K) +(COEF(2,K) +(COEF(3,K) +(COEF(4,K)            0FFD1652
     X    +(COEF(5,K) +COEF(6,K)*S)*S)*S)*S)*S                     0FFD1653
      P2= COEF(1,K+1) +(COEF(2,K+1) +(COEF(3,K+1) +(COEF(4,K+1)    0FFD1654
     X    +(COEF(5,K+1) +COEF(6,K+1)*S)*S)*S)*S)*S                 0FFD1655
      SLOPE= (?2-P1)*(A-DEG(K))/(DEG(K+1)-DEG(K)) +P1              0FFD1656
      RETURN                                                       0FFD1657
      END                                                          0FFD1658
```

```
         SCN.        -  EFN   SOURCE STATEMENT  -  IFN(S)  -

      FUNCTION SLOPE N(S,SOLID)                                          OFFD0236
C -----   REFERENCE MINIMUM-LOSS-INCIDENCE-ANGLE SLOPE FACTOR DEDUCED    OFFD0237
C       FROM LOW-SPEED-CASCADE DATA FOR NACA 65-(A10)-SERIES BLADES AS   OFFD0238
C        EQUIVALENT CIRCULAR ARCS.                                       OFFD0239
C         FIGURE 138  NASA  SP-36                                        OFFD0240
      DIMENSION COEF(6,9),SC(8)                                          OFFD0241
      COMMON /SCALAR/ QQ(81),  RADIAN,   QQQ(21)                         OFFD0242
      DATA  COEF, SC  /                                                  OFFD0243
     X -0.49855324E-1,-0.36393752E-2,-0.11206091E-4,                     OFFD0244
     X -0.55598232E-6,0.75141597E-8,-0.53636150E-10,                     OFFD0245
     X -0.44041025E-1,-0.29902579E-2,0.18044037E-4,                      OFFD0246
     X -0.17597340E-5,0.30013278E-7,-0.21709220E-9,                      OFFD0247
     X -0.37907809E-1,-0.26679713E-2,0.64371193E-4,                      OFFD0248
     X -0.38966434E-5,0.69512138E-7,-0.47494801E-9,                      OFFD0249
     X -0.35055707E-1,-0.12668957E-2,-0.13698955E-4,                     OFFD0250
     X -0.10026503E-5,0.24044315E-7,-0.22515083E-9,                      OFFD0251
     X -0.30145675E-1,-0.90753056E-3,0.17156383E-4,                      OFFD0252
     X -0.25536417E-5,0.51905073E-7,-0.39190039E-9,                      OFFD0253
     X -0.24796629E-1,-0.22605509E-3,-0.23662573E-4,                     OFFD0254
     X -0.42005339E-6,0.87044762E-8,-0.10488527E-9,                      OFFD0255
     X -0.20089289E-1,0.17616179E-3,-0.23213523E-4,                      OFFD0256
     X -0.41501533E-6,0.60103574E-8,-0.72904324E-10,                     OFFD0257
     X -0.15260021E-1,0.29408091E-3,-0.28628478E-4,                      OFFD0258
     X 0.39496235E-6,-0.13306952E-7,0.59930345E-10,                      OFFD0259
     X -0.10160368E-1,0.17022481E-3,-0.15264751E-4,                      OFFD0260
     X 0.40024713E-6,-0.17382094E-7,0.96414519E-10,                      OFFD0261
     X 0.4, 0.6, 0.8, 1.0, 1.2, 1.4, 1.6, 1.8/                           OFFD0262
      SOD=SOLID                                                          OFFD0263
      A=S*RADIAN                                                         OFFD0264
      K=MAX0(1,MIN0(8,INT(5.0*SOD)-1))                                   OFFD0265
      P1=COEF(1,K)+(COEF(2,K)+(COEF(3,K)+(COEF(4,K)+(COEF(5,K)+COEF(6,K)OFFD0266
     X *A)*A)*A)*A)*A                                                    OFFD0267
      P2=COEF(1,K+1) +(COEF(2,K+1) +(COEF(3,K+1) +(COEF(4,K+1)          OFFD0268
     X  +(COEF(5,K+1) +COEF(6,K+1)*A)*A)*A)*A)*A                         OFFD0269
      SLOPE N= (P2-P1)*(SOD-SC(K))*5.0 +P1                               OFFD0270
      RETURN                                                             OFFD0271
      END                                                                OFFD0272
```

```
      FUNCTION  SP36(QQQQ)
      LOGICAL  CIRCLE,  SIXTY5
      REAL            IREF,           JOULE,          MACH,
     X METAL,         MIN,            MINR,           MOUT,
     X MOUTR
      INTEGER BLADE,                  COUNT
      LOGICAL         OFF,            OK,             ROFLO,
     X RESTAR,        TONE
      INTEGER  RULE
      REAL KDEL,KDEL2
      COMMON  /VECTOR/
     .ALPHA(29,11),ATAR(25,11),BETA(29,11),BH(32),BLADE(25),BT(32),CIRCL
     .E(25),CO(32,11),CPCO(6),CR(32,11),CSLOPE(32,11),CU(32,11),CX(32,11
     .),CXM(11),CXNEW(11),DA(10),DELM(11),DEPV(32,11),DF(20),DFLOW(32),F
     .LOW(32),FORM(25),FOUND(20,3,10),IREF(25,11),ITYPE(25),METAL(2),MET
     .HOD(25),MIN(8,25),MINR(8,25),MOUT(8,25),MOUTR(8,25),NIN(25),NRAD(2
     .5),NS(25),NSS(25),NTC(25),NTH(25),NXIT(25),OBAR(25,11),OFFD(25),PO
     .(32,11),R(32,11),RAD(8,25),RADF(8,25),RCURVE(32,11),RH(32),RINT(11
     .),RPM(2),PS(32),RSLOPE(32,11),RULE(25),SHAPE(25),SIXTY5(25),SC(8,2
     .5),SOR(8,25),SS(8,25),SSF(8,25),TERMC(11),TH(8,25),THC(8,25),THCR(
     .8,25),THR(8,25),TITLE(36),TO(32,11),TSTAT(11),X(32)
      COMMON  /SCALAR/
     .A,AA,A101A0,A202A0,A303A0,A404A0,A505A0,ANG,B,BB,CC,CENT,CM,CMEAN,C
     .MEANP,CM2,COREC,COUNT,CP,CPI2,CPI3,CPI4,CPI5,CPI6,CPO2,CPO3,CPO4,C
     .PO5,DAMP,DCP,DELFLO,DFACT,EMACH,EPISON,FACTM,G,GAMMER,GASK,GJ,GR2,
     .H,HIGH,HIPRES,I,IJ,IGO,ICUTTR,IPASS,J,JJ,JM,JM1,JOULE,K,KDEL,KK,L,
     .LAST,LC1,LEVEL,LST,LSTAGE,M,MACH,MAXPT,MINPT,N,NBLADE,NDATA,NLINES
     .,NSETS,NSPEED,NTUBES,NX,NX1,OFF,OK,PHI,PLOW,Q,RA,RADIAN,RDFLO,REF,
     .RESTAR,RMACH,S,SOLID,SPEED,STOP,T,TERMD,THICK,TIME,TOLAT,TOLCX,TOL
     .MIN,TOLR,TONE,V,VMI,YES

      S= METAL(1) +0.01
   10 DO 20 K=1,25
      SP36= COREC*CAMBER(S,SOLID) +PHI*SLOPE N(S,SOLID)
      S= METAL(1) +SP36
      IF (ABS(S-B).LE.0.0101) RETURN
   20 S= B
      CALL  ERROR (9)
      GO TO 10
      END
```

```
      SUBROUTINE STREAM

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

      LOGICAL  YES
      LOGICAL  CIRCLE,  SIXTY5
      REAL              IREF,              JOULE,             MACH,
     X METAL,           MIN,               MINR,              MOUT,
     X MOUTR
      INTEGER BLADE,                       COUNT
      LOGICAL           OFF,               OK,                RDFLO,
     X RESTAR,          IONE
      INTEGER  RULE
      REAL KDEL,KDEL2
      COMMON  /VECTOR/
     .ALPHA(29,11),ATAR(25,11),BETA(29,11),BH(32),BLADE(25),BT(32),CIRCL
     .E(25),CU(32,11),CPCO(6),CR(32,11),CSLOPE(32,11),CU(32,11),CX(32,11
     .),CXM(11),CXNEW(11),DA(10),DELM(11),DEPV(32,11),DF(20),DFLOW(32),F
     .LOW(32),FORM(25),FCUND(20,3,10),IREF(25,11),ITYPE(25),METAL(2),MET
     .HOD(25),MIN(8,25),MINR(8,25),MOUT(8,25),MOUTR(8,25),NIN(25),NRAD(2
     .5),NS(25),NSS(25),NTC(25),NTH(25),NXIT(25),OBAR(25,11),OFFD(25),PO
     .(32,11),R(32,11),RAD(8,25),RADR(8,25),RCURVE(32,11),RH(32),RINT(11
     .),RPM(1),RS(32),RSLOPE(32,11),RULE(25),SHAPE(25),SIXTY5(25),SO(8,2
     .5),SOR(9,25),SS(8,25),SSR(8,25),TERMC(11),TH(8,25),THC(8,25),THCR(
     .8,25),THR(8,25),TITLE(36),TO(32,11),TSTAT(11),X(32)
      COMMON  /SCALAR/
     .A,AA,A1OA0,A2O2A0,A3O3A0,A4O4A0,A5O5A0,ANG,B,BB,CC,CENT,CM,CMEAN,C
     .MEANP,CM2,COREC,COUNT,CP,CPI2,CPI3,CPI4,CPI5,CPI6,CPO2,CPO3,CPO4,C
     .PO5,DAMP,DCP,DELFLO,DFACT,EMACH,EPISON,FACTM,G,GAMMER,GASK,GJ,GR2,
     .H,HIGH,HIPRES,I,IG,IGO,IOUTTR,IPASS,J,JJ,JM,JM1,JOULE,K,KDEL,KK,L,
     .LAST,LC1,LEVEL,LST,LSTAGE,M,MACH,MAXPT,MINPT,N,NBLADE,NDATA,NLINES
     .,NSETS,NSPEED,NTUBES,NX,NX1,OFF,OK,PHI,PLOW,Q,RA,RADIAN,RDFLO,REF,
     .RESTAR,RMACH,S,SOLID,SPEED,STOP,T,TERMD,THICK,TIME,TOLAT,TOLCX,TOL
     .MIN,TOLR,TONE,V,VM1,YES
      DIMENSION TERMB(11),TERM1(11)
      DIMENSION TERMA(11)

      CMEAN=CX(I,JM)

C        *** COMPUTE VALUES OF CXM,ROSTAG,AND TERMA,(CU**2+CR**2)

      DO 150 J=1,NLINES
      CXM(J)= CX(I,J)/CMEAN
  150 TERMA(J)=CU(I,J)**2+CR(I,J)**2

C        *** START OF LOOP ON CM CONVERGENCE

      J= JM
      H= -(CMEAN**2 +TERMA(JM))/GJ
      T= TO(I,JM)
      CALL  ENTALP
      CALL  GAM
      VM1= GR2*GAMMER*TSTAT(JM)
```

```
C         *** ERROR TRANSFER TO A NEW DATA SET

      IF (VM1.LT.0.) CALL ERROR(16)
      VM = SQRT(VM1)
  155 IF (CMEAN.LE.VM1) GO TO 205
  195 CALL ERROR( 2)
  205 DO 260 J=1,NLINES
      H= -(TERMA(J) +CX(I,J)**2)/GJ
      T= TO(I,J)
      CALL  ENTALP
      DEPV(I,J)= CXM(J)*PO(I,J)*EXP((THERM3(TSTAT(J)) -THERM3(T))/DCP)
     X         /TSTAT(J)/GASK
  260 CONTINUE

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

  265 CALL INTEG (DEPV,1)
      TOTINT=RINT(NLINES)-RINT(1)
      B= TOTINT * 6.283185 * CMEAN
      B= AMIN1( 1.02*FLOW(I), AMAX1( 0.98*FLOW(I),B))
      CMEANP=  CMEAN*FLOW(I)/B

C         *** CHECK CONVERGENCE OF CM


C             DEPV(L,J)=(INTEGRAL RHO*CXM*R VS. R FROM RH TO R(J))/TOTINT

  300 TERMC(1)= 0.0
      TERMC(NLINES)= 1.0
      TERMA(1)= R(I,1)
      TERMA(NLINES)= R(I,NLINES)
      DO 350 J=2,NTUBES
      TERMC(J)= TERMC(J-1) +DA(J-1)/TOTINT
      TERMA(J)= R(I,J)
  350 IF (ABS(TERMC(J)-DELM(J)).GT.0.005) YES= .TRUE.
      DO 505 J=2,NTUBES
      R(I,J)= R(I,J) +(SLINE(DELM(J),TERMC,TERMA,NLINES) -R(I,J))/DAMP

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

  505 CX(I,J)= CXM(J)*CMEANP
      CX(I,1)= CXM(1)*CMEANP
      CX(I,NLINES)= CXM(NLINES)*CMEANP
  700 RETURN
      END
```

```
      FUNCTION   THERM1(Z)                                                     OFFD0638
      LOGICAL   CIRCLE,   SIXTY5                                               OFFD0639
      REAL             IREF,           JOULE,          MACH,                   OFFD0640
     X METAL,          MIN,            MINR,           MOUT,                   OFFD0641
     X MOUTR                                                                   OFFD0642
      INTEGER BLADE,                   COUNT                                   OFFD0643
      LOGICAL          OFF,            OK,             RDFLO,                  OFFD0644
     X RESTAR,         TONE                                                    OFFD0645
      INTEGER   RULE                                                           OFFD0646
      REAL KDEL,KDEL2                                                          OFFD0647
      COMMON   /VECTOR/                                                        OFFD0648
     .ALPHA(29,11),ATAR(25,11),BETA(29,11),BH(32),BLADE(25),BT(32),CIRCLOFFD0649
     .E(25),CO(32,11),CPCO(6),CR(32,11),CSLOPE(32,11),CU(32,11),CX(32,11OFFD0650
     .),CXM(11),CXNEW(11),DA(10),DELM(11),DEPV(32,11),DF(20),DFLOW(32),FOFFD0651
     .LOW(32),FORM(25),FOUND(20,3,10),IREF(25,11),ITYPE(25),METAL(2),METOFFD0652
     .HOD(25),MIN(8,25),MINR(8,25),MOUT(8,25),MOUTR(8,25),NIN(25),NRAD(2OFFD0653
     .5),NS(25),NSS(25),NTC(25),NTH(25),NXIT(25),OBAP(25,11),OFFO(25),PUOFFD0654
     .(32,11),R(32,11),RAD(8,25),RADR(8,25),RCURVE(32,11),RH(32),RINT(11OFFD0655
     .),PPM(1),RS(32),RSLOPE(32,11),RULE(25),SHAPE(25),SIXTY5(25),SO(8,2OFFD0656
     .5),SOR(8,25),SS(8,25),SSR(8,25),TERMC(11),TH(8,25),THC(8,25),THCR(OFFD0657
     .8,25),THR(8,25),TITLE(36),TO(32,11),TSTAT(11),X(32)                 OFFD0658
      COMMON   /SCALAR/                                                        OFFD0659
     .A,AA,A10A0,A202A0,A303A0,A404A0,A505A0,ANG,B,BB,CC,CENT,CM,CMEAN,COFFD0660
     .MEANP,CM2,COREC,COUNT,CP,CPI2,CPI3,CPI4,CPI5,CPI6,CP02,CP03,CP04,COFFD0661
     .P05,DAMP,DCP,DELFLO,DFACT,EMACH,EPISON,FACTM,G,GAMMER,GASK,GJ,GR2,OFFD0662
     .H,HIGH,HIPRES,I,IG,IGO,ICUTTR,IPASS,J,JJ,JM,JM1,JOULE,K,KDEL,KK,L,OFFD0663
     .LAST,LC1,LEVEL,LST,LSTAGE,M,MACH,MAXPT,MINPT,N,NBLADE,NDATA,NLINESOFFD0664
     .,NSETS,NSPEED,NTUBES,NX,NX1,OFF,OK,PHI,PLOW,Q,RA,RADIAN,RDFLO,REF,OFFD0665
     .RESTAR,RMACH,S,SOLID,SPEED,STOP,T,TERMO,THICK,TIME,TOLAT,TOLCX,TOLOFFD0666
     .MIN,TOLR,TONE,V,VMI,YES                                                 OFFD0667
C        *** CALCULATES H = INTEGRAL FROM 0.0 TO T OF CP DT, WHERE CP ISOFFD0668
C                GIVEN AS A FIFTH DEGREE POLYNOMIAL                           OFFD0669
                                                                               OFFD0670
      THERM1= (CPCO(1)+(CPI2+(CPI3+(CPI4+(CPI5+CPI6*Z)*Z)*                     OFFD0671
     X Z)*Z)*Z)*Z                                                              OFFD0672
      RETURN                                                                   OFFD0673
      END                                                                      OFFD0674
```

```
      SUBROUTINE  THERM2(POVER,TOP,Z)
      LOGICAL  CIRCLE,  SIXTY5
      REAL              IREF,              JOULE,             MACH,
     X METAL,           MIN,               MINR,              MOUT,
     X MOUTR
      INTEGER BLADE,                       COUNT
      LOGICAL           OFF,               OK,                ROFLO,
     X RSTAR,           TONE
      INTEGER  RULE
      REAL KDEL,KDEL2
      COMMON  /VECTOR/
     .ALPHA(29,11),ATAR(25,11),BETA(29,11),BH(32),BLADE(25),BT(32),CIRCL
     .E(25),CO(32,11),CPCO(6),CR(32,11),CSLOPE(32,11),CU(32,11),CX(32,11
     .),CXM(11),CXNEW(11),DA(10),DELM(11),DEPV(32,11),DF(20),DFLOW(32),F
     .LOW(32),FORM(25),FOUND(20,3,10),IREF(25,11),ITYPE(25),METAL(2),MET
     .HOD(25),MIN(8,25),MINR(8,25),MOUT(8,25),MOUTR(8,25),NIN(25),NRAD(2
     .5),NS(25),NSS(25),NTC(25),NTH(25),NXIT(25),OBAR(25,11),OFFO(25),PO
     .(32,11),R(32,11),RAD(8,25),RADR(8,25),RCURVE(32,11),RH(32),RINT(11
     .),RPM(1),RS(32),RSLOPE(32,11),RULE(25),SHAPE(25),SIXTY5(25),SO(8,2
     .5),SOR(8,25),SS(8,25),SSR(8,25),TERMC(11),TH(8,25),THC(8,25),THCR(
     .8,25),THR(8,25),TITLE(36),TO(32,11),TSTAT(11),X(32)
      COMMON  /SCALAR/
     .A,AA,A1OA0,A202A0,A303A0,A404A0,A505A0,ANG,B,BB,CC,CENT,CM,CMEAN,C
     .MEANP,CM2,COREC,COUNT,CP,CPI2,CPI3,CPI4,CPI5,CPI6,CPO2,CPO3,CPO4,C
     .PO5,DAMP,DCP,DELFLO,DFACT,EMACH,EPISON,FACTM,G,GAMMER,GASK,GJ,GR2,
     .H,HIGH,HIPRES,I,IG,IGO,IOUTTR,IPASS,J,JJ,JM,JM1,JOULE,K,KDEL,KK,L,
     .LAST,LC1,LEVEL,LST,LSTAGE,M,MACH,MAXPT,MINPT,N,NBLADE,NDATA,NLINES
     .,NSETS,NSPEED,NTUBES,NX,NX1,OFF,OK,PHI,PLOW,Q,RA,RADIAN,ROFLO,REF,
     .RESTAR,RMACH,S,SOLID,SPEED,STOP,T,TERMO,THICK,TIME,TOLAT,TOLCX,TOL
     .MIN,TOLR,TONE,V,VMI,YES
      F(X)=ALOG(X)+(A1OA0+(A202A0+(A303A0+(A404A0+A505A0*X)*X)*X)*X)*X

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).

      DUMMY= DCP*ALOG(POVER)/CPCO(1) +F(Z)
      DO 10 JA =1,50
      XA= -500.0*(F(TOP)-DUMMY)
      TOP= TOP+XA
      IF (ABS(XA/TOP).LE.TOLR) GO TO 15
   10 CONTINUE

C        *** ERROR TRANSFER TO A NEW DATA SET

      CALL ERROR(19)
   15 RETURN
      END
```

05/02/68

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

```
      FUNCTION  THERM3(Z)
C
C        *** CALCULATE THE INTEGRAL OF CP/T DT FROM 0.0 TO T
C
      LOGICAL   CIRCLE,  SIXTY5
      REAL              IREF,             JOULE,            MACH,
     X METAL,           MIN,              MINR,             MOUT,
     X MOUTR
      INTEGER BLADE,                      COUNT
      LOGICAL           OFF,              OK,               ROFLO,
     X RESTAR,          TONE
      INTEGER   RULE
      REAL KDEL,KDEL2
      COMMON   /VECTOR/
     .ALPHA(29,11),ATAR(25,11),BETA(29,11),BH(32),BLADE(25),BT(32),CIRCL
     .E(25),CO(32,11),CPCO(6),CR(32,11),CSLOPE(32,11),CU(32,11),CX(32,11
     .),CXM(11),CXNEW(11),DA(10),DELM(11),DEPV(32,11),DF(20),DFLOW(32),F
     .LOW(32),FORM(25),FOUND(20,3,10),IREF(25,11),ITYPE(25),METAL(2),MET
     .RO(25),MIN(8,25),MINR(8,25),MOUT(8,25),MOUTR(8,25),NIN(25),NRAD(2
     .5),NS(25),NSS(25),NTC(25),NTH(25),NXIT(25),OBAR(25,11),OFFD(25),PO
     .(32,11),R(32,11),RAD(8,25),RADR(8,25),RCURVE(32,11),RH(32),RINT(11
     .),RPPM(1),RS(32),RSLOPE(32,11),RULE(25),SHAPE(25),SIXTY5(25),SO(8,2
     .5),SOR(8,25),SS(8,25),SSR(8,25),TERMC(11),TH(8,25),THC(8,25),THCR(
     .8,25),THR(8,25),TITLE(36),TO(32,11),TSTAT(11),X(32)
      COMMON   /SCALAR/
     .A,AA,A1OA0,A2O2A0,A3O3A0,A4O4A0,A5O5A0,ANG,B,BB,CC,CENT,CM,CMLAN,CO
     .MEANP,CM2,COREC,COUNT,CP,CPI2,CPI3,CPI4,CPI5,CPI6,CPO2,CPO3,CPO4,CO
     .PO5,DAMP,DCP,DELFLO,DFACT,EMACH,EPISON,FACTM,G,GAMMER,GASK,GJ,GR2,
     .H,HIGH,HIPRES,I,IG,IGO,IOUTTR,IPASS,J,JJ,JM,JM1,JOULE,K,KDEL,KK,L,
     .LAST,LC1,LEVEL,LST,LSTAGE,M,MACH,MAXPT,MINPT,N,NBLADE,NDATA,NLINES
     .,NSETS,NSPEED,NTUBES,NX,NX1,OFF,OK,PHI,PLOW,Q,RA,RADIAN,ROFLO,REF,
     .RESTAR,RMACH,S,SOLID,SPEED,STOP,T,TERMD,THICK,TIME,TOLAT,TOLCX,TOL
     .MIN,TOLR,TONE,V,VM1,YES
      THERM3= CPCO(1)*ALOG(Z)+(CPCO(2)+(CPO2+(CPO3+(CPO4+CPO5*Z)*Z)*Z)
     X *Z)*Z
      RETURN
      END
```

05/02/6[illegible]

TIM[illegible] - EFN SOURCE STATEMENT - IFN(S) -

```
SUBROUTINE TIME[illegible](T)                                    OFF00191
CALL CK(X)                                                       OFF00192
T= X*3600.0                                                      OFF00193
RETURN                                                           OFF00194
END                                                              OFF00195
```

```
      SUBROUTINE  XDERIV(Y,DYDX)                                        OFFD0290
                                                                        OFFD0291
C -----   CALCULATE THE FIRST DERIVATIVE OF Y WITH RESPECT TO AXIAL     OFFD0292
C         LENGTH.                                                       OFFD0293
                                                                        OFFD0294
      LOGICAL   CIRCLE,   SIXTY5                                        OFFD0295
      REAL            IREF,           JOULE,          MACH,             OFFD0296
     X METAL,         MIN,            MINR,           MOUT,             OFFD0297
     Y MOUTR                                                            OFFD0298
      INTEGER BLADE,                  COUNT                             OFFD0299
      LOGICAL         OFF,            OK,             RDFLC,            OFFD0300
     X RESTAR,        TONE                                              OFFD0301
      INTEGER  RULE                                                     OFFD0302
      REAL KDEL,KDEL2                                                   OFFD0303
      COMMON  /VECTOR/                                                  OFFD0304
     .ALPHA(29,11),ATAR(25,11),BETA(29,11),BH(32),BLADE(25),BT(32),CIRCLOFFD0305
     .E(25),CO(32,11),CPCO(6),CR(32,11),CSLOPE(32,11),CU(32,11),CX(32,11OFFD0306
     .),CXM(11),CXNEW(11),DA(10),DELM(11),DEPV(32,11),DF(20),DFLOW(32),FOFFD0307
     .LOW(32),FORM(25),FOUND(20,3,10),IREF(25,11),ITYPE(25),METAL(2),METOFFD0308
     .HOD(25),MIN(8,25),MINR(8,25),MOUT(8,25),MOUTR(8,25),NIN(25),NRAD(2OFFD0309
     .5),NS(25),NSS(25),NTC(25),NTH(25),NXIT(25),OBAR(25,11),OFFD(25),POOFFD0310
     .(32,11),R(32,11),RAD(8,25),RADR(8,25),RCURVE(32,11),RH(32),RINT(11OFFD0311
     .),RPM(11),RS(32),RSLOPE(32,11),RULE(25),SHAPE(25),SIXTY5(25),SO(8,2OFFD0312
     .5),SOR(8,25),SS(8,25),SSR(8,25),TERMC(11),TH(8,25),THC(8,25),THCR(OFFD0313
     .8,25),THR(8,25),TITLE(36),TO(32,11),TSTAT(11),X(32)               OFFD0314
      COMMON  /SCALAR/                                                  OFFD0315
     .A,AA,A10A0,A202A0,A303A0,A404A0,A505A0,ANG,B,BB,CC,CENT,CM,CMEAN,COFFD0316
     .MEANP,CM2,COREC,COUNT,CP,CP12,CP13,CP14,CP15,CP16,CP02,CP03,CP04,COFFD0317
     .P05,DAMP,DCP,DELFLO,DFACT,EMACH,EPISON,FACTM,G,GAMMER,GASK,GJ,GR2,OFFD0318
     .H,HIGH,HIPRES,I,IG,IGG,IGUTTR,IPASS,J,JJ,JM,JM1,JOULE,K,KDEL,KK,L,OFFD0319
     .LAST,LC1,LEVEL,LST,LSTAGE,M,MACH,MAXPT,MINPT,N,NBLADE,NDATA,NLINESOFFD0320
     .,NSETS,NSPEED,NTUBES,NX,NX1,OFF,OK,PHI,PLOW,Q,RA,RADIAN,RDFLC,REF,OFFD0321
     .RESTAR,RMACH,S,SOLID,SPEED,STOP,T,TERMD,THICK,TIME,TOLAT,TOLCX,TOLOFFD0322
     .MIN,TOLR,TONE,V,VM1,YES                                           OFFD0323
      DIMENSION  Y(32,11), DYDX(32,11)                                  OFFD0324
      DO 5 I=2,NX1                                                      OFFD0325
      AA= (Y(I,J) -Y(I-1,J))/X(I-1)                                     OFFD0326
      BB= (Y(I+1,J) -Y(I,J))/X(I)                                       OFFD0327
      DYDX(I,J)=(AA+BB)*.5                                              OFFD0328
    5 CONTINUE                                                          OFFD0329
    6 RETURN                                                            OFFD0330
      END                                                               OFFD0331
```

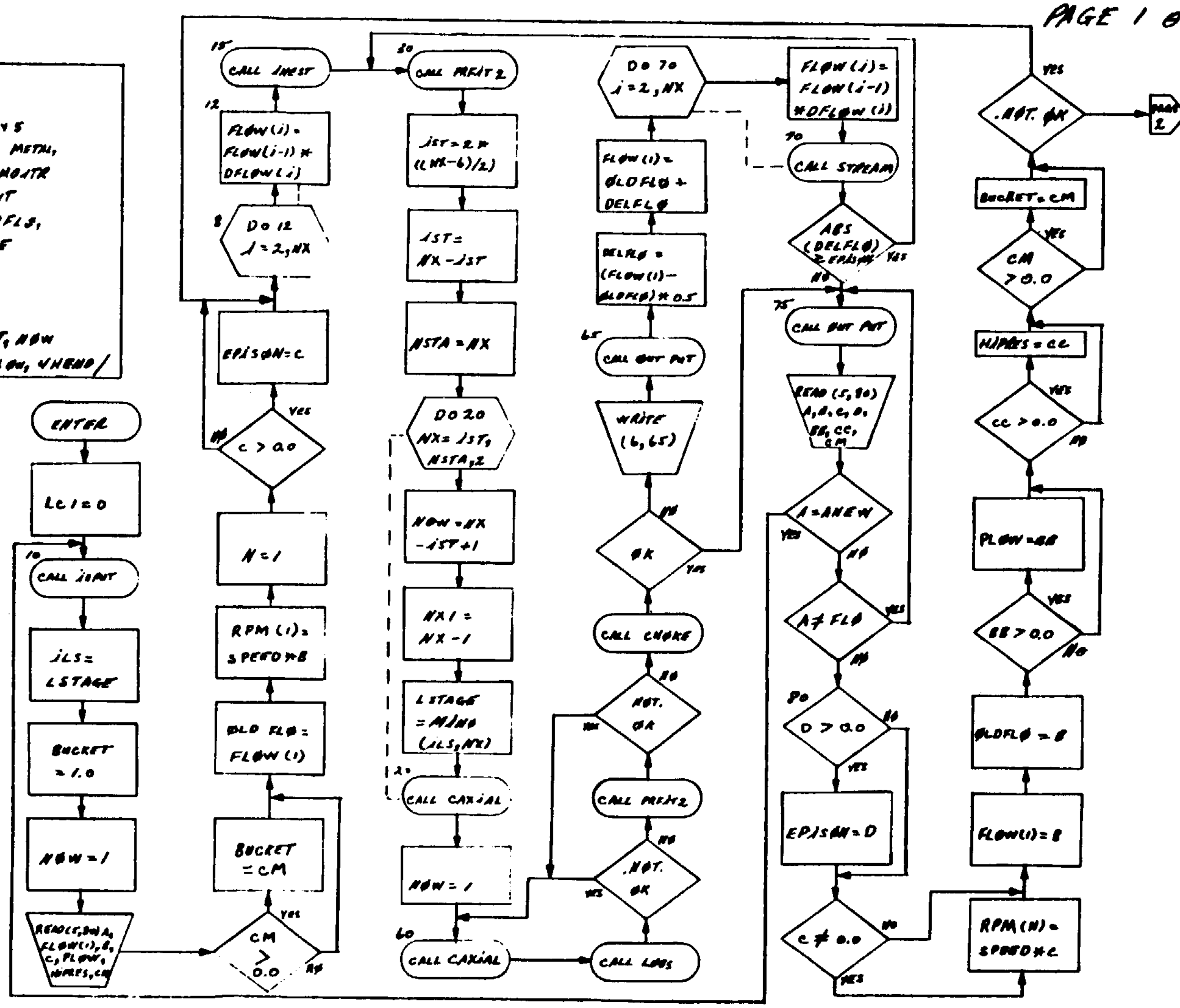
APPENDIX C

PROGRAM FLOW CHARTS

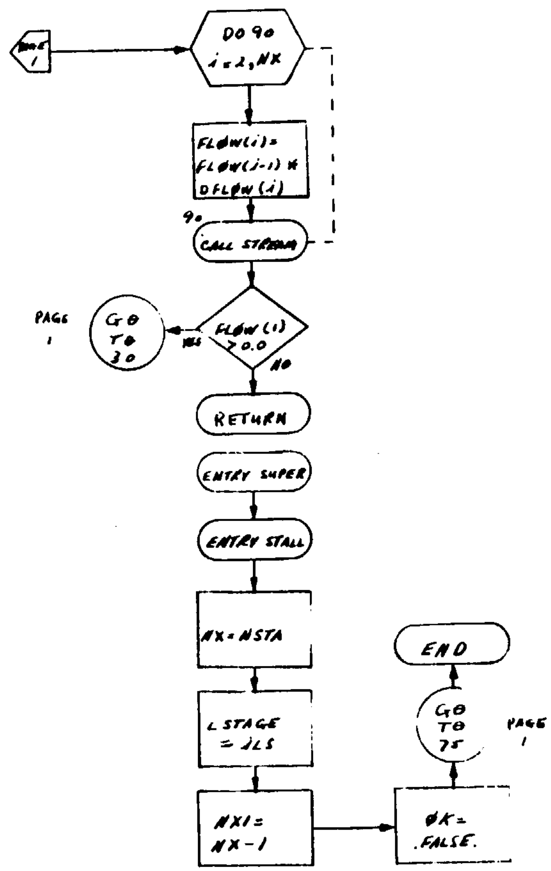
INDEX

SUBROUTINE BOSS

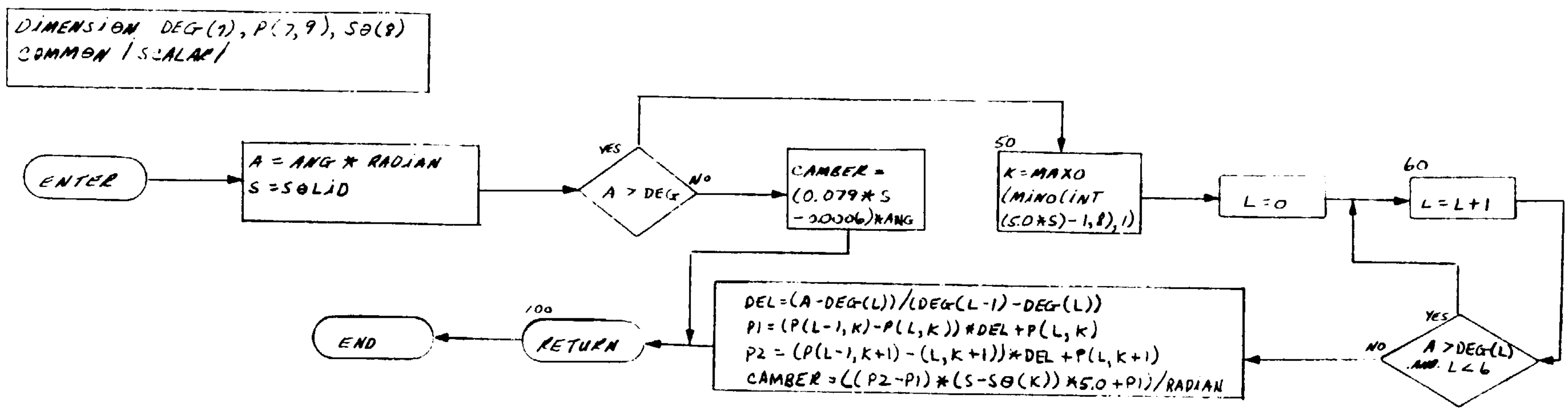

```
SUBROUTINE BOSS

LOGICAL CIRCLE, SIXTY5
REAL JMP, JOULE, MACH, METAL,
     MIN, MINO, MOUT, MOATR
INTEGER BLADE, COUNT
LOGICAL OFF, OK, NOFLO,
        RESTAR, TIME
INTEGER RULE
REAL KDEL, KDEL2
COMMON /SCALAR/
COMMON /FULL/BUCKET, NOW
DATA FLO, ANEW/4HFLOW, 4HNEHO/
```



SUBROUTINE BOSS

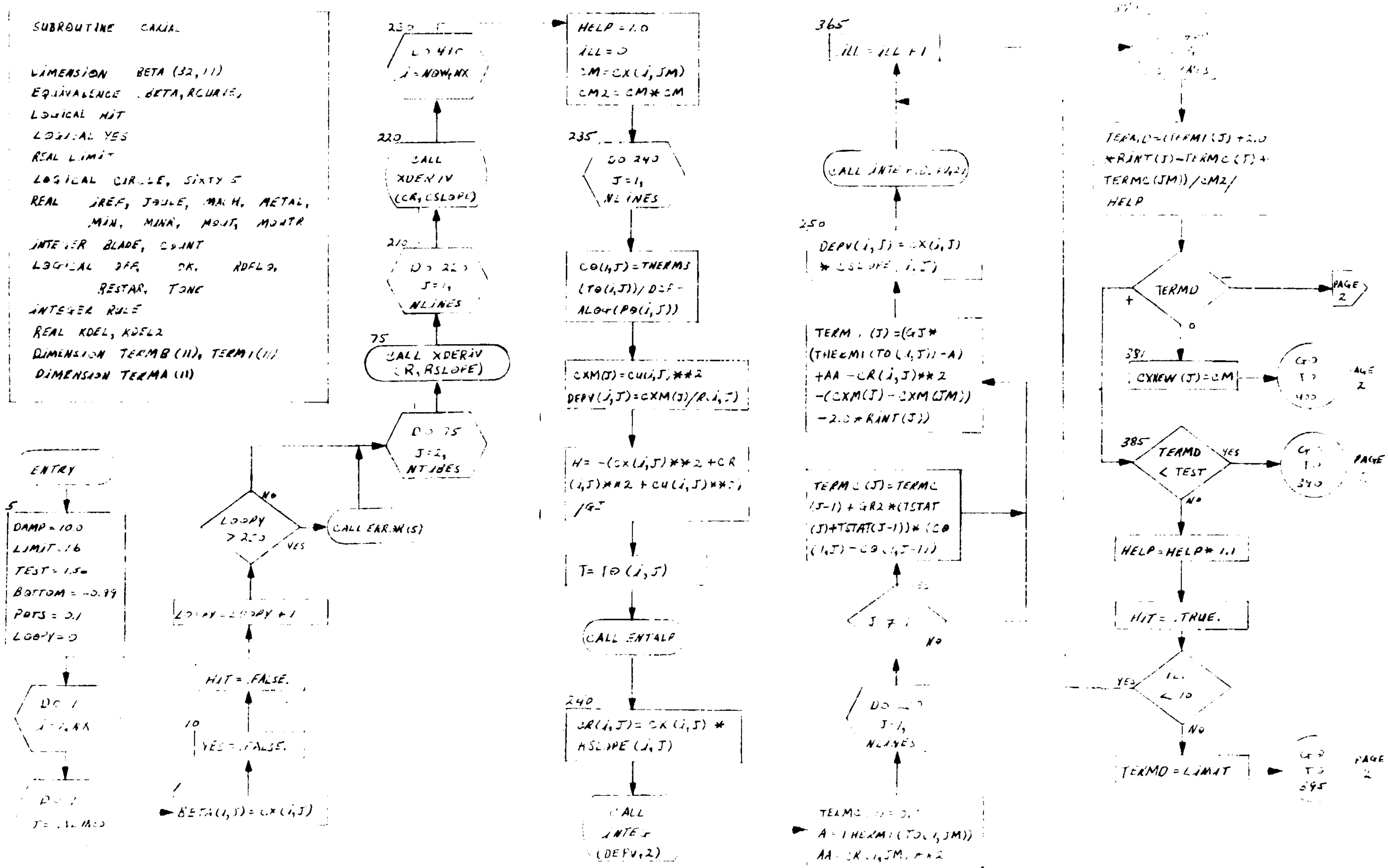


SUBROUTINE CAMBER (ANG, SOLID)

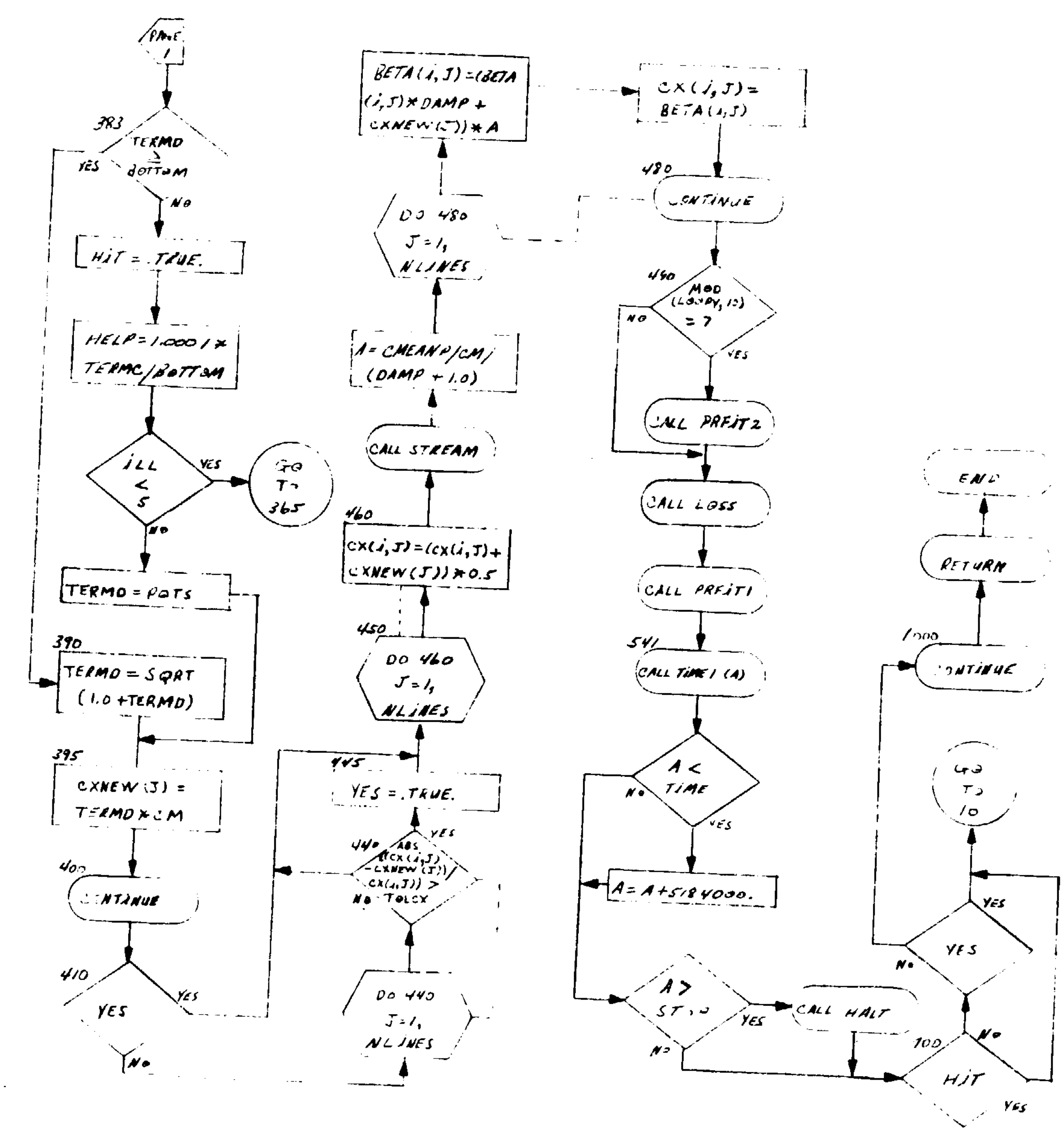


SUBROUTINE CANAL

PAGE 1 OF 2

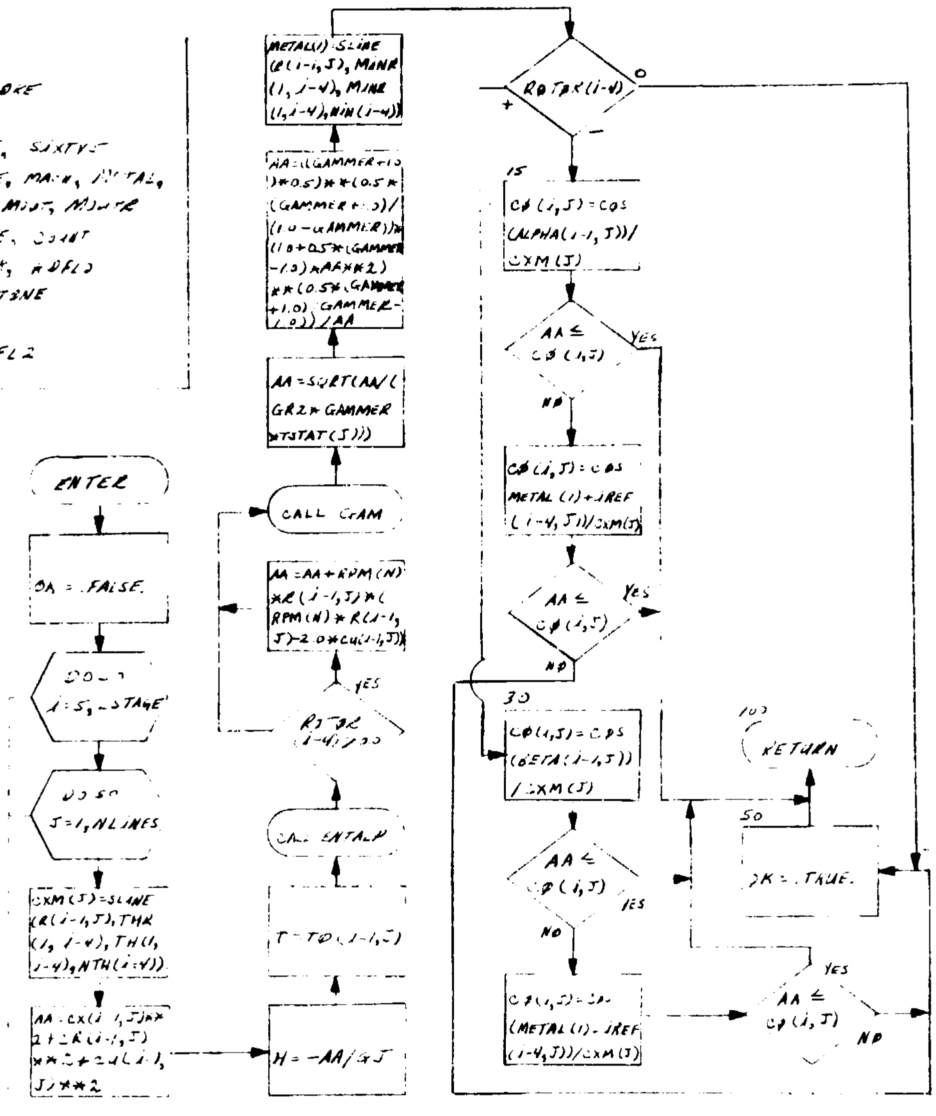


SUBROUTINE CAXIAL

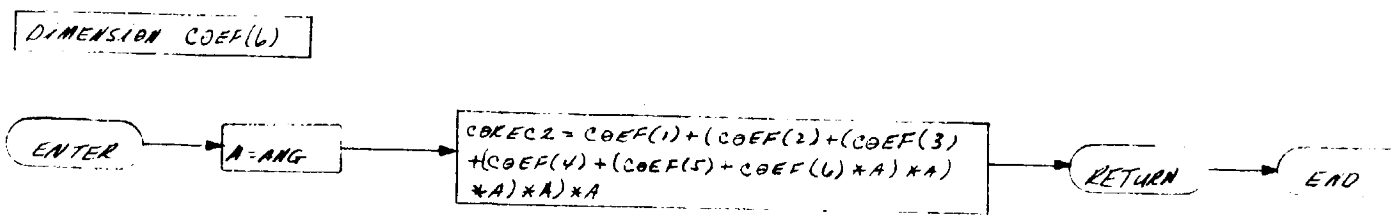


SUBROUTINE CHOKE

```
SUBROUTINE CHOKE

LOGICAL CIRCLE, SIXTY
REAL AREF, SCALE, MACH, METAL,
     MIN, MINE, MIST, MIXTR
INTEGER BLADE, CONT
LOGICAL DES, OK, KDELO
     KESTAR, TONE
INTEGER RULE
REAL KDEL, KDEL2
```

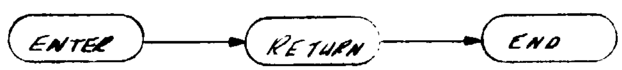


SUBROUTINE CORECZ (ANG)

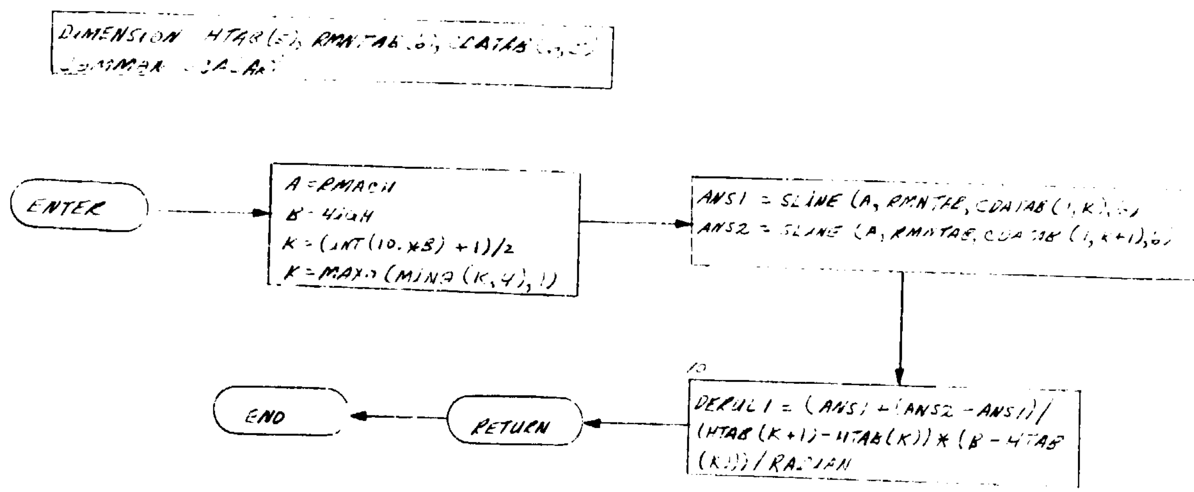


SUBROUTINE DATA

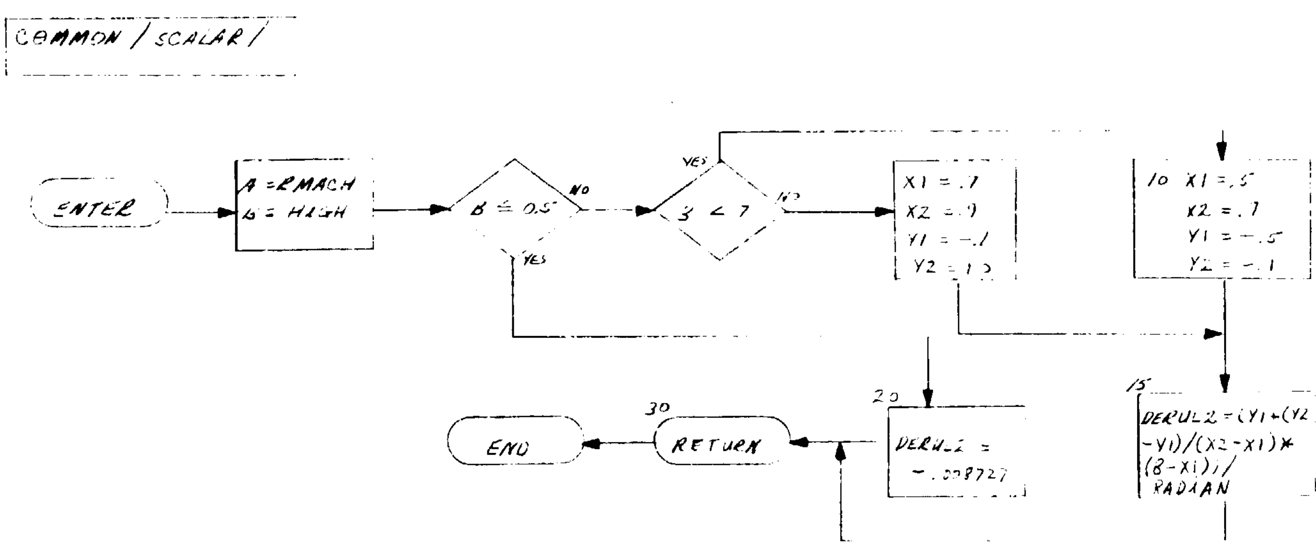

```
BLOCK DATA
LOGICAL CIRCLE, SIXTYS
REAL IREF, JOULE, MACH, METAL,
     MIN, MINR, MOUT, MOUTR
INTEGER BLADE, COUNT
LOGICAL OFF, OK, RDFLO,
        RESTAR, TONE
INTEGER RULE
REAL KDEL, KDEL2
COMMON /VECTOR/
COMMON / SCALAR/
DATA DFLOW(1), DFLOW(2), DFLOW(3), DFLOW(4), DFLOW(5) /5*1.0/
DATA G, GJ, JOULE / 1545.44, 50070.47, 778.12 /
DATA DF/0.0, .1, .15, .2, .25, .3, .35, .4, .45, .5, .55, .6, .65, .7,
        .75, .8, .85, .9, .95, 1.0/
DATA RADIAN /57.29578/
```



SUBROUTINE DFRUL1 (RMACH, HIGH)



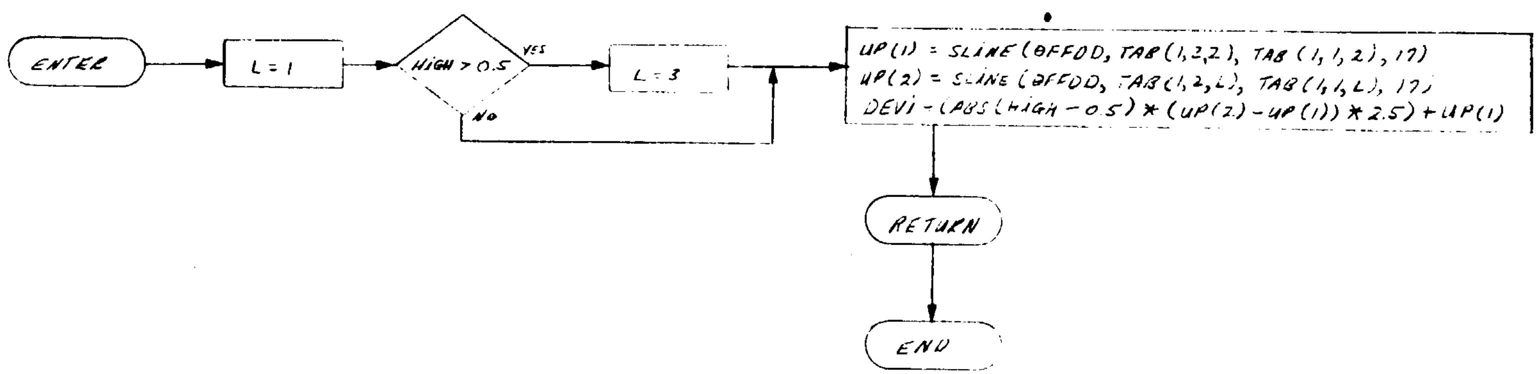
SUBROUTINE DERUL2 (RMACH, HIGH)



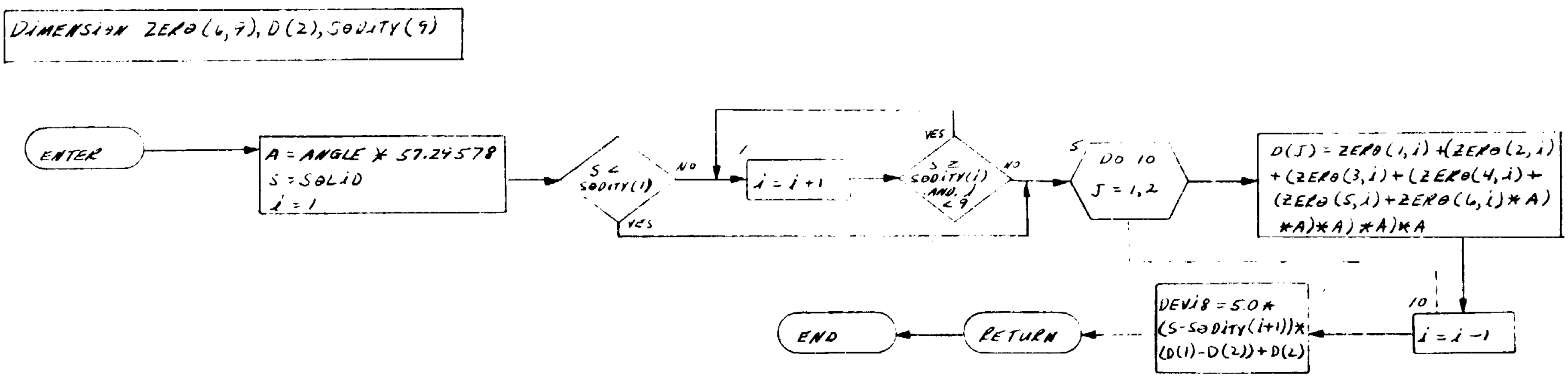
SUBROUTINE DEVI (OFFDD)

PAGE 1 OF 1

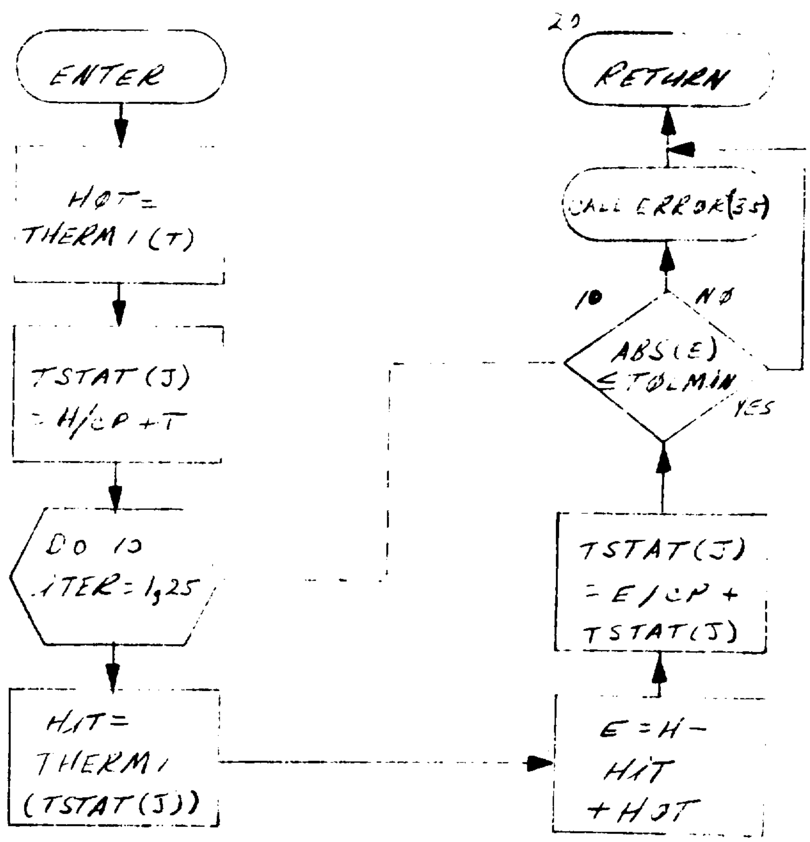
```
COMMON /GET IT/
LOGICAL CIRCLE, SIXTYS
REAL IREF, JOULE, MACH, METAL,
     MIN, MIAR, MOUT, MOUTR
INTEGER BLADE, COUNT
LOGICAL OFF, OK, REPLY,
        RESTAR, TONE
INTEGER RULE
REAL KDEL, KDEL2
COMMON /VECTOR/
COMMON /SCALAR/
DIMENSION UP(2), TAB(17,2,3)
```



SUBROUTINE DEVI8

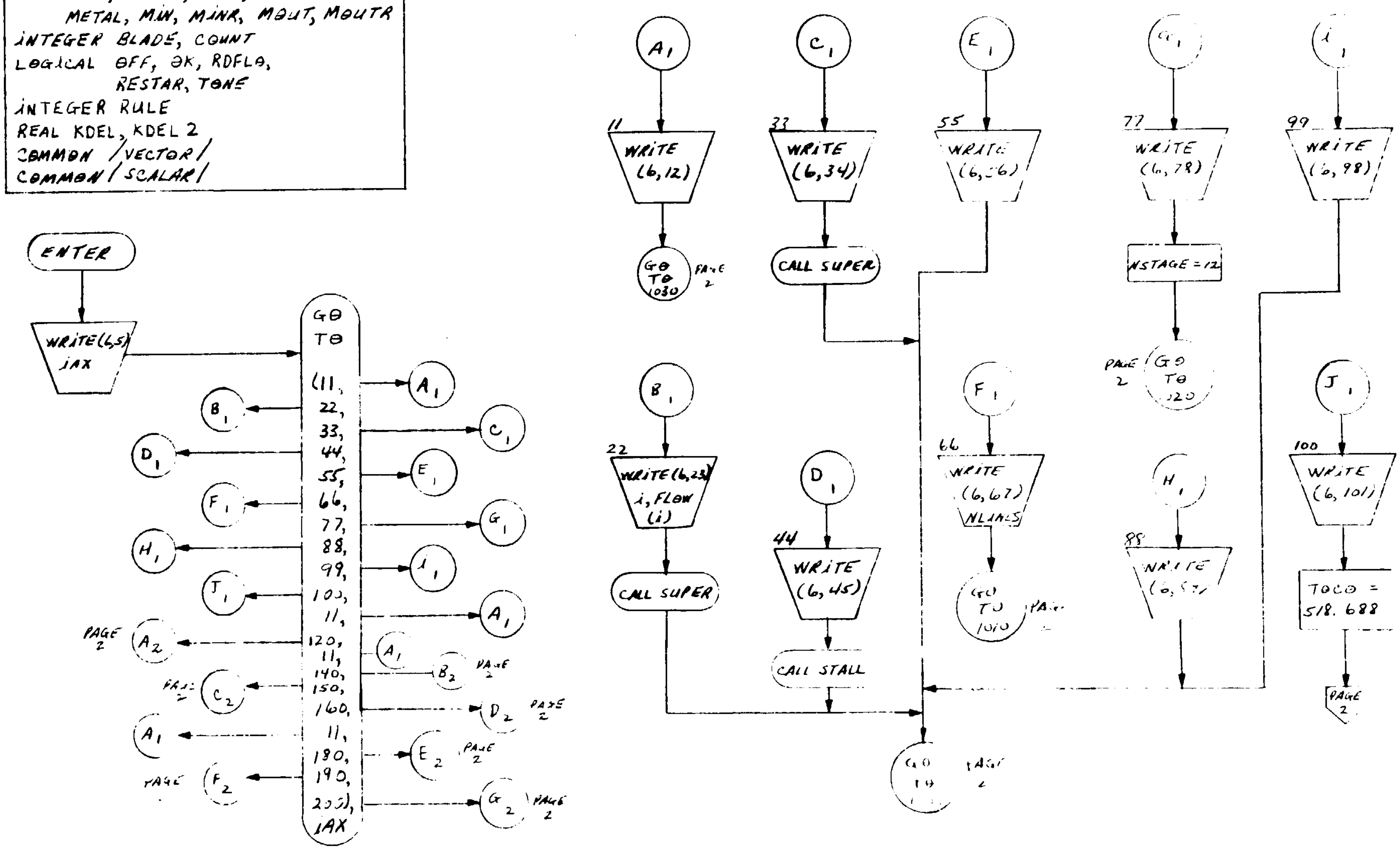


```
SUBROUTINE ENTALP

LOGICAL CIRCLE, SIXTY5
REAL IREF, JOULE, MACH, METAL,
     MIN, MINR, MOUT, MOUTR
INTEGER SLADE, COUNT
LOGICAL OFF, ON, WORLD
     RESTAR, TIME
INTEGER RULE
REAL KOEF, KOEF2
```



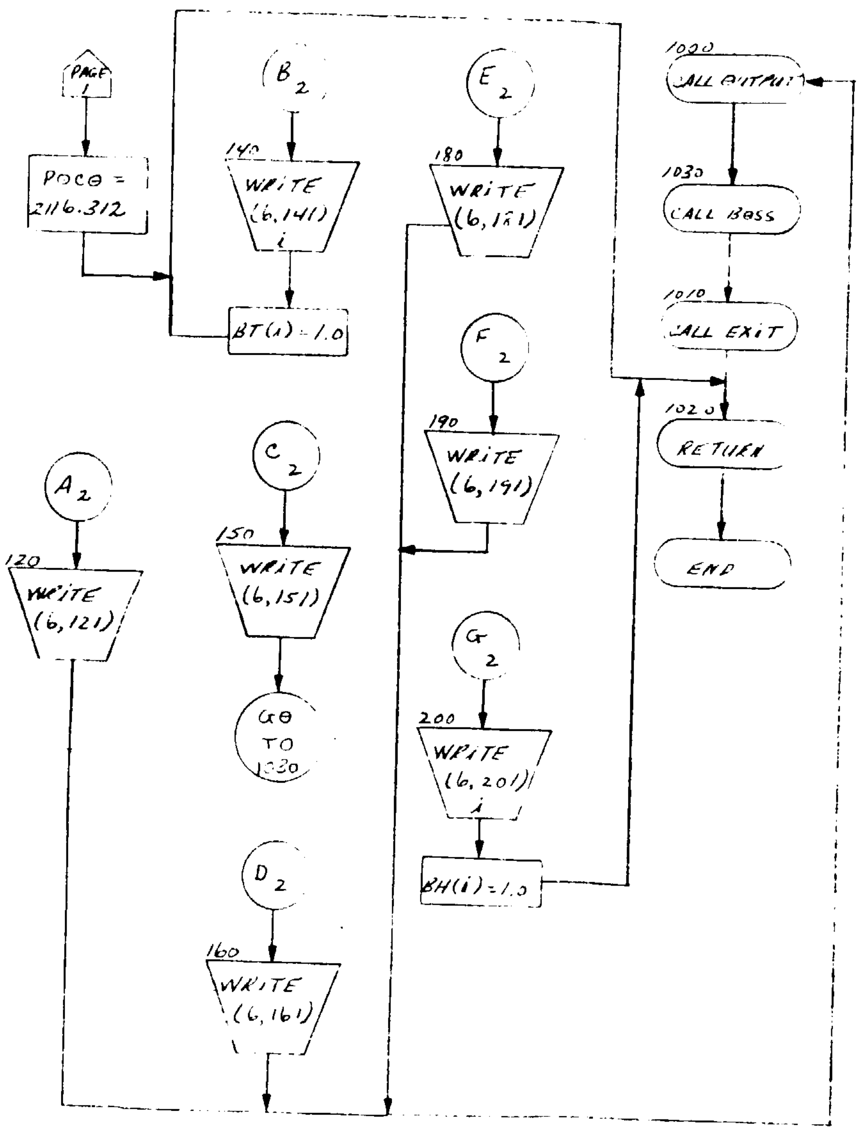
SUBROUTINE ERROR (IAX)

```
LOGICAL CIRCLE, SIXTYS
REAL IREF, JOULE, MACH,
     METAL, MIN, MINR, MOUT, MOUTR
INTEGER BLADE, COUNT
LOGICAL OFF, OK, RDFLO,
        RESTAR, TONE
INTEGER RULE
REAL KDEL, KDEL 2
COMMON /VECTOR/
COMMON /SCALAR/
```

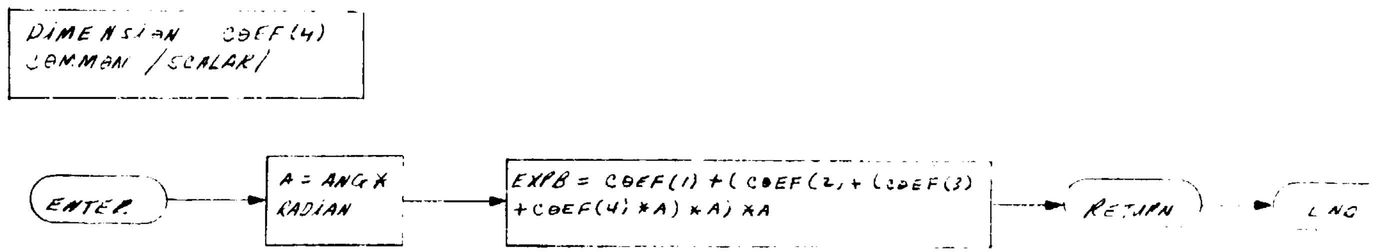


SUBROUTINE ERROR (iAX)

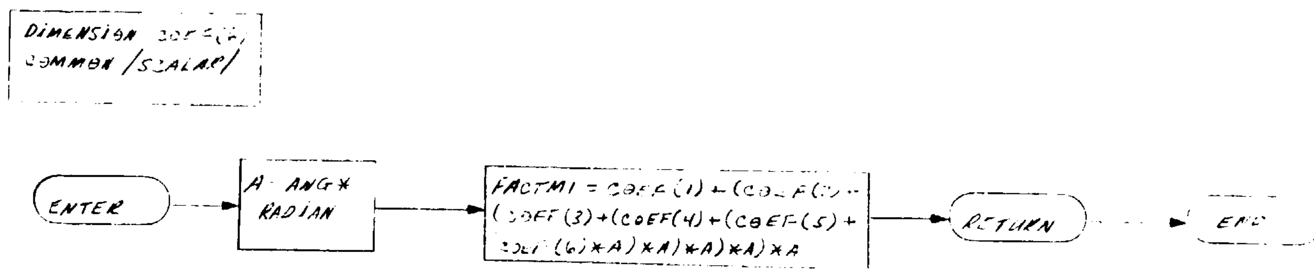
PAGE 2 OF 2



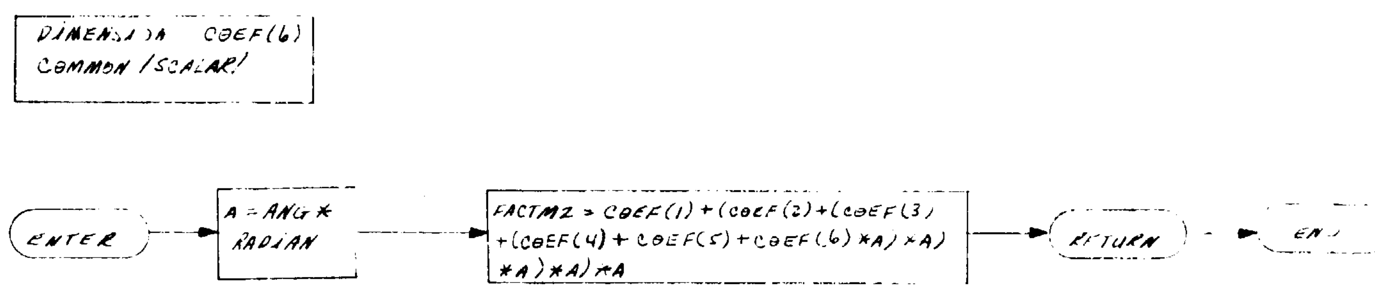
SUBROUTINE EXPB(ANG)



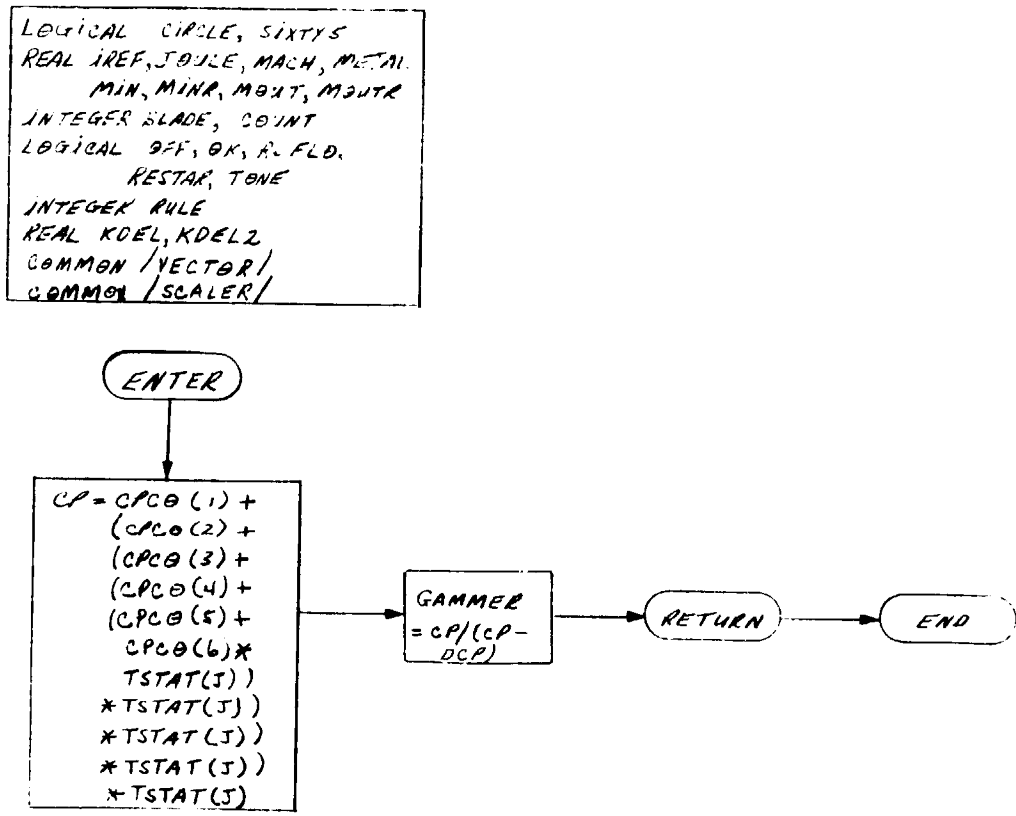
SUBROUTINE FACTMI(ANG)



SUBROUTINE FACTM2(ANG)

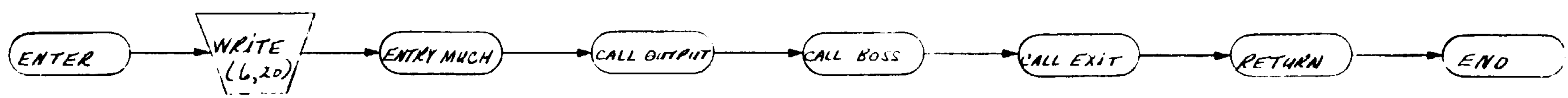


SUBROUTINE GAM

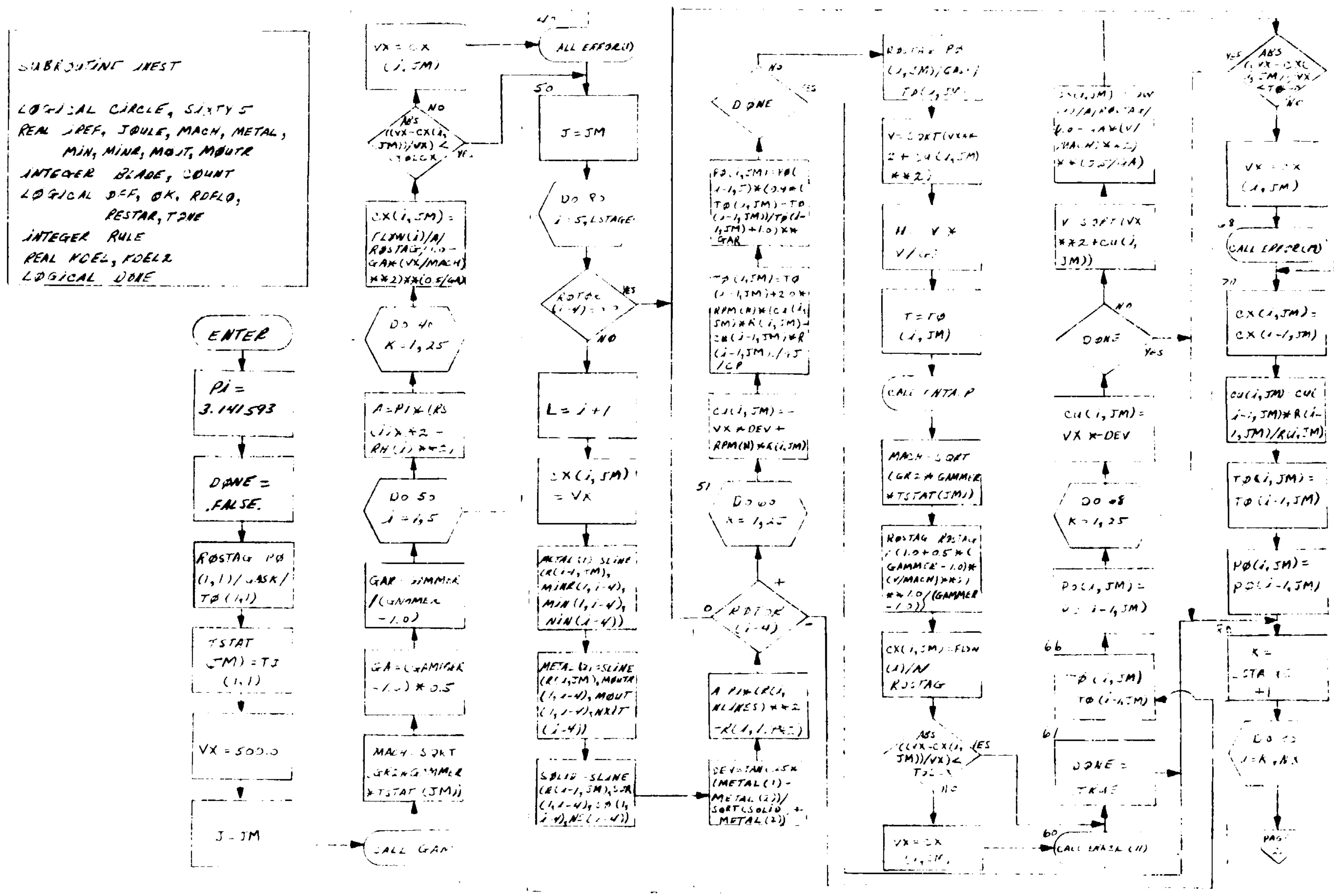


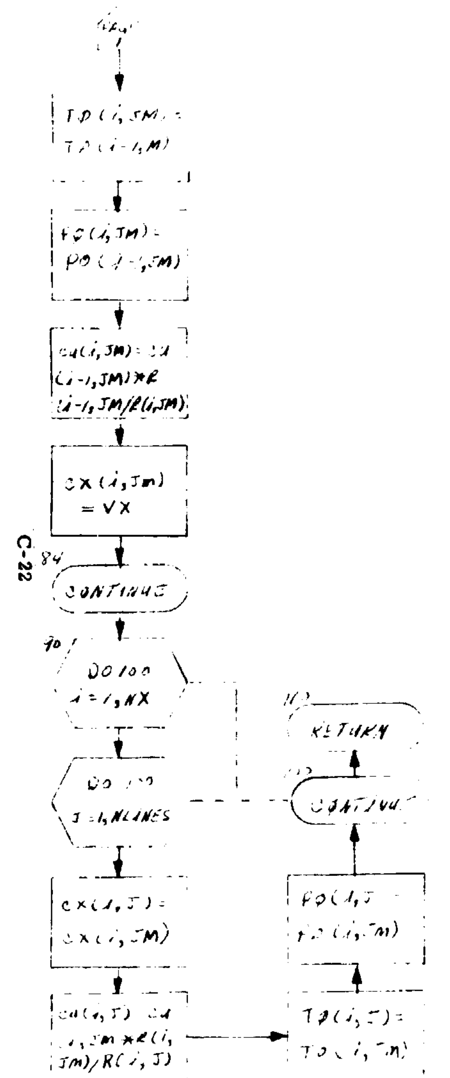
SUBROUTINE HALT

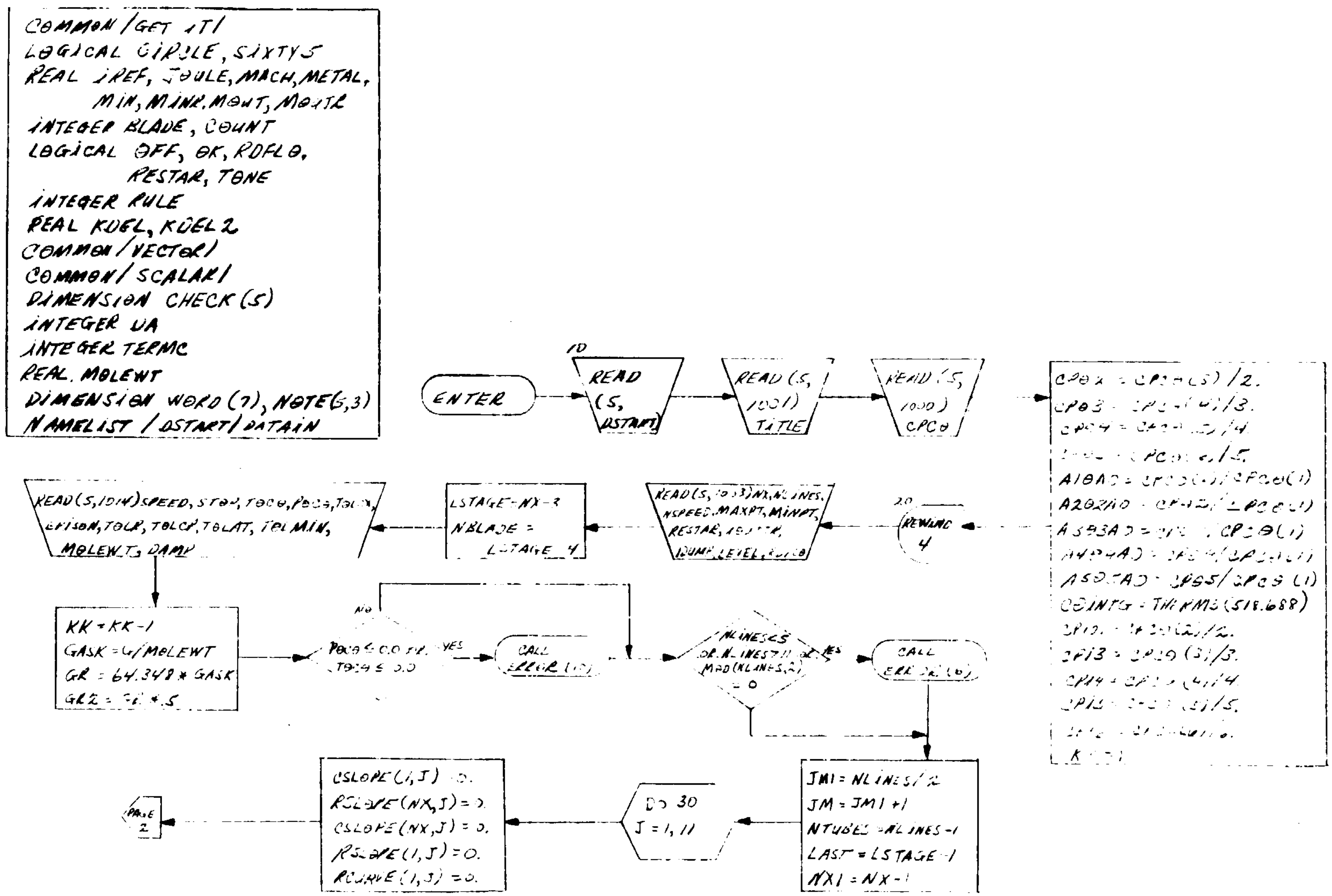

```
LOGICAL CIRCLE, SIXTYS
REAL IREF, JOULE, MACH, METAL,
     MIN, MINK, MOUT, MOUTR
INTEGER BLADE, COUNT
LOGICAL OFF, OK, RDFLO,
        RESTAR, TONE
INTEGER K.E
REAL KDEL, KDEL2
COMMON /VECTOR/
COMMON /SCALAR/
```

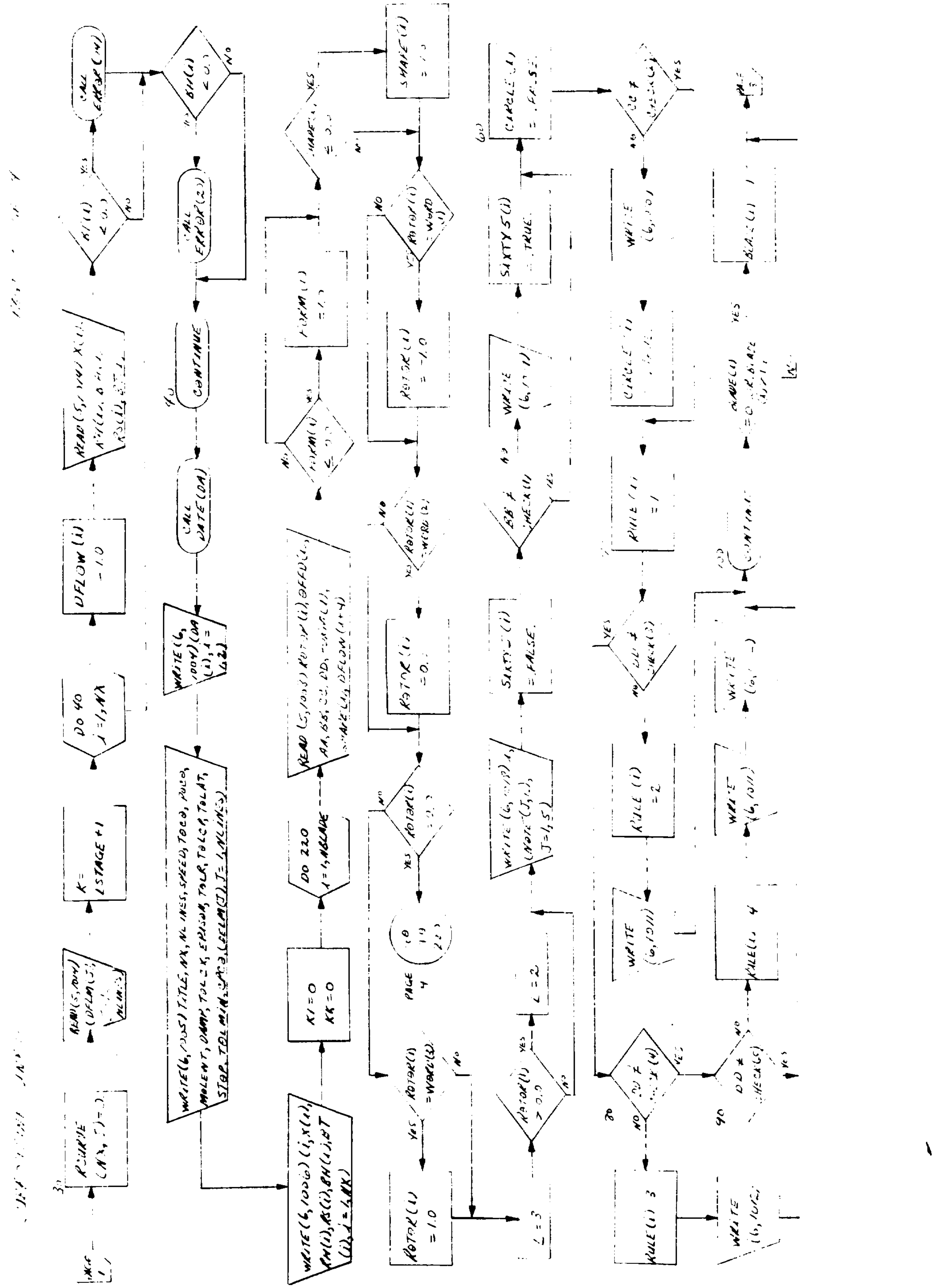


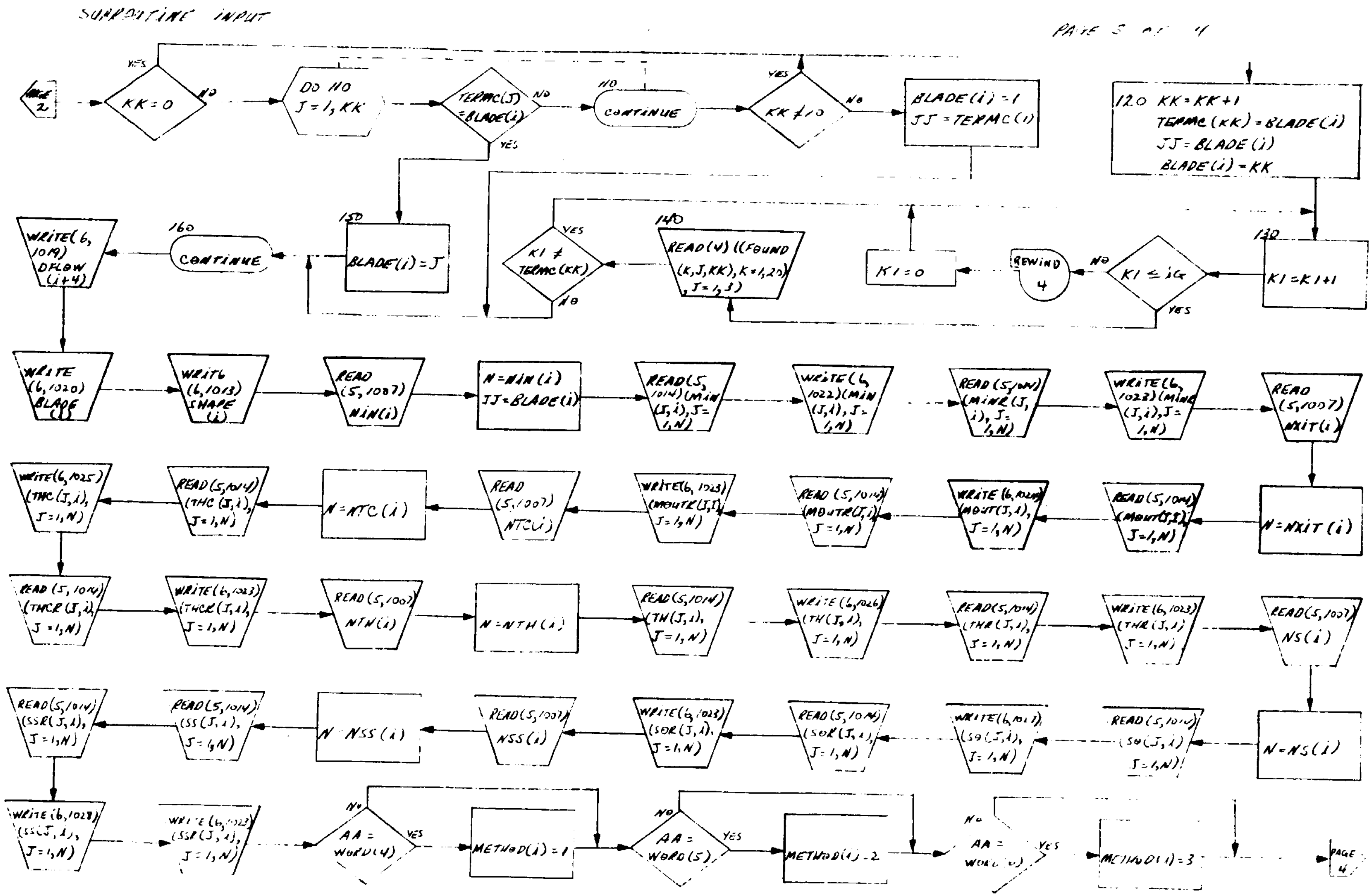
SUBROUTINE INEST

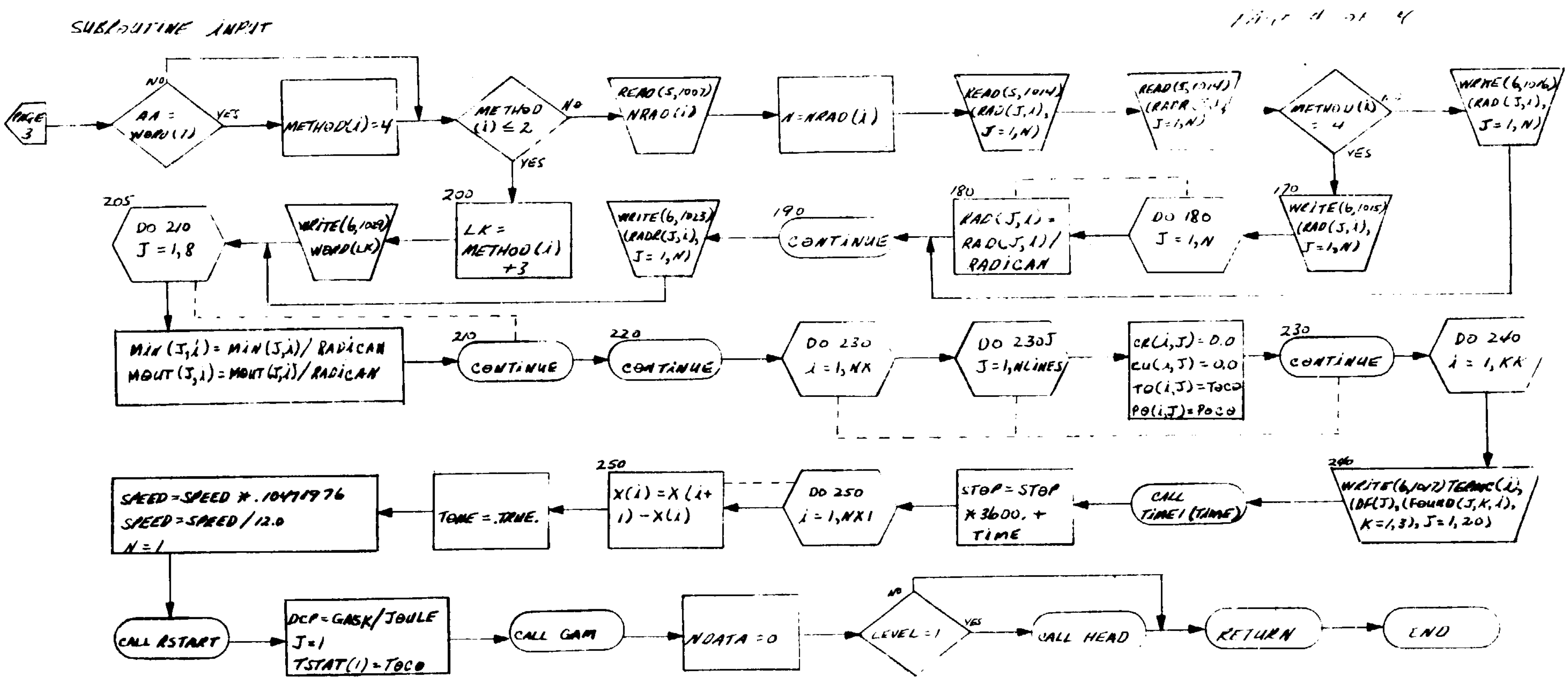



CX(I,JM)
= VX
84
CONTINUE
DO 100
I=1,NX
RETURN
J=1,NLINES


COMMON /GET IT/
LOGICAL CIRCLE, SIXTY5
REAL IREF, JOULE, MACH, METAL,
MIN, MINR, MOUT, MOUTR
INTEGER BLADE, COUNT
LOGICAL OFF, OK, RDFLO,
RESTAR, TONE
INTEGER RULE
REAL KUEL, KUEL2
COMMON/VECTOR/
COMMON/SCALAR/
DIMENSION CHECK(5)
INTEGER UA
INTEGER TERMC
REAL MOLEWT
DIMENSION WORD(7), NOTE(5,3)
NAMELIST /DSTART/ DATAIN
ENTER
10
READ (5, DSTART)
READ (5, 1001) TITLE
READ (5, 1000) CPC0
20
REWIND 4
READ (5, 1014) SPEED, STOP, TOC0, POC0, TOL, EPISON, TOLR, TOLCP, TOLAT, TOLMIN, MOLEWT, DAMP
LSTAGE = NX - 3
NBLADE = LSTAGE - 4
KK = KK - 1
GASK = G/MOLEWT
GR = 64.348 * GASK
NO
YES
CALL ERROR
NLINES < 5 OR NLINES > 11 OR MOD(NLINES, 2) = 0
YES
CALL ERROR
JM1 = NLINES/2
JM = JM1 + 1
NTUBES = NLINES - 1
LAST = LSTAGE - 1
NX1 = NX - 1
DO 30
J = 1, 11
CSLOPE(1, J) = 0.
RSLOPE(NX, J) = 0.
CSLOPE(NX, J) = 0.
RSLOPE(1, J) = 0.
RCURVE(1, J) = 0.
PAGE 2
A1BA1
A2B2A0
A3B3A0
A4B4A0
A5B5A0
COINTG = THERMS (518.688)
CPI3
K

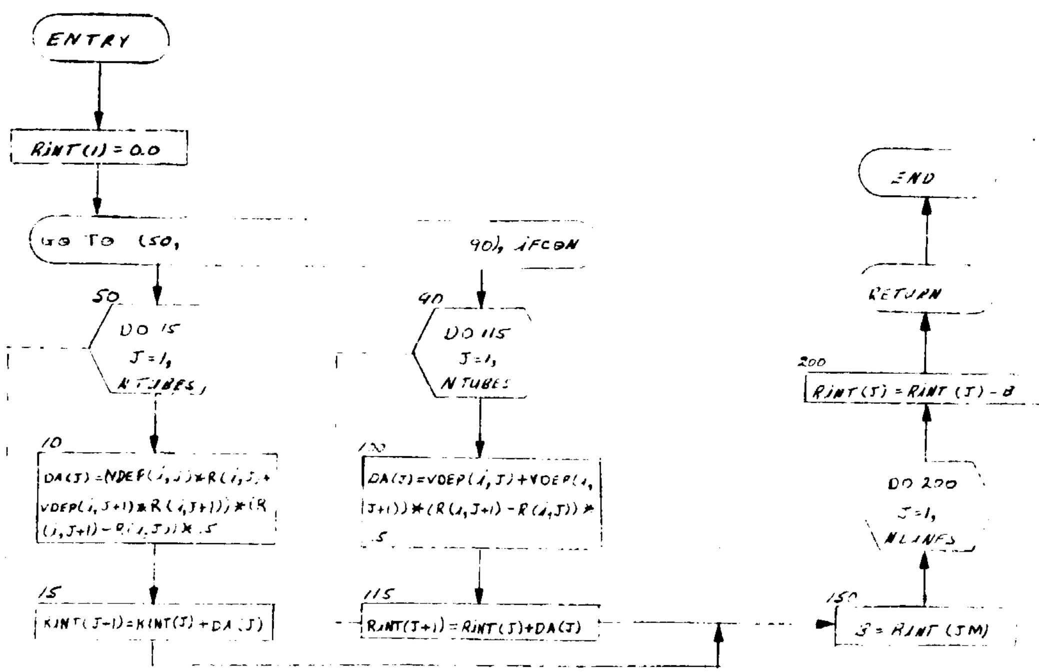

DO 40 I=1,NX
DFLOW(I) = -1.0
CALL ERROR(21)
CONTINUE
CALL DATE(DA)
KI=0 KK=0
DO 220 I=1,NBLADE
ROTOR(I) = 1.0
ROTOR(I) = -1.0
SIXTY5(I) = .TRUE.
SIXTY5(I) = .FALSE.
L = 2
L = 3


SUBROUTINE INPUT
PAGE 3 OF 4
PAGE 2
KK=0
YES
NO
DO 110 J=1,KK
TERMC(J) =BLADE(i)
110 CONTINUE
KK ≠ 10
BLADE(i)=1 JJ=TERMC(i)
120 KK=KK+1
TERMC(KK)=BLADE(i)
JJ=BLADE(i)
BLADE(i)=KK
130 KI=KI+1
KI ≤ 16
REWIND 4
KI=0
140 READ(4) ((FOUND(K,J,KK),K=1,20),J=1,3)
KI ≠ TERMC(KK)
150 BLADE(i)=J
160 CONTINUE
WRITE(6,1019) DFLOW(i+4)
WRITE (6,1020) BLADE (i)
WRITE (6,1013) SHAPE (i)
READ (5,1007) MIN(i)
N=MIN(i) JJ=BLADE(i)
READ(5,1014)(MIN(J,i),J=1,N)
WRITE(6,1022)(MIN(J,i),J=1,N)
READ (5,1014)(MINR(J,i),J=1,N)
WRITE(6,1022)(MINR(J,i),J=1,N)
READ (5,1007) NXIT(i)
N=NXIT (i)
READ (5,1014)(MOUT(J,i),J=1,N)
WRITE (6,1024) MOUT(J,i),J=1,N)
READ (5,1014)(MOUTR(J,i),J=1,N)
WRITE(6,1023)(MOUTR(J,i),J=1,N)
READ (5,1007) NTC(i)
N=NTC(i)
READ(5,1014)(THC(J,i),J=1,N)
WRITE(6,1025)(THC(J,i),J=1,N)
READ (5,1014)(THCR(J,i),J=1,N)
WRITE(6,1023)(THCR(J,i),J=1,N)
READ (5,1007) NTH(i)
N=NTH(i)
READ(5,1014)(TH(J,i),J=1,N)
WRITE (6,1026)(TH(J,i),J=1,N)
READ(5,1014)(THR(J,i),J=1,N)
WRITE (6,1023)(THR(J,i),J=1,N)
READ(5,1007) NS(i)
N=NS(i)
READ (5,1014)(SO(J,i),J=1,N)
WRITE(6,1017)(SO(J,i),J=1,N)
READ (5,1014)(SOR(J,i),J=1,N)
WRITE(6,1023)(SOR(J,i),J=1,N)
READ(5,1007) NSS(i)
N=NSS(i)
READ(5,1014)(SS(J,i),J=1,N)
READ(5,1014)(SSR(J,i),J=1,N)
WRITE (6,1028)(SS(J,i),J=1,N)
WRITE (6,1023)(SSR(J,i),J=1,N)
AA = WORD(4)
METHOD(i)=1
AA = WORD(5)
METHOD(i)=2
METHOD(i)=3
PAGE 4

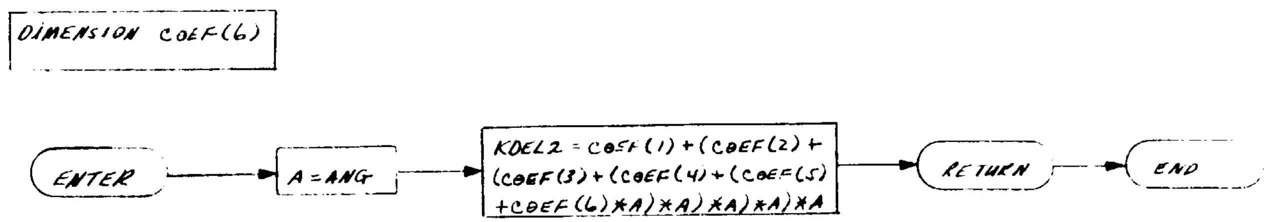

SUBROUTINE INPUT
PAGE 3
AA = WORD(I)
NO
YES
METHOD(I)=4
METHOD (I) ≤ 2
NO
YES
READ(5,1007) NRAD(I)
N=NRAD(I)
READ(5,1014) (RAD(J,I), J=1,N)
METHOD(I) = 4
YES
WRITE(6,1016) (RAD(J,I), J=1,N)
170
WRITE(6,1015) (RAD(J,I), J=1,N)
DO 180 J=1,N
180
RAD(J,I) = RAD(J,I)/ RADICAN
190
CONTINUE
WRITE(6,1023) (RADR(J,I), J=1,N)
200
LK = METHOD(I) +3
WRITE(6,1029) WORD(LK)
205
DO 210 J=1,8
MIN(J,I) = MIN(J,I)/ RADICAN
MOUT(J,I) = MOUT(J,I)/ RADICAN
210
CONTINUE
220
CONTINUE
DO 230 I=1,NX
DO 230 J=1,NLINES
CR(I,J) = 0.0
CU(I,J) = 0.0
TO(I,J) = TOCO
PO(I,J) = POCO
230
CONTINUE
DO 240 I = 1,KK
240
WRITE(6,1012) TEMC(I), (DF(J), (FOUND(J,K,I), K=1,3), J=1,20)
CALL TIME1(TIME)
STOP = STOP * 3600. + TIME
DO 250 I=1,NX1
250
X(I) = X(I+1) - X(I)
TONE = .TRUE.
SPEED = SPEED * .10471976
SPEED = SPEED / 12.0
N = 1
CALL RSTART
DCP = GASK/JOULE
J=1
TSTAT(1) = TOCO
CALL GAM
NDATA = 0
LEVEL = 1
NO
YES
CALL HEAD
RETURN
END

SUBROUTINE INTEG (VDEP, IFCON).

```
SUBROUTINE INTEG (VDEP, IFCON)

LOGICAL   CIRCLE, SUTTLE
REAL  IREF,   TOULE,   MACH,  METAL,
      MIN,    MINR,    MBUG,  MOUTR
INTEGER  BLADE,  JOINT
LOGICAL   OFF,  OK,  RDFLD,
          RESTAR, TONE
INTEGER  RULE
REAL  KDEL, KDEL2
DIMENSION  VDEP (32, 11)
```

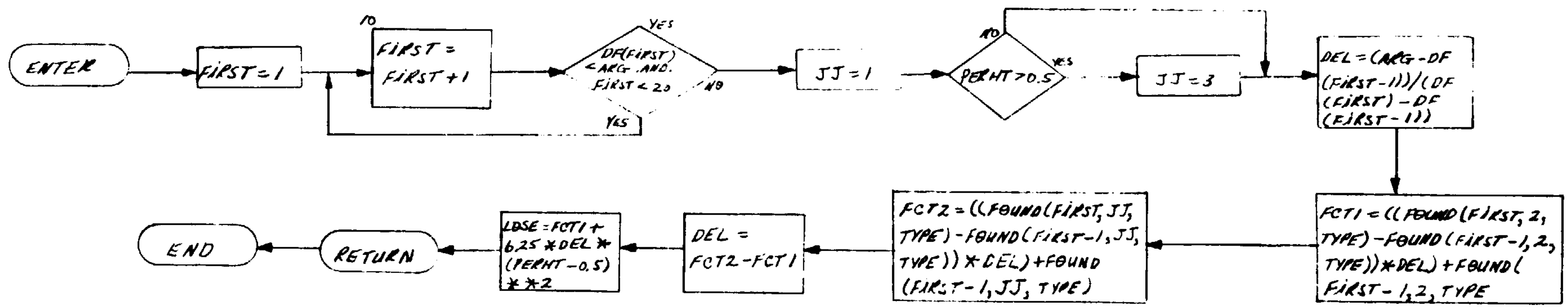


SUBROUTINE KOEL2 (ANG)

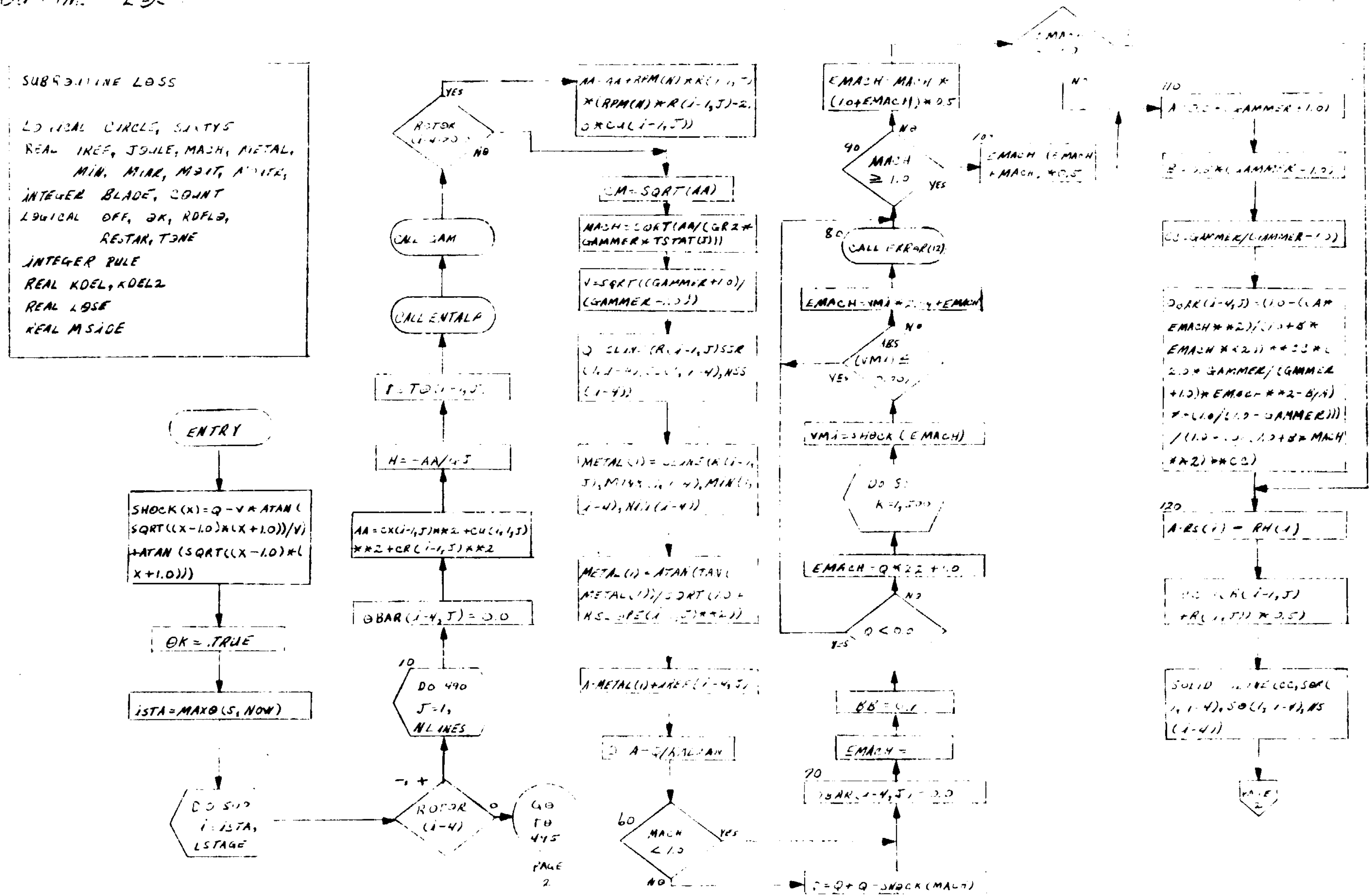


SUBROUTINE LOSE

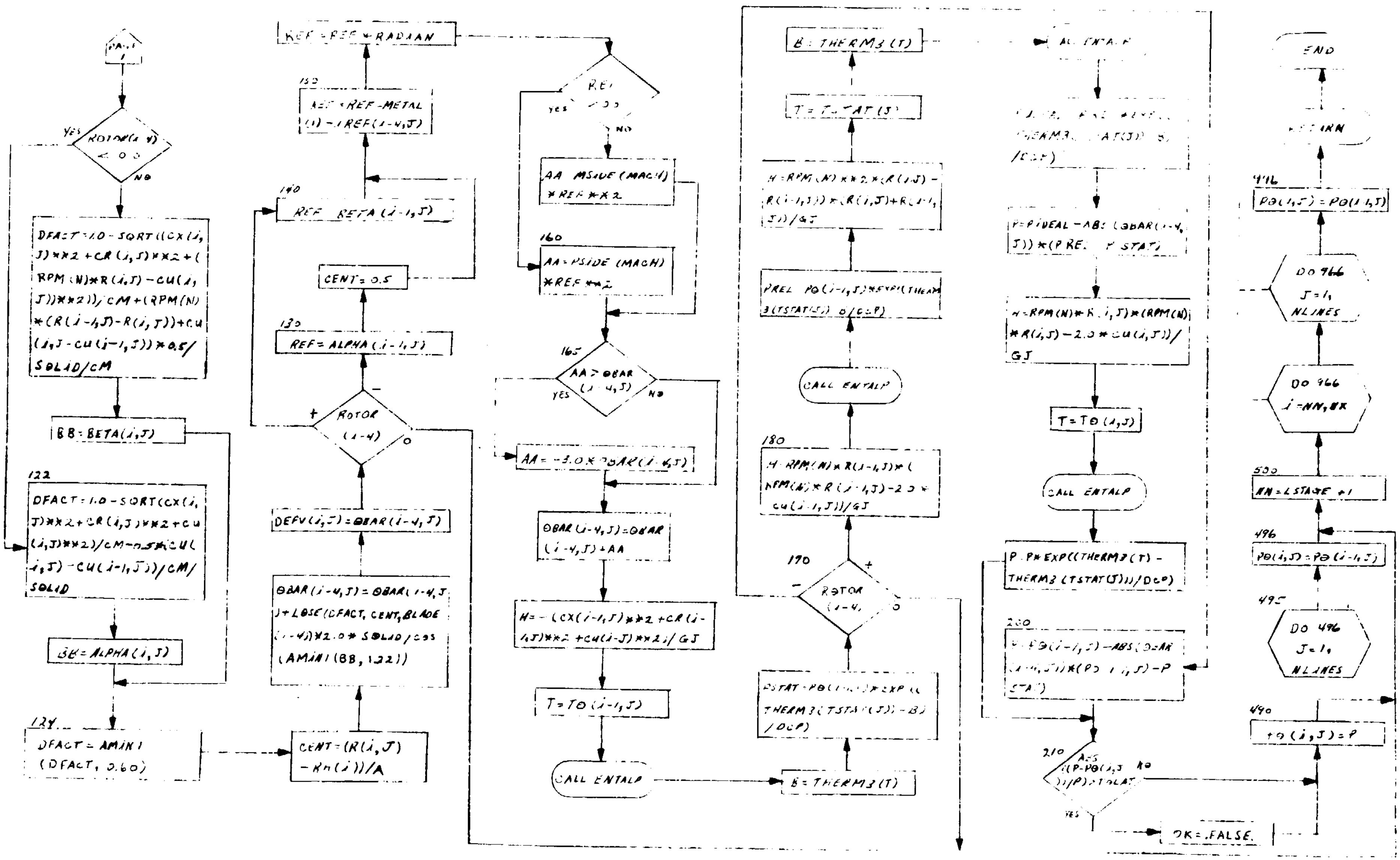

```
LOGICAL CIRCLE, SIXTYS
REAL IREF, JOULE, MACH, METAL,
     MIN, MINR, MOUT, MOUTR

INTEGER BLADE, COUNT
LOGICAL OFF, OK, ROFLO, RESTAR
        TONE
INTEGER RULE
REAL KDEL, KDEL2
COMMON /VECTOR/
COMMON /SCALAR/
INTEGER TYPE, FIRST
```



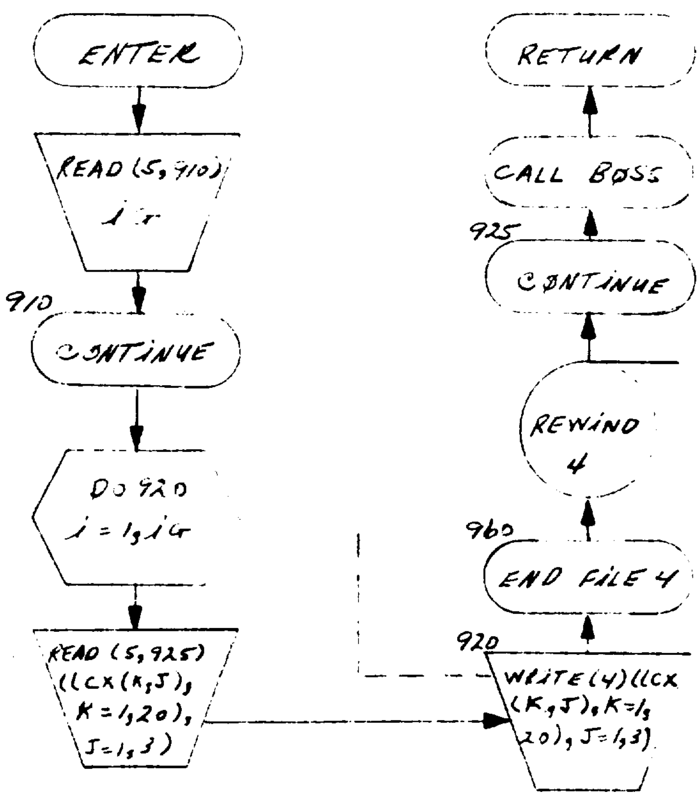
SUBROUTINE LOSS



SUBROUTINE LOSS PAGE 2 OF 2

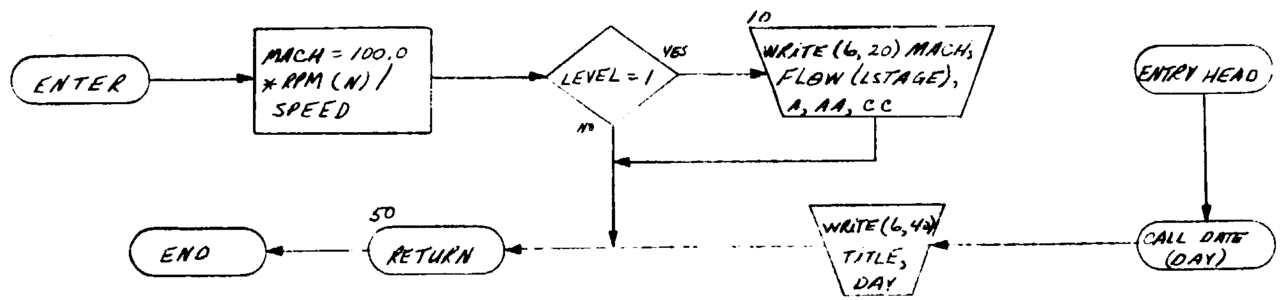


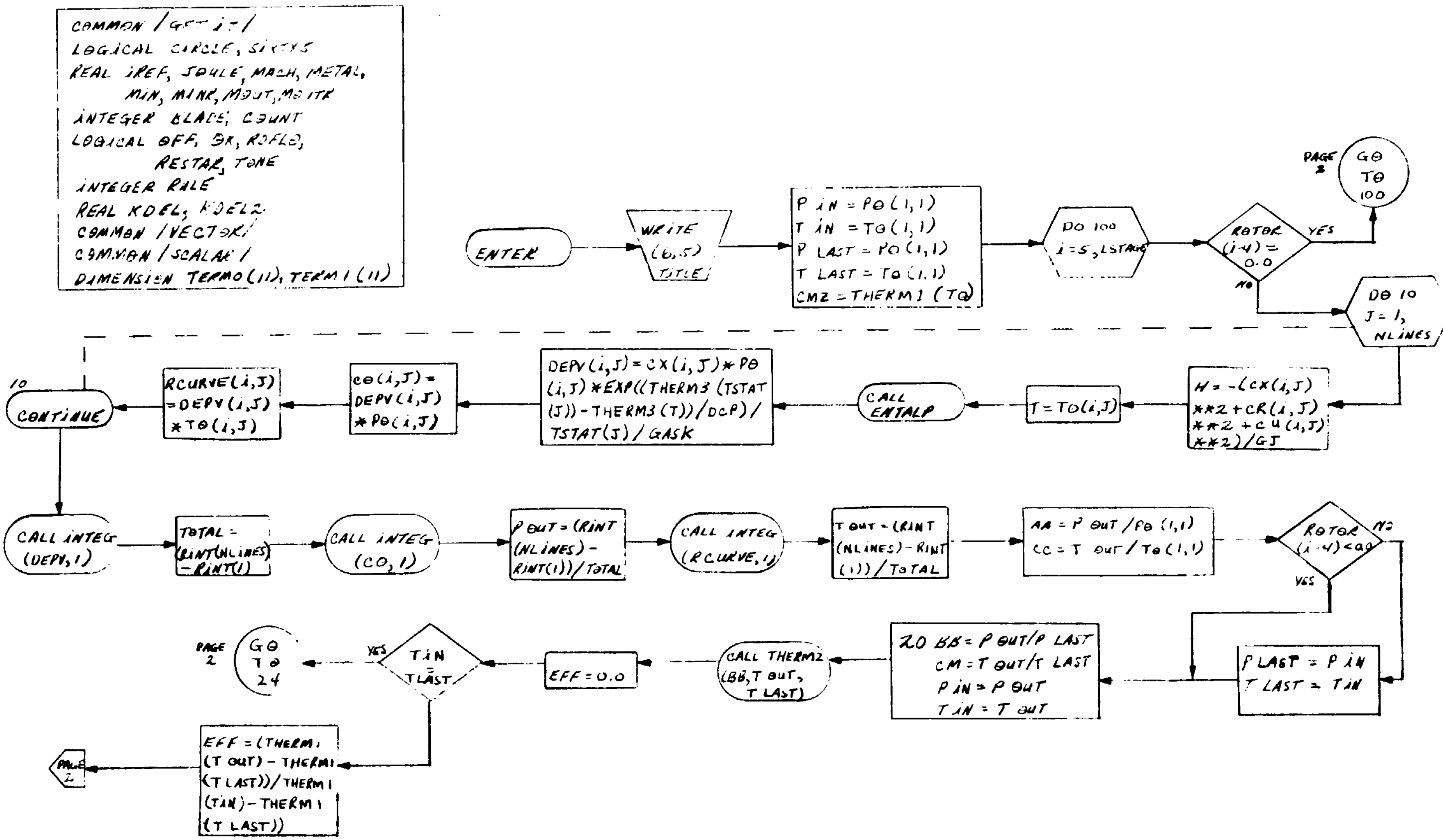
```
MAIN

LOGICAL CIRCLE, SIXTY5
REAL IREF, JOULE, MACH, METAL,
     MIN, MINR, MOUT, MOUTR
INTEGER BLADE
LOGICAL OFF, OK, RDFLO,
     RESTAR, TONE
INTEGER RULE
REAL KDEL, KDEL2
```

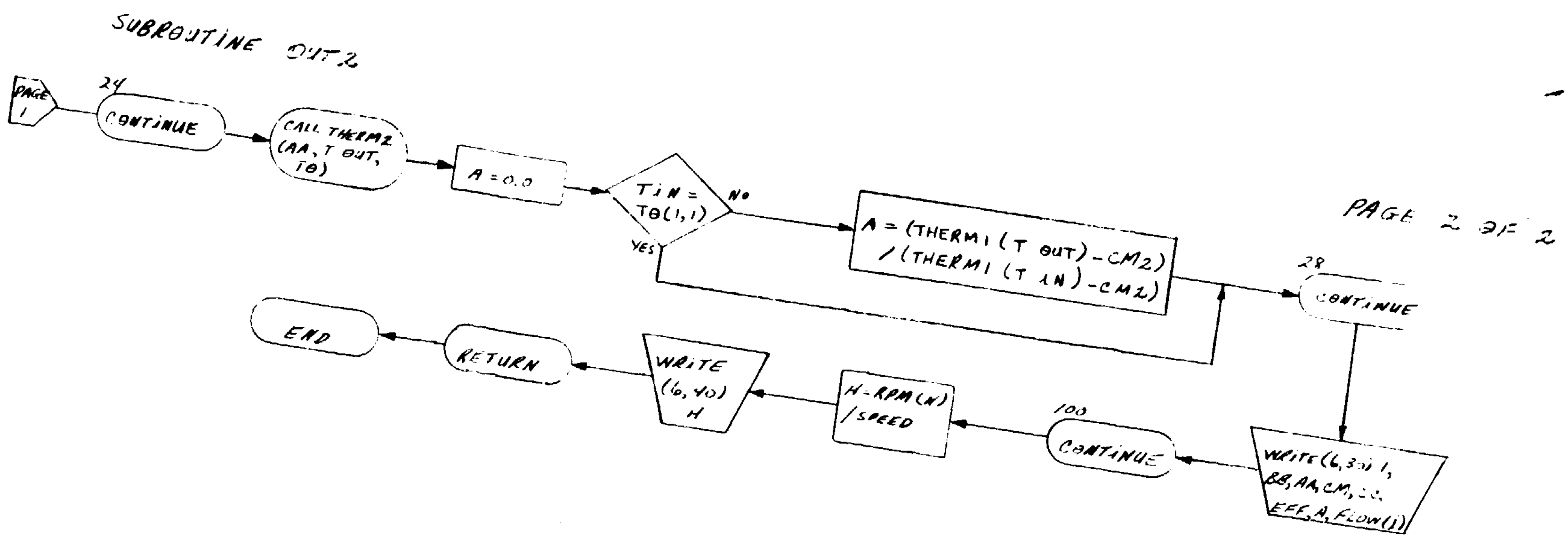


SUBROUTINE OUT1

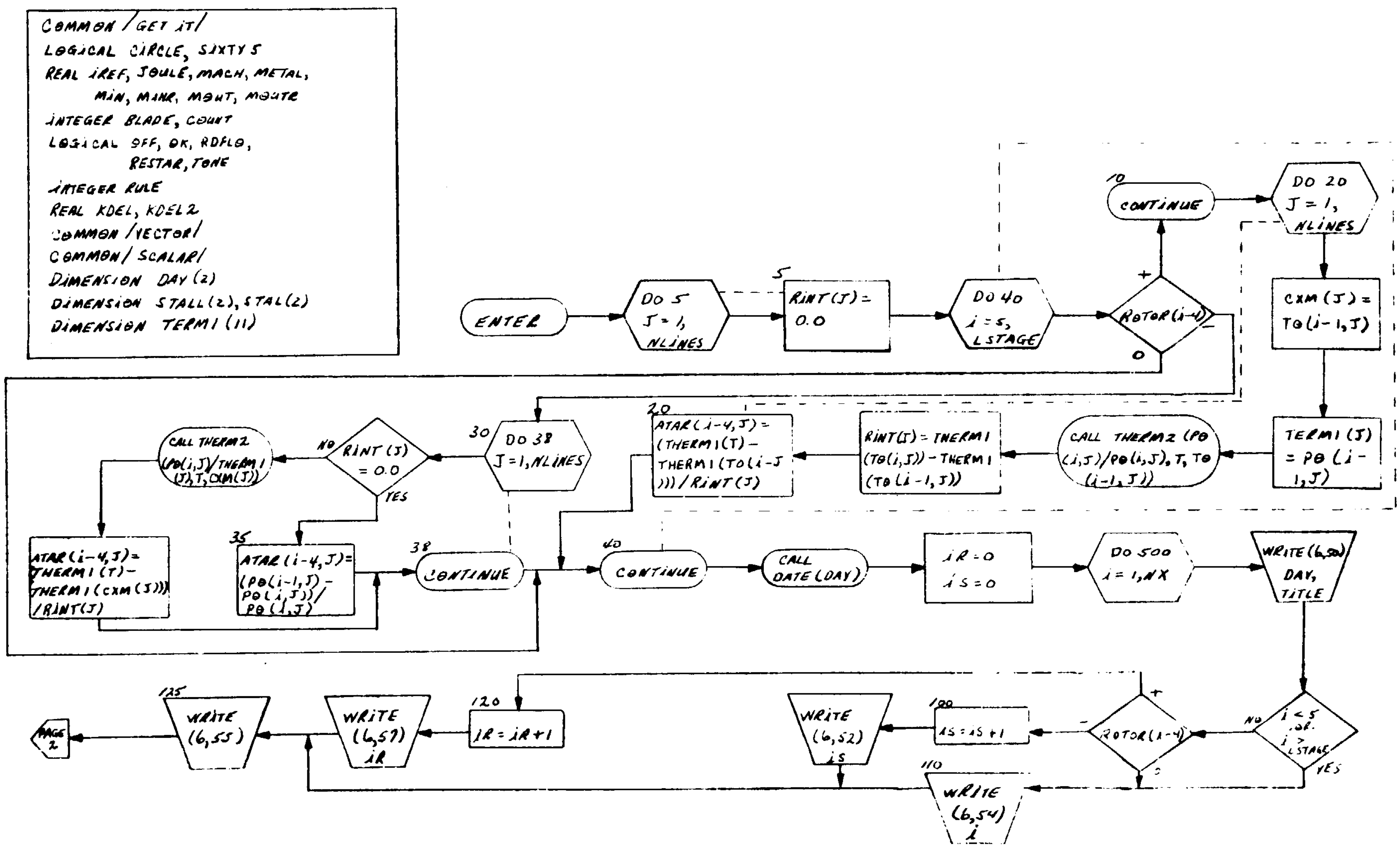
```
COMMON /GET IT/
LOGICAL CIRCLE, SIXTY5
REAL IREF, JOULE, MACH, METAL,
     MIN, MINR, MOUT, MOUTR
INTEGER BLADE, COUNT
LOGICAL OFF, OK, RDFLO,
        RESTAR, TONE
INTEGER RULE
REAL KDEL, KDEL2
COMMON /VECTOR/
COMMON /SCALAR/
DIMENSION DAY(2)
```




COMMON /GEN I/
LOGICAL CIRCLE, SIXTYS
REAL IREF, JOULE, MACH, METAL,
MIN, MINR, MOUT, MOITR
INTEGER BLADE, COUNT
LOGICAL OFF, BK, ROFLO,
RESTAR, TONE
INTEGER RALE
REAL KDEL, KDEL2
COMMON /VECTOR/
COMMON /SCALAR/
DIMENSION TERMO(11), TERM1(11)
ENTER
WRITE (6,5) TITLE
P IN = PO(1,1)
T IN = TO(1,1)
P LAST = PO(1,1)
T LAST = TO(1,1)
CMZ = THERM1 (TO)
DO 100 I=5, LSTAGE
ROTOR (I-4) = 0.0
YES
NO
PAGE 2
GO TO 100
DO 10 J=1, NLINES
H = -(CX(I,J)**2+CR(I,J)**2+CU(I,J)**2)/GJ
T=TO(I,J)
CALL ENTALP
DEPV(I,J)=CX(I,J)*PO(I,J)*EXP((THERM3(TSTAT(J))-THERM3(T))/DCP)/TSTAT(J)/GASK
CO(I,J)=DEPV(I,J)*PO(I,J)
RCURVE(I,J)=DEPV(I,J)*TO(I,J)
10
CONTINUE
CALL INTEG (DEPV,1)
TOTAL = RINT(NLINES) - RINT(1)
CALL INTEG (CO,1)
P OUT = (RINT(NLINES) - RINT(1))/TOTAL
CALL INTEG (RCURVE,1)
T OUT = (RINT(NLINES) - RINT(1))/TOTAL
AA = P OUT / PO(1,1)
CC = T OUT / TO(1,1)
ROTOR (I-4)<0.0
NO
YES
P LAST = P IN
T LAST = T IN
20 BB = P OUT/P LAST
CM = T OUT/T LAST
P IN = P OUT
T IN = T OUT
CALL THERM2 (BB,T OUT, T LAST)
EFF=0.0
T IN = T LAST
YES
PAGE 2
GO TO 24
EFF = (THERM1(T OUT) - THERM1(T LAST))/THERM1(T IN) - THERM1(T LAST))
PAGE 2

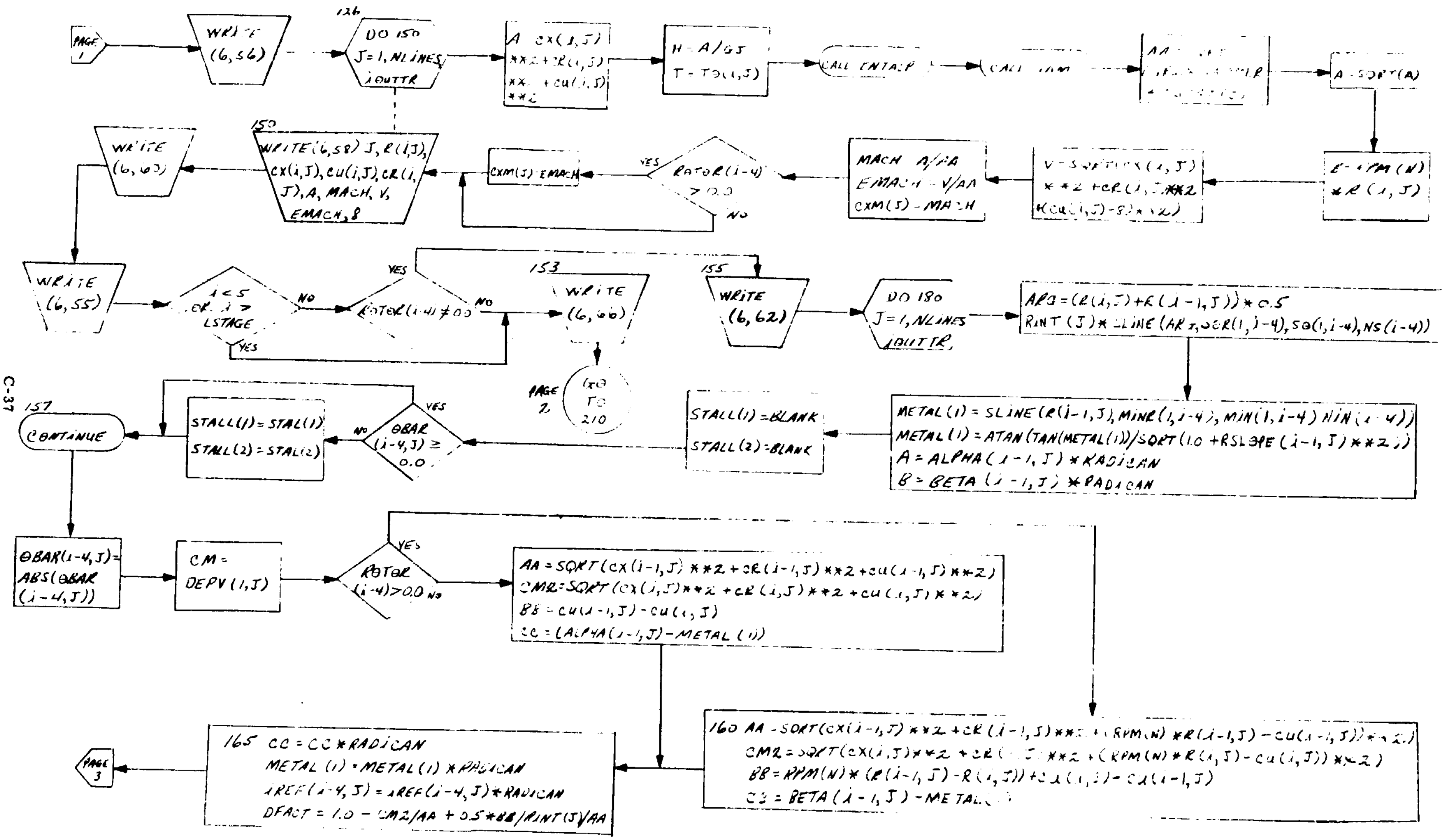

SUBROUTINE OUT2
PAGE 2 OF 2
PAGE 1
24
CONTINUE
CALL THERM2 (AA, T OUT, TΘ)
A = 0.0
TIN = TΘ(1,1)
NO
YES
A = (THERM1 (T OUT) - CM2) / (THERM1 (T IN) - CM2)
28
CONTINUE
WRITE (6,30) I, BB, AA, CM, CC, EFF, A, FLOW(I)
100
CONTINUE
H = RPM(N) / SPEED
WRITE (6,40) H
RETURN
END

SUBROUTINE OUT3

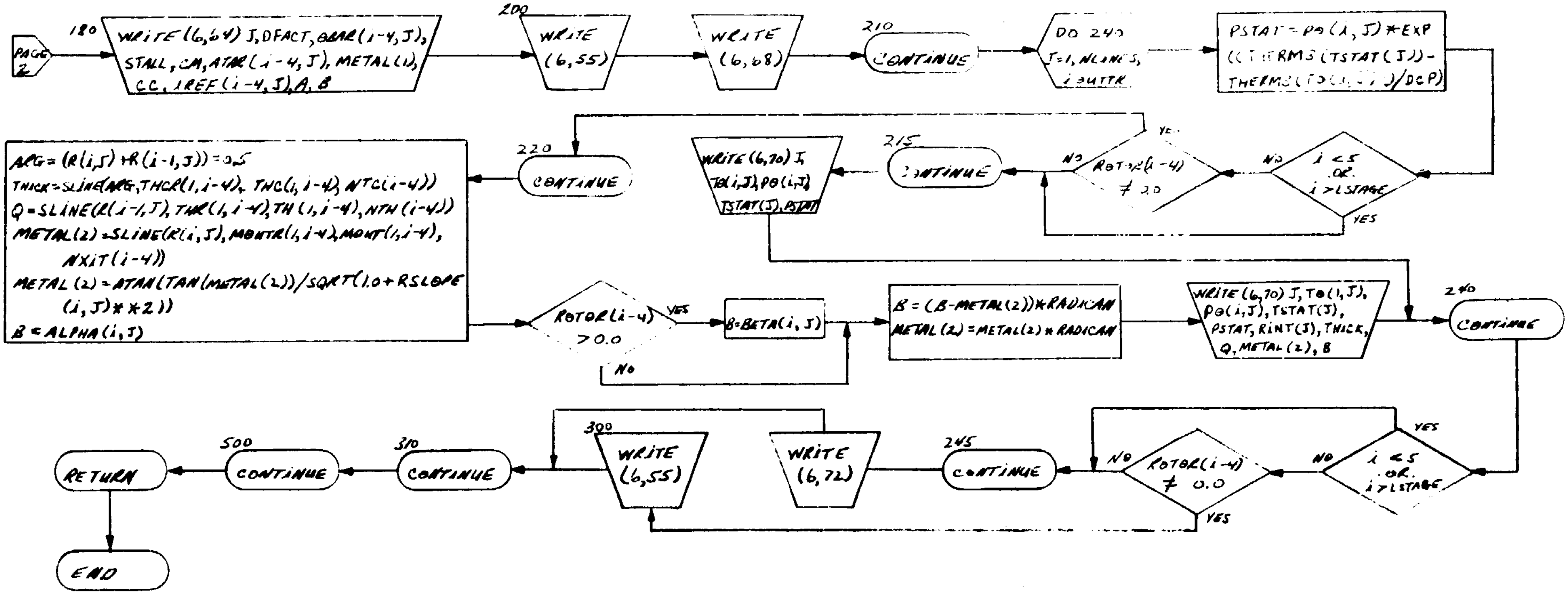


SUBROUTINE OUT3

PAGE 2 OF 3

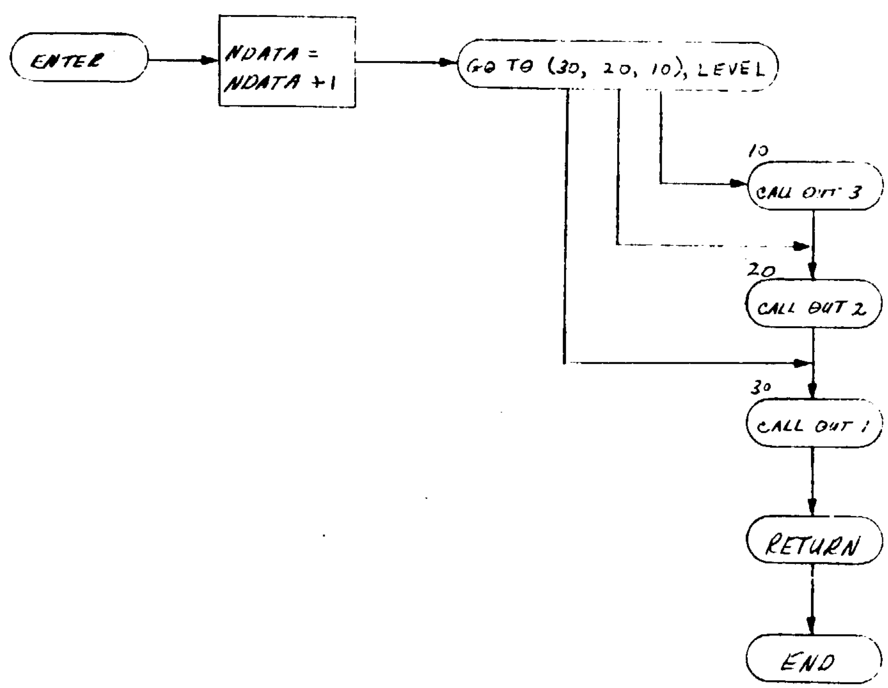


SUBROUTINE OUT3

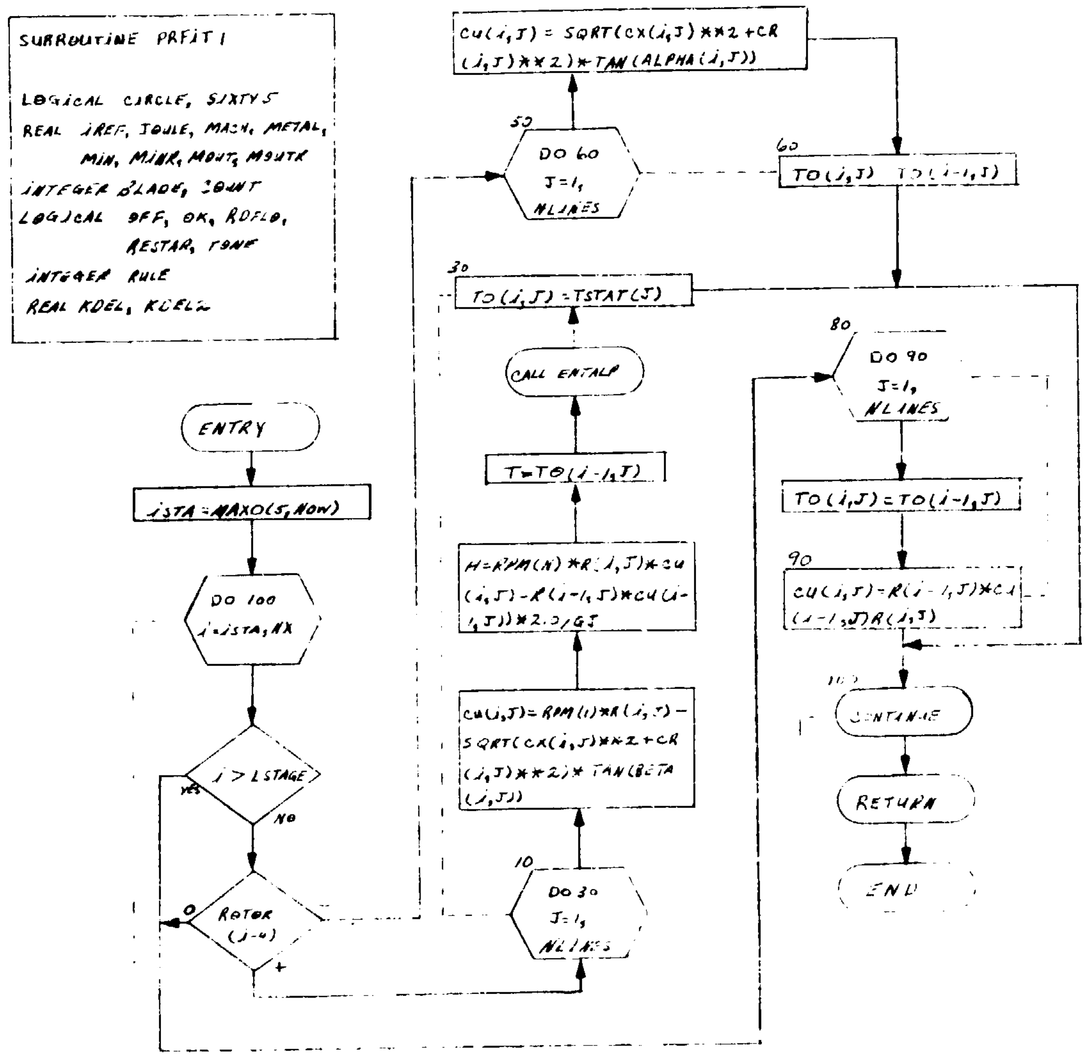


SUBROUTINE OUTPUT

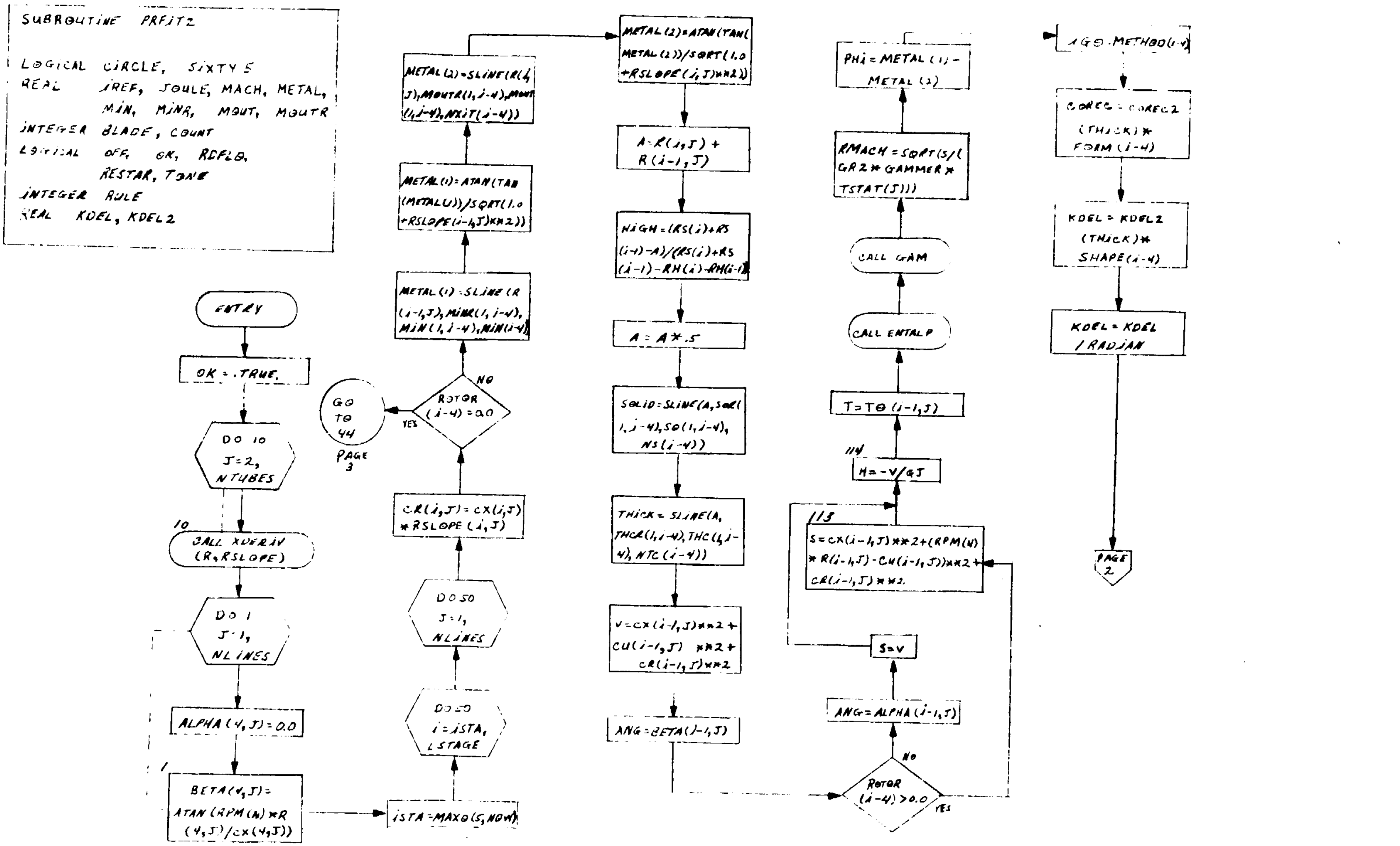
```
LOGICAL CIRCLE, [illegible]
REAL [illegible], [illegible], MACH, METAL,
     MIN, [illegible], MOUT, [illegible]
INTEGER [illegible], COUNT
LOGICAL OFF, OK, [illegible], RESTAR, TONE
INTEGER RULE
REAL [illegible], [illegible]
COMMON /[illegible]/
COMMON /SCALAR/
```

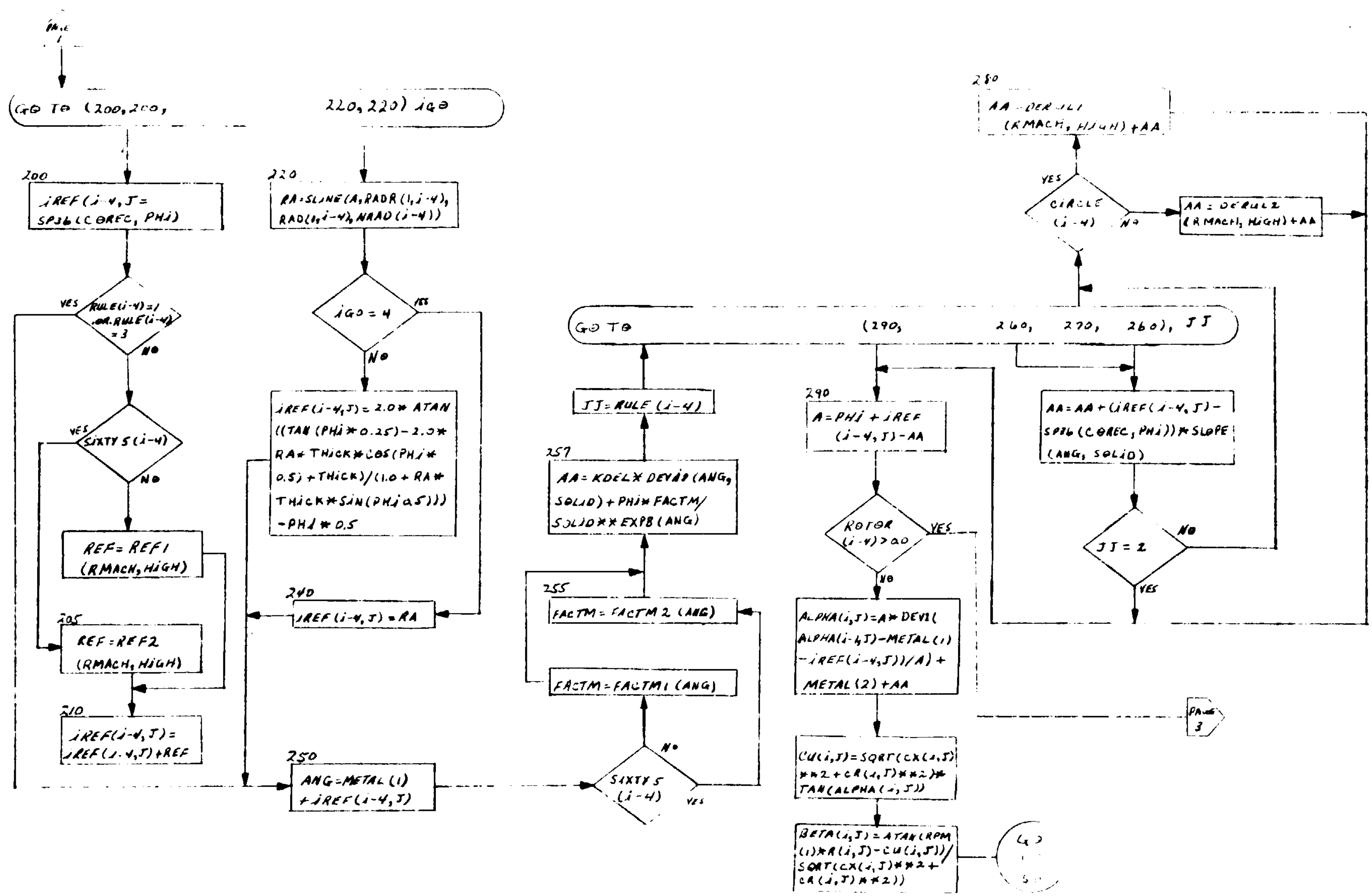


SUBROUTINE PRFIT1

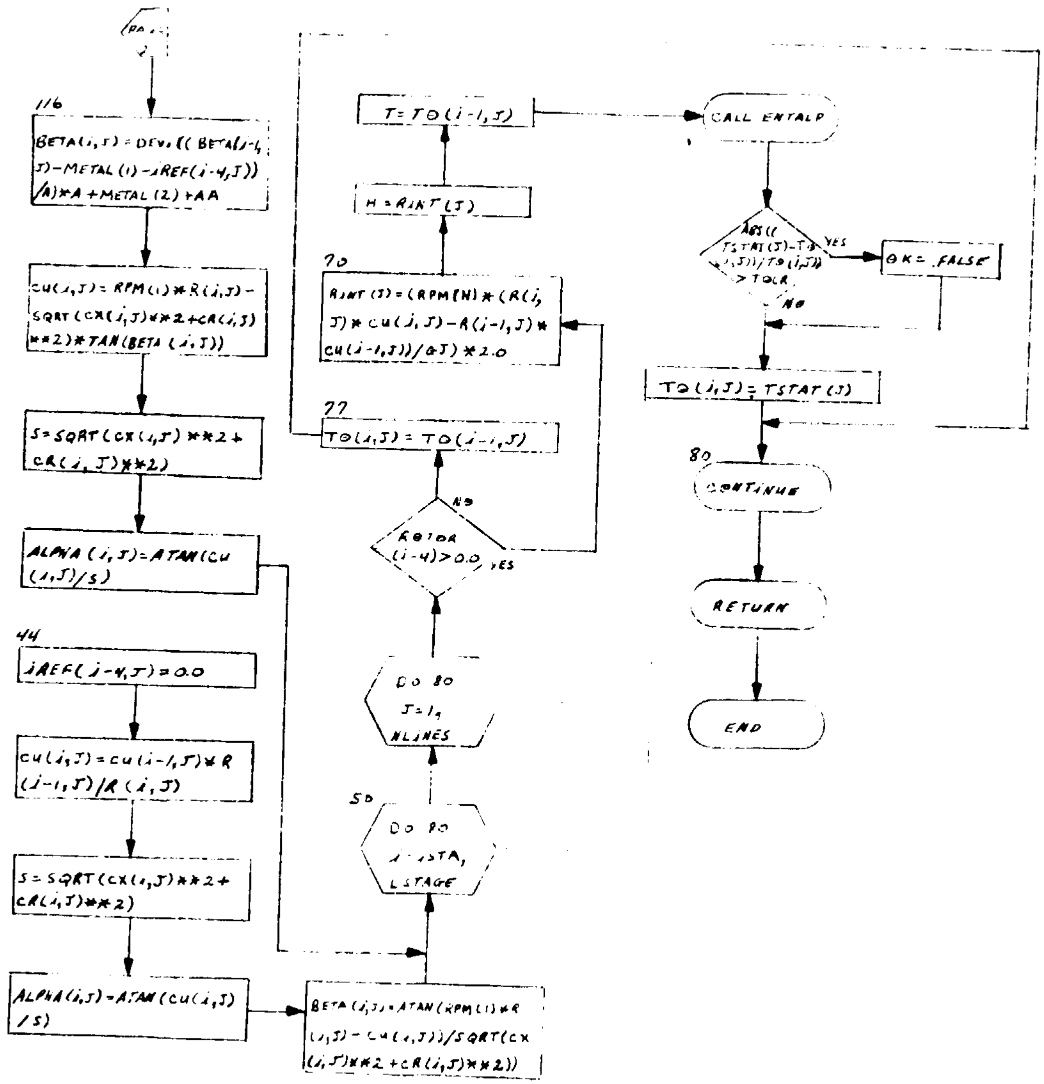


SUBROUTINE PREJT2

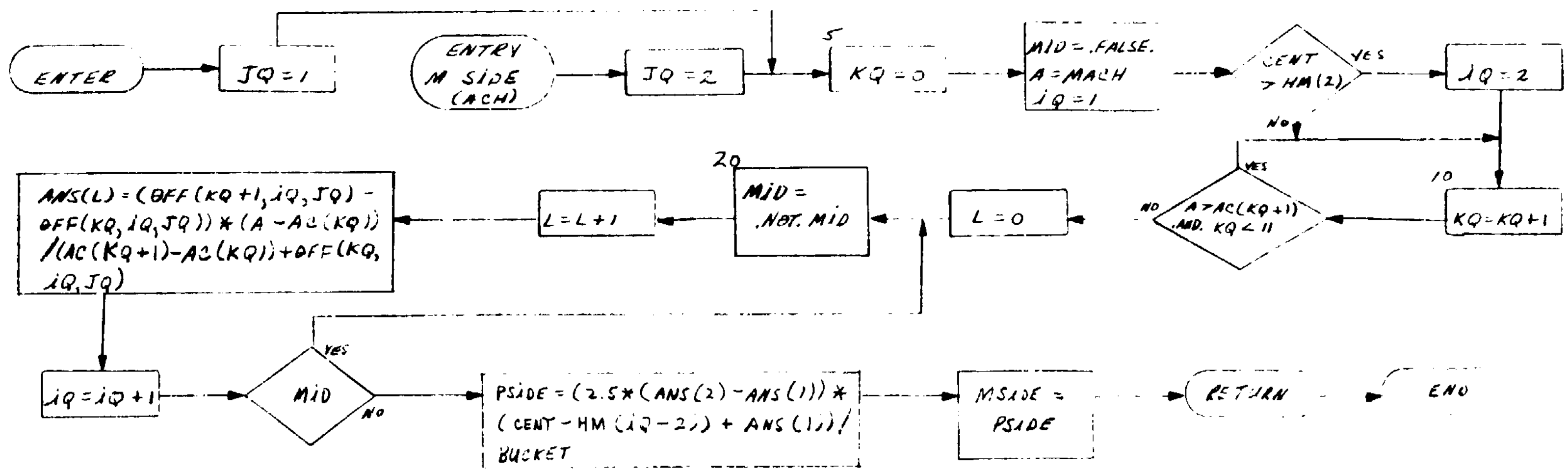



PAGE 1
GO TO (200,200, 220,220) IGO
200
IREF(I-4,J)= SP36(COREC, PHI)
RULE(I-4)=1 .OR. RULE(I-4)=3
YES
NO
SIXTY S(I-4)
YES
NO
REF=REF1 (RMACH,HIGH)
205
REF=REF2 (RMACH,HIGH)
210
IREF(I-4,J)= IREF(I-4,J)+REF
220
RA=SLINE(A,RADR(1,I-4), RAD(1,I-4),NRAD(I-4))
IGO=4
YES
NO
IREF(I-4,J)=2.0*ATAN ((TAN(PHI*0.25)-2.0* RA*THICK*COS(PHI* 0.5)+THICK)/(1.0+RA* THICK*SIN(PHI*0.5))) -PHI*0.5
240
IREF(I-4,J)=RA
250
ANG=METAL(1) +IREF(I-4,J)
SIXTY S (I-4)
NO
YES
FACTM=FACTM1(ANG)
255
FACTM=FACTM2(ANG)
257
AA=KDEL*DEVAP(ANG, SOLID)+PHI*FACTM/ SOLID**EXPB(ANG)
JJ=RULE(I-4)
GO TO (290, 260, 270, 260), JJ
290
A=PHI+IREF (I-4,J)-AA
ROTOR (I-4)>0.0
YES
NO
ALPHA(I,J)=A*DEV1(ALPHA(I-4,J)-METAL(1) -IREF(I-4,J))/A)+ METAL(2)+AA
CU(I,J)=SQRT(CX(I,J) **2+CR(I,J)**2)* TAN(ALPHA(I,J))
BETA(I,J)=ATAN(RPM (I)*R(I,J)-CU(I,J))/ SQRT(CX(I,J)**2+ CR(I,J)**2))
PAGE 3
AA=AA+(IREF(I-4,J)- SP36(COREC,PHI))*SLOPE (ANG, SOLID)
JJ=2
NO
YES
CIRCLE (I-4)
YES
NO
280
AA=DERUL1 (RMACH,HIGH)+AA
AA=DERUL2 (RMACH,HIGH)+AA

SUBROUTINE FRSIT2

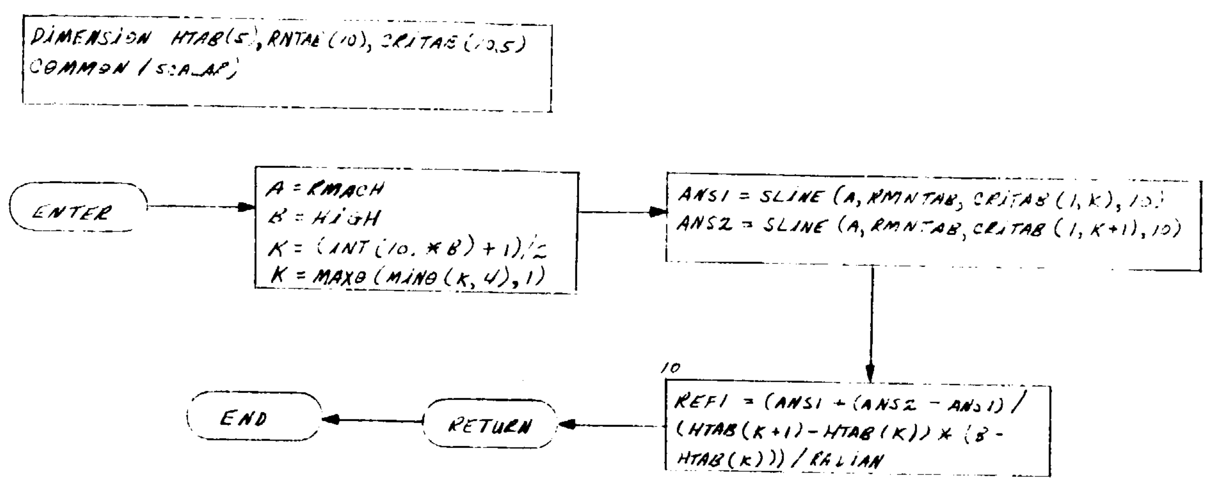


```
REAL MSIDE
COMMON /FULL/
LOGICAL CIRCLE, SIXTYS
REAL IREF, JOULE, MACH, METAL,
      MIN, MINR, MOUT, MOUTR
INTEGER BLADE, COUNT
INTEGER RULE
REAL KDEL, KDEL2
COMMON /VECTOR/
COMMON/ SCALAR/
LOGICAL MID
DIMENSION OFF (12,3,2), ANS(2), HM(2)
DIMENSION AC(12)
```

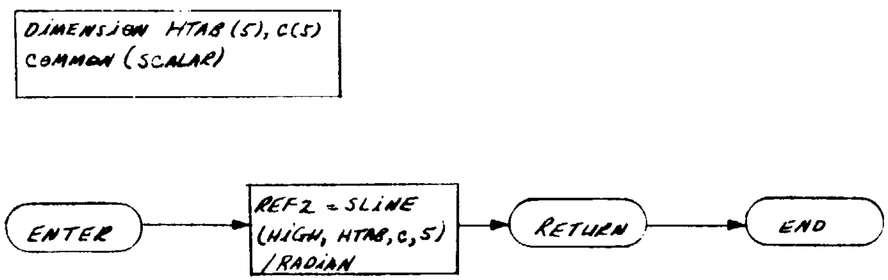


SUBROUTINE REF1 (RMACH, HIGH)

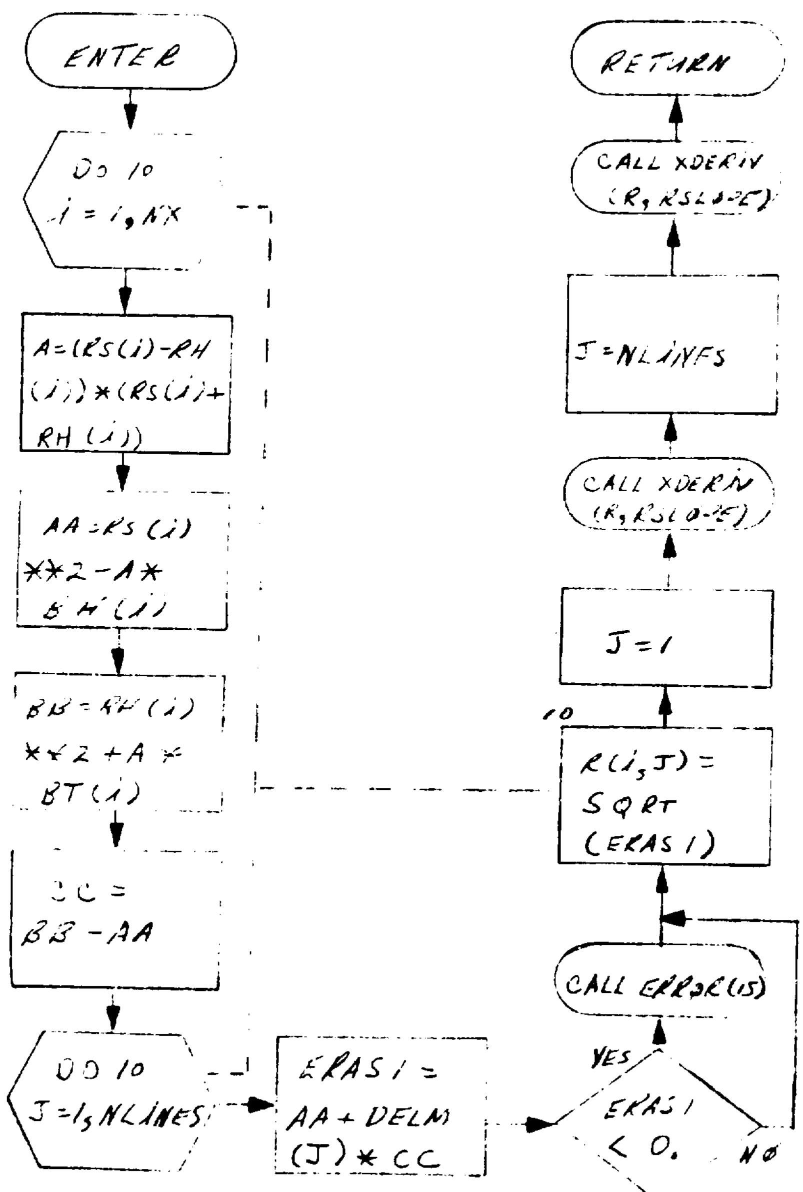
PAGE 1 9.5 1



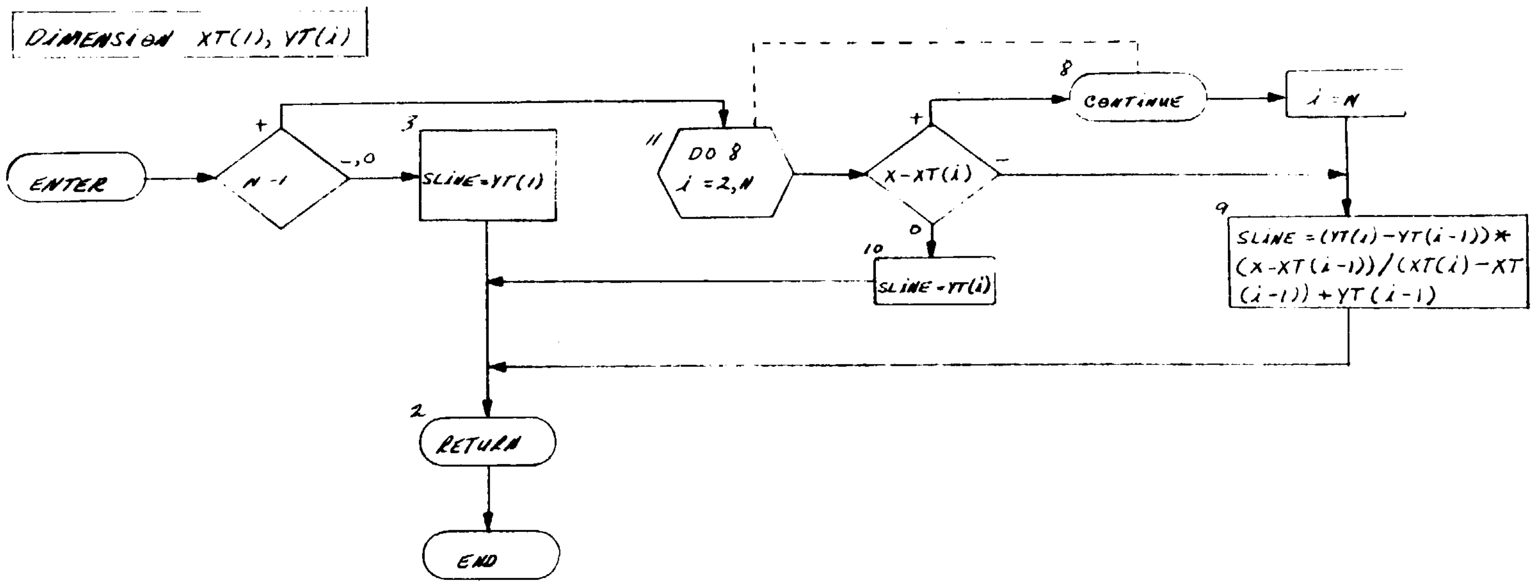
SUBROUTINE REF2 (RMACH, HIGH)



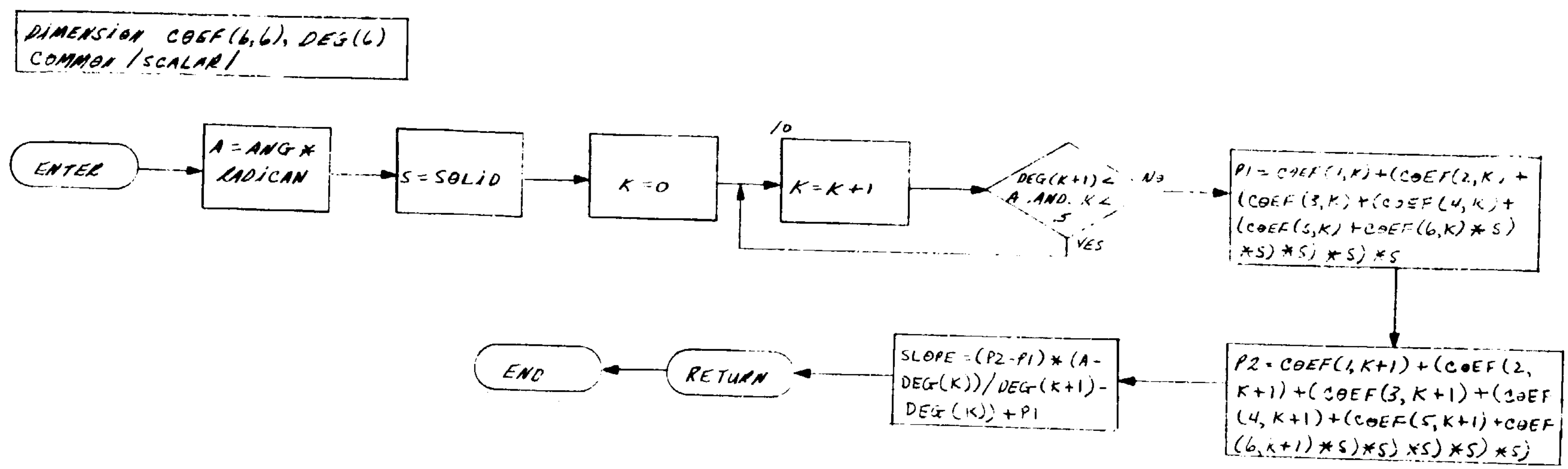
```
SUBROUTINE RSTART ;

LOGICAL CIRCLE, SIXTYS
REAL IREF, JOULE, MACH, METAL,
     MIN, MINR, MOUT, MOUTR,
INTEGER BLADE, COUNT
LOGICAL OFF, OK, RDFLD,
     RESTAR, TONE
INTEGER RULE
REAL RDEL, RDELD
```



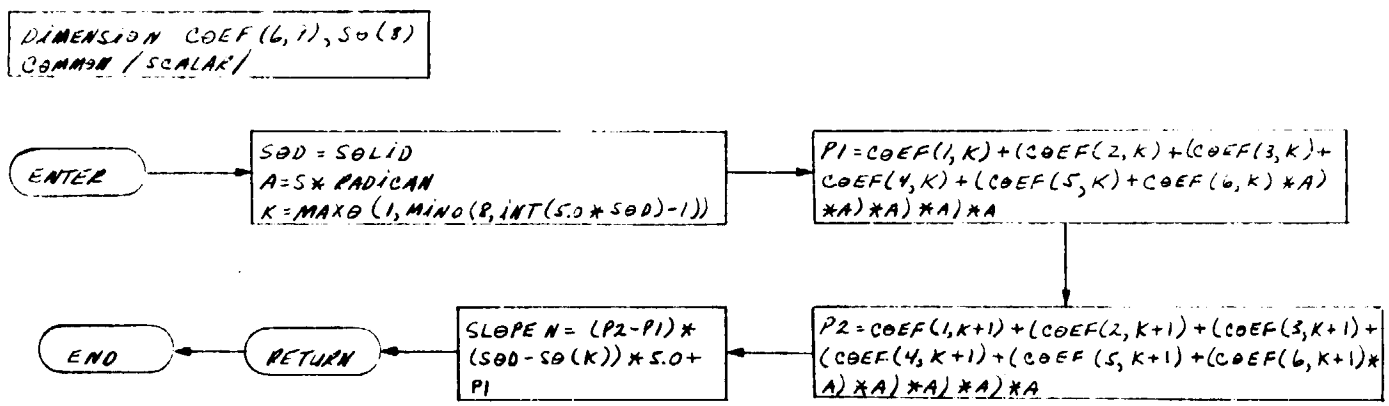
SUBROUTINE SLINE



SUBROUTINE SLOPE (ANG, SOLID)

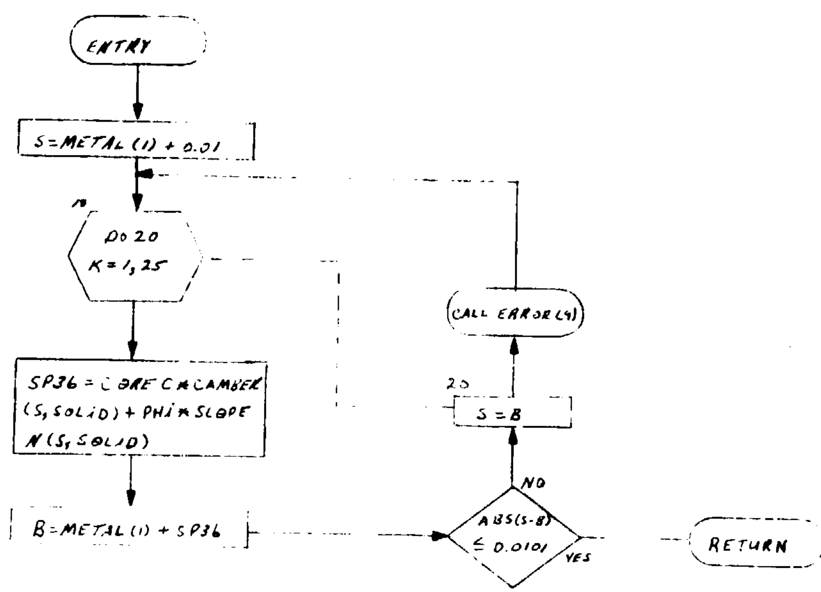


SUBROUTINE SLOPE N(S, SOLID)

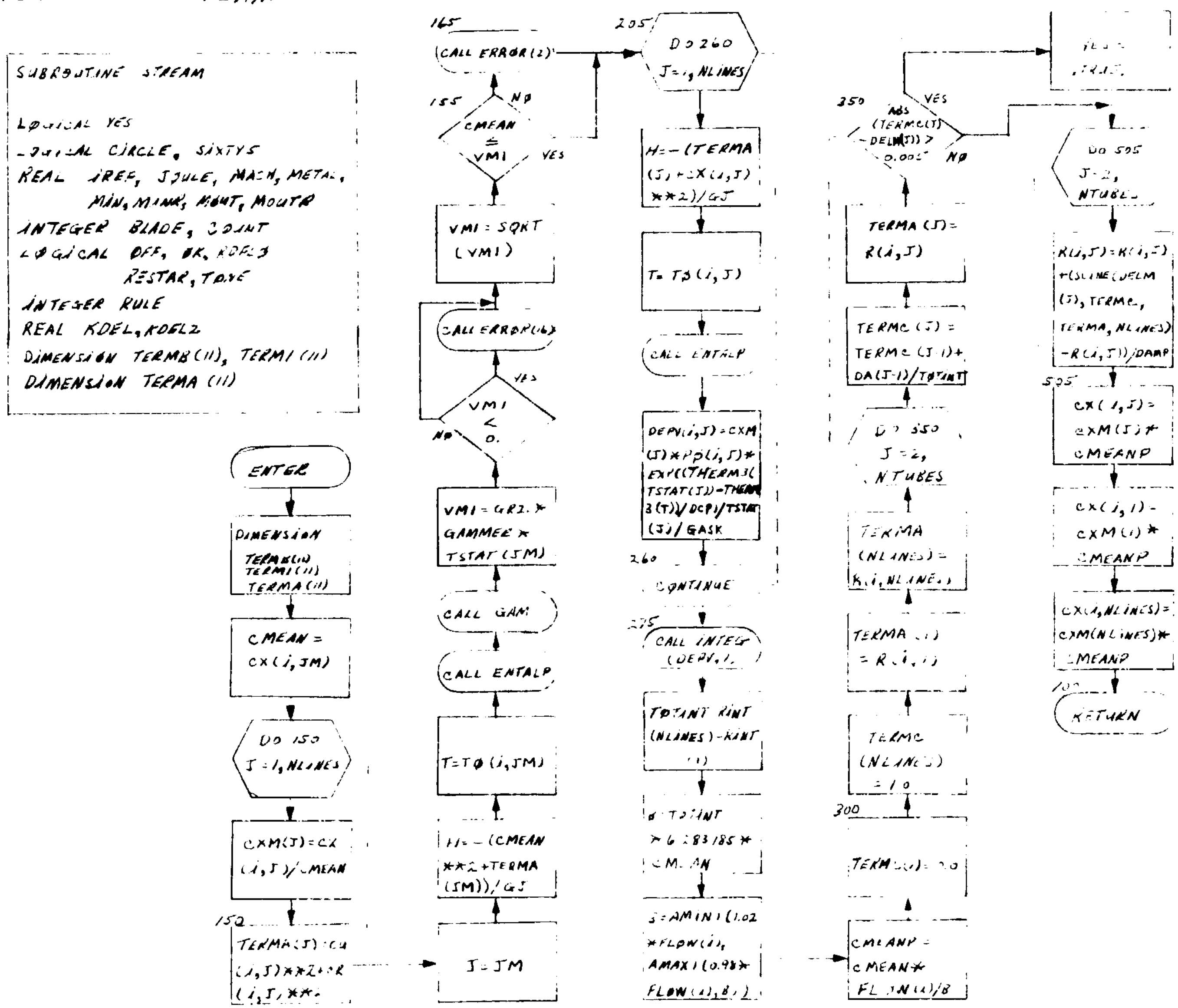


SUBROUTINE SP36

```
SUBROUTINE SP36
 FUN...ON SP36(QQQQ)
 LOGICAL CIRCLE, SIXTYS
 REAL IREF, JOULE, MACH, METAL,
      MIN, MINR, MOST, MOTR
 INTEGER BLADE, COUNT
 LOGICAL SFF, OK, RDFLD
      RESTAR, TONE
 INTEGER RULE
 REAL KDEL, KDEL2
```

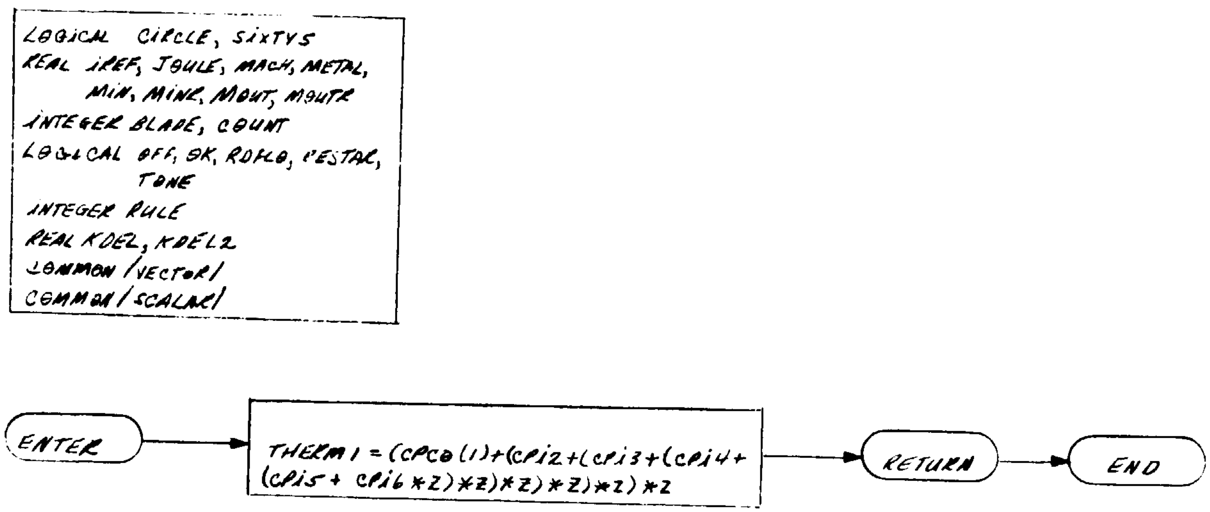


SUBROUTINE STREAM



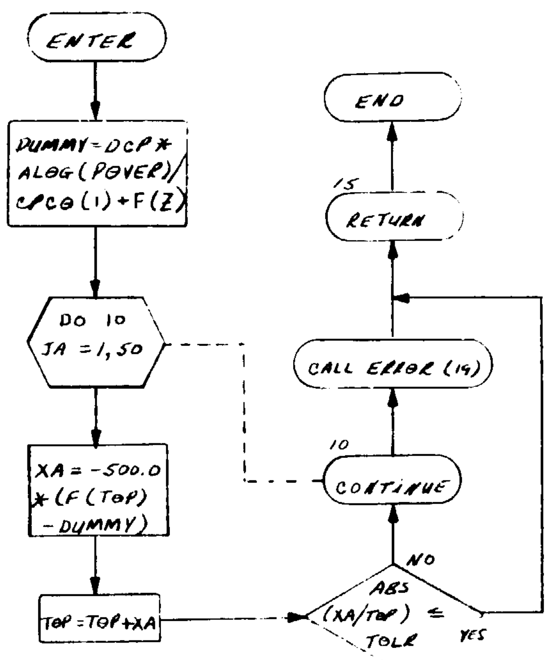
SUBROUTINE THERM1 (Z)

PAGE 1 OF 1



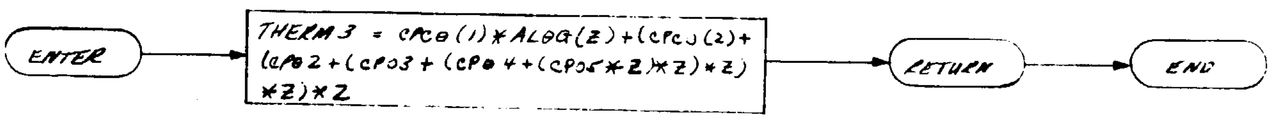
SUBROUTINE THERM2 (POVER, TOP, Z)

```
LOGICAL  CIRCLE, SIXTY5
REAL  AREF, JOULE, MACH, METAL,
      MIN, MINR, MOUT, MOUTR
INTEGER BLADE, COUNT
LOGICAL OFF, OK, RDFLO, RESTAR, TONE
INTEGER RULE
REAL KOEL, KOEL2
COMMON /VECTOR/
COMMON /SCALAR/
```

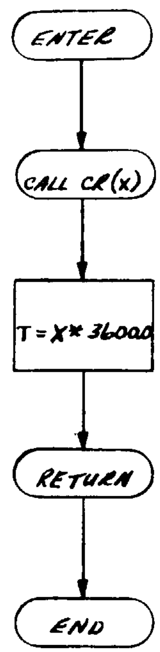


SUBROUTINE THERM3(Z)

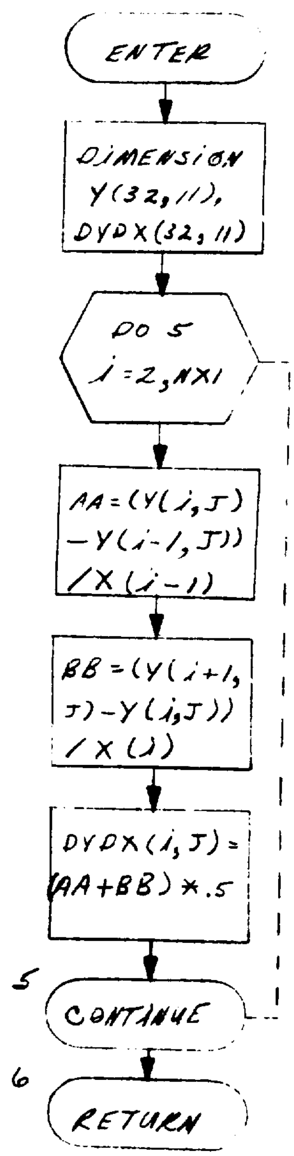

```
LOGICAL CIRCLE, SIXTYS
REAL IREF, JOULE, MACH, METAL, MIN,
      MINR, MOUT, MOUTR
INTEGER BLADE, COUNT
LOGICAL OFF, OK, RDFLD, RESTAR, TONE
INTEGER RULE
REAL KDEL, KDEL2
COMMON /VECTOR/
COMMON / SCALAR/
```



SUBROUTINE TIME1 (T)



```
SUBROUTINE XDERIV(Y,DYDX)

LOGICAL CIRCLE, SIXTY5
REAL IREF, JOULE, MACH, METAL,
     MIN, MINR, MOUT, MOUTR
INTEGER BLADE, COUNT
LOGICAL OFF, OK, RDFLO, RESTAR,
     TONE
INTEGER RULE
REAL KDEL, KDEL2
```



APPENDIX D

INPUT FORMAT AND SAMPLE DATA SET

APPENDIX D

Part A. Input Format — Data Preparation

PROGRAM AN-36 DATA PREPARATION

Tne N36 program is an off-design axial-flow compressor performance calculation program (IBM 7094) which iterates on efficiency through use of blade element loss information. The total loss coefficient for any blade element is based on reference total loss, plus an off-design increment in total loss correlated as a function of $i - i_{ref}$ and M'. The reference total loss is computed using correlations of reference profile loss parameter vs diffusion factor and using shock loss across a normal shock-in-passage.

All integer input data must be placed in the right most columns of the field specified. Decimal numbers should be placed in the left most part of the field and the decimal point must be included. Alphameric information must be spelled exactly as specified. No cards may be left out even if zero or blank unless specifically noted. See the following sample card format in connection with the following discussion.

CARD 1—COLUMNS 2-10 $DSTART $

This is used to recover from an error condition when several data sets are being run. Note spacing as shown.

CARDS 2-4—TITLE CARDS

Three cards to be used for identification. Columns 1-72 may be used.

CARDS 5-6—CONSTANT PRESSURE SPECIFIC HEAT AS FUNCTION OF ABSOLUTE TEMPERATURE

The fields shown on these cards are for the coefficients of a fifth degree polynomial used to evaluate the specific heat at constant pressure:

$$c_p(T) = a_0 + a_1\ T + a_2\ T^2 + a_3\ T^3 + a_4\ T^4 + a_5\ T^5$$

Values of these coefficients for air are shown in the following table.

Temperature	0° to 1700°R	500° to 3400°R	1500° to 5000°R
a_0	0.23746571	0.257348261	0.18198209
a_1	0.21961999 X10^{-4}	-0.82118436 X10^{-4}	0.87076455 X10^{-4}
a_2	-0.87791471 X10^{-7}	0.11967112 X10^{-6}	-0.28093746 X10^{-7}
a_3	0.1399136 X10^{-9}	-0.57795091 X10^{-10}	0.50606304 X10^{-11}
a_4	-0.78056154 X10^{-13}	0.12572563 X10^{-13}	-0.40556182 X10^{-15}
a_5	0.15042604 X10^{-16}	-0.10414624 X10^{-17}	0.18191946 X10^{-19}

CARD 7—GENERAL DATA AND OPTIONS

Columns 1-5. (Integer, right adjusted)

The number of axial stations ≤ 32. There are to be four stations ahead of and three stations behind the blades. See Figures 1 - 3 for typical configurations. Note that the number of blade sections is equal to the value of Item 1 minus 7. Also note that some of these passages may be empty and are referred to as annular rows. Energy and angular momentum are conserved across an annular row.

Columns 6-10. (Integer, right adjusted)

The number of streamlines at which calculations are to be performed; must be either 5, 7, 9, or 11.

Columns 11-15. (right adjusted)

The number of speed lines desired, ≤ 15.

Columns 16-20. (right adjusted)

The maximum number of data points to be calculated per speed line.

Columns 21-25. (right adjusted)

The minimum number of data points to be calculated per speed line.

Columns 31-35. (right adjusted)

= 1 if the results at all streamlines are to be printed
= 2 if the results at the odd numbered streamlines are to be printed
= 3 if the hub, mean, and tip streamline quantities are to be printed
= 4 if the hub and tip quantities are to be printed

Columns 41-45. (right adjusted)

1 if only overall mass averaged quantities are to be printed (η, temperature ratio, pressure ratio, ω, etc.)

2 if the mass averaged blade row properties are also to be printed

3 if all interstage data are also to be printed

CARD 8—GENERAL DATA AND RELATIVE ERROR TOLERANCES

Columns 1-10.

Design speed, rpm.

Columns 11-20.

Execution time - the number of minutes (fixed point number) the calculation is permitted to run. If computations are still proceeding at the end of this time, the computation is stopped and output is printed to reflect computed performance at the end of permitted execution time.

Columns 21-30.

Inlet total temperature in °R.

Columns 31-40.

Inlet total pressure in psia.

Columns 41-50.

Relative error tolerance on axial velocity, 0.01 is suggested.

Columns 51-60.

Minimum mass flow rate reduction. (lb/sec)

Columns 61-70.

Relative error tolerance on continuity, 0.0005 is suggested.

Columns 71-80.

Relative error tolerance on enthalpy, 0.01 is suggested.

CARD 9—GENERAL DATA AND RELATIVE ERROR TOLERANCES

Columns 1-10.

Relative error tolerance on efficiency, 0.01 is suggested.

Columns 11-20.

Relative error tolerance on temperature rise, 0.01 is suggested.

Columns 21-30.

Molecular weight of the flowing fluid, 28.97 for air.

Columns 31-40.

Iteration damping factor, 10.0 is suitable under most circumstances.

CARD TYPE 10—STREAMTUBE MASS FLOW

In the data fields shown, enter the fraction of the mass flow between each streamline and the hub. The first value must be 0.0, the final value must be 1.0 and the entered values must progress monotonically. Continue on another card if required.

CARD TYPE 11—FLOW PATH AND BLOCKAGE INFORMATION

There must be one card for each axial station, with the program requiring four axial stations upstream of the first blade row and three axial stations downstream of the last blade row. Units used must be consistent with those used for inlet total pressure. The blockage factor at a hub or tip represents the fraction of the local geometric annulus area not blocked there.

The following cards, Types 12-16, are used to identify blade rows throughout the compressor, from front to rear consecutively. While a dummy blade row (typically used to provide extra inlet or exit stations, or spacing between blade row) requires only one Type 12 card and one Type 13 card, a rotor or stator blade row requires each of these plus as many groups of card Types 14-16 as required to provide all the necessary blade element data. As described below, evaluation of reference incidence through the criterion of suction surface tangency or by means of table input requires the inclusion of one extra blade element data table (i.e., one extra group of Card Types 14-16).

CARD TYPE 12—BLADE ROW INFORMATION

Columns 1-10. (left adjusted)

Rotor designates a rotor blade row
Stator designates a stator blade row
Annulus designates a dummy row with no blades. No further information need be entered on this card for a dummy blade row.

Columns 11-15. (right adjusted)

Identification number for reference profile loss data set. Up to 999 loss data sets can be stored as permanent data.

Columns 21-30. (left adjusted)

Specifies means of evaluating the reference incidence angle at each streamline for the blade row.

2-D SP36 — Denotes use of NASA 2-D rules. See Reference 4. Leave 1 blank column between D and S.

3-D SP36 — Denotes use of NASA 3-D rules. See Reference 4. Leave 1 blank column between D and S.

SUCTION — Denotes use of the tangent to the suction surface at its intersection with the leading edge circle to define the reference incidence direction. This may be used only for dca blades, and a table of values for ler/t_{max} must be included at the end of tabled blade element data in the format of Card Types 14-16. ler/t_{max} is input as a function of average streamline radius.

TABLE — Denotes use of tabled input for reference incidence angle. This table is in the format of Card Types 14-16 and must be placed at the end of the tabled blade element data. These data are input as a function of average streamline radius, and reflect a streamwise orientation (as opposed to stacking plane orientation).

Columns 31-40. (left adjusted)

Identifies one of two types of blade sections.

65-SERIES — NACA 65-series blade section. Leave no blank columns.

CIRCULAR — Double-circular-arc blade section.

Columns 51-60.

Information specifies the corrections made to NASA 2-D reference deviation angle. See Equation 287 of Reference 4.

INCIDENCE — Causes the term $(i_{ref} - i_{2-D})(\frac{d\delta}{di})_{2-D}$ to be included in the evaluation of δ_c using Equation 287.

DEVIATION — Causes the term $(\delta_c - \delta_{2-D})$ to be included in the evaluation of δ_c using Equation 287.

BOTH — Causes both terms mentioned above to be used in evaluating δ_c.

NONE — Deletes both terms mentioned above from the evaluation of δ_c.

Columns 61-70. Form factor; a multiplier in K_i of Equation 286, Reference 4.

1.0 for NASA 65-series airfoils
0.7 for double-circular-arc airfoils

Columns 71-80. Shape factor; a multiplier in K_δ of Equation 287, Reference 4.

1.0 for NASA 65-series airfoils
0.7 for double-circular-arc airfoils

CARD TYPE 13—FLOW INCREMENT CARD

Columns 1-10. The ratio of exit flow rate to inlet flow rate for the subject blade row.

As indicated earlier, card Types 14-16 are used in sets of one each to supply blade element data for each rotor or stator blade row in the compressor. Before discussing the format of these cards further, it is appropriate to summarize the required blade element information, in the proper input order.

Input Item	Radius	Orientation
Inlet metal angle	Inlet	Stacking plane
Exit metal angle	Exit	Stacking plane
Max thickness/chord	Average	Stream plane
Throat/spacing	Inlet	Stream plane
Solidity	Average	Stream plane
Flow angle at shock	Inlet	Stream plane

Note; as previously discussed, options SUCTION and TABLE in Columns 21-30 of Card Type 12 each require one additional table of blade element data for each blade row where these options are used.

CARD TYPE 14—BLADE ELEMENT DATA

Columns 1-5. (right adjusted)

Enter the integer number of points to be included in the associated table. Maximum number of points equals eight. (straight-line interpolation between points is used in the program)

CARD TYPE 15—BLADE ELEMENT DATA

Columns 1-80. (In fields of 10 columns each)

Enter individual items of blade element data, using as many fields as indicated on the corresponding Card Type 14. The corresponding radii must increase monotonically from left to right in the table.

CARD TYPE 16—BLADE ELEMENT DATA

Columns 1-80. (In fields of 10 columns each)

Enter radius values corresponding to the data items shown on the corresponding Card Type 15. Radii must increase monotonically from left to right in the table.

With all necessary blade element information established, row by row from front to rear of the compressor, there remains only to specify those combinations of speed and flow rate at which compressor performance is to be calculated. This is done using as many cards of the following type as needed.

CARD TYPE 17—SPEED, FLOW, AND FLOW DECREMENT

Columns 1-10. (left adjusted)

FLOW

Columns 11-20.

Total flow entering compressor, lb/sec

Columns 21-30.

Wheel speed as fraction of design corrected speed. (1.0 = design)

Columns 31-40.

Minimum flow rate decrement. Flow rate decrement is only used if the speed and flow combination for this card results in a choked condition somewhere in the machine. The choke check is made after complete convergence is attained and if $O/A^* < 1.05$ at any station, any streamline in the compressor, the choke check is considered failed. If the program is computing performance at points along a characteristic, and successive FLOW cards carry increasing values of flow rate, the program backs off when failure of the choke check is encountered after at least one point on the characteristic has been established satisfactorily. The program reattempts performance computations at a flow rate midway between the last successful value and the value at which choke was encountered. This is continued until the minimum flow decrement is violated. Note that the minimum flow decrement is also specified earlier in the program data. The earlier specified value is used wherever a value is not specified on the FLOW card(s).

APPENDIX D

Part B. Sample Design Problem Data Set

N-36 - Compressor Off-Design Program (Program IV)
Format of Data Input Cards

Card								
1	$DSTART $							
2	TITLE CARD NO. 1							
3	TITLE CARD NO. 2							
4	TITLE CARD NO. 3							
5	a_0		a_1		a_2			
6	a_3		a_4		a_5			
7								
8	DESIGN RPM	MAX. TIME	INLET T_t	INLET P_t	AX. VEL. TOL.	MIN. ΔW	CONTINUITY TOL.	ENTHALPY TOL.
9	EFFICIENCY TOL.	TEMP. RISE TOL.	MOL. WEIGHT	ITERATION DAMP.				
10	FRACTION OF MASS FLOW BETWEEN EACH STREAMLINE AND HUB.							
11	AXIAL COORDINATE	HUB RADIUS	HUB BLOCKAGE	TIP RADIUS	TIP BLOCKAGE			
12	BLADE ROW IDENT.	LOSS SET	REF. INCIDENCE	AIRFOIL TYPE		REF. DEV. CORR.	FORM FACTOR	SHAPE FACTOR

IBM 7090 CODING SHEET

CARD							
13	FLOWOUT/FLOW IN						
14	NO. POINTS						
15	BLADE ELEMENT	DATA →					
16	CORRESPONDING	RADII →					
17	FLOW	ω	SPEED (1.0 = DESIGN)	MIN. Δω			

USE SYMBOL: i θ Z — FOR LETTER: I O Z

FORM 2455(REV 1/68)

ALLISON COMPRESS COMPUTER DATA SHEET

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

PROBLEM TITLE N-36 Compressor Off-Design Program (Program IV)

JOB NUMBER ______ CHARGE NO ______

RETURN TO ______ DEPT. ______

PAGE 1 OF 15

	1–10	11–20	21–30	31–40	41–50	51–60	61–70	71–80
1	$DSTART $END							
2	RON TAYLOR'S CASE i USED FOR AN36 CHECK OUT							
3	MiKE PRATHER JAN 2 1968							
4	iNFORMATiON FROM C2-6,CS-5,DN-8							
5	0.23746571E 00		0.2196199E-04		-0.87791479E-07		ICP VS T 0000-1700 R	
6	0.13991136E-09		-0.78056154E-13		0.15042604E-16		2CP VS T 0000-1700 R	
7	22 11	1 10	1	1	3			
8	5503.18	18.0	518.69	14.7	0.01	0.05	0.0005	0.01
9	.01	.01	28.97	10.0				
10	0.0	.1	.2	.3	.4	.5	.6	.7
11	.8	.9	1.0					
12	0.0	7.00	1.0	25.0	1.0			
13	3.0	7.415	1.0	25.0	1.0			
14	6.0	8.58	1.0	25.0	1.0			
15	9.0	10.35	1.0	25.0	1.0			
16	12.0	12.50	.995	25.0	.995			
17	15.125	14.90	.9925	25.0	.9925			
18	17.65	16.40	.990	25.0	.990			
19	20.107	17.75	.9875	25.0	.9875			
20	22.178	18.70	.985	25.0	.985			
21	24.658	19.688	.9825	25.0	.9825			
22	26.783	20.522	.980	25.0	.980			
23	28.575	21.15	.980	25.0	.980			
24	30.173	21.625	.980	25.0	.980			

USE SYMBOL: i, θ, Z — FOR LETTER: I, O, Z

FORM 2455 (REV. 1/68)

ALLISON COMPRESS COMPUTER DATA SHEET

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

PROBLEM TITLE N-36 Compressor Off-Design Program (Program IV)

JOB NUMBER ______ CHARGE NO. ______

RETURN TO ______ DEPT. ______

	1–10	11–20	21–30	31–40	41–50	51–60	61–70	71–80
1	31.525	21.991	.980	25.0	.980			
2	33.10	22.40	.98	25.0	.98			
3	34.48	22.733	.98	25.0	.98			
4	35.40	22.948	.98	25.0	.98			
5	36.80	23.240	.98	25.0	.98			
6	37.70	23.30	.98	25.0	.98			
7	39.0	23.405	.98	25.0	.98			
8	40.0	23.423	.98	25.0	.98			
9	41.0	23.441	.98	25.0	.98			
10	ANNULAR							
11	1.0							
12	ROTOR	1	TABLE	CIRCULAR		INCIDENCE	0.7	0.7
13	1.0							
14	6							
15	44.94769	47.54232	50.44064	53.23616	55.91168	58.43071		
16	12.59300	16.25500	18.91400	21.15000	23.13600	24.95300		
17	6							
18	20.32743	34.50797	41.71940	46.59746	50.31016	53.43152		
19	15.00100	17.66000	19.79400	21.65500	23.35000	24.94000		
20	6							
21	.08	.07	.06	.05	.04	.03		
22	13.7	15.96	18.22	20.48	22.74	25.0		
23	6							
24	.7942	.7066	.6461	.5983	.5592	.5249		

USE SYMBOL: i θ Ƶ
FOR LETTER: I O Z

FORM 2455 (REV. 1/68)

ALLISON COMPRESS COMPUTER DATA SHEET

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

PROBLEM TITLE N-36 Compressor Off-Design Program (Program IV)

JOB NUMBER ________ CHARGE NO. ________

RETURN TO ________ DEPT. ________

	1–10	11–20	21–30	31–40	41–50	51–60	61–70	71–80
1	12.593	16.255	18.914	21.15	23.136	24.953		
2	6							
3	2.282	1.749	1.536	1.422	1.348	1.296		
4	13.797	16.957	19.354	21.402	23.243	24.946		
5	6							
6	36.439	41.2356	45.252	48.7418	51.6373	54.3136		
7	12.593	16.255	18.914	21.15	23.136	24.953		
8	6							
9	8.057	6.471	5.316	4.348	3.49	2.709		
10	13.797	16.957	19.354	21.402	23.243	24.946		
11	STATOR	2	TABLE	CIRCULAR		INCIDENCE	0.7	0.7
12	1.0							
13	6							
14	40.19376	32.66423	28.53438	25.79101	24.27866	23.71770		
15	15.00100	17.66000	19.79400	21.65500	23.35000	24.94000		
16	6							
17	-8.52849	-8.34035	-8.50066	-8.72950	-9.20535	-9.96298		
18	16.50800	18.60400	20.40600	22.02800	23.52500	24.92900		
19	6							
20	.03	.04	.05	.06	.07	.08		
21	15.65	17.52	19.39	21.26	23.13	25.0		
22	6							
23	.9078	.9102	.9116	.9127	.9105	.9061		
24	15.001	17.660	19.794	21.655	23.35	24.94		

USE SYMBOL: i θ Z
FOR LETTER: I O Z

FORM 2455 (REV. 1/68)

ALLISON COMPRESS COMPUTER DATA SHEET

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

PROBLEM TITLE N-36 Compressor Off-Design Program (Program IV)

JOB NUMBER ______ CHARGE NO. ______

RETURN TO ______ DEPT. ______

	1–10	11–20	21–30	31–40	41–50	51–60	61–70	71–80
1	6							
2	1.844	1.473	1.280	1.158	1.070	1.003		
3	15.75450	18.13200	20.10000	21.84150	23.43750	24.93450		
4	6							
5	25.4639	21.2999	19.0179	17.4453	16.4942	15.7089		
6	15.001	17.66	19.794	21.655	23.35	24.94		
7	6							
8	2.659	3.844	4.856	5.76	6.592	7.372		
9	15.754	18.132	20.100	21.841	23.437	24.934		
10	ROTOR	1	TABLE	CIRCULAR		INCIDENCE	0.7	0.7
11	1.0							
12	6							
13	45.72750	49.01673	51.80886	54.30124	56.55834	58.72223		
14	16.50800	18.60400	20.40600	22.02800	23.52500	24.92900		
15	6							
16	28.79670	36.57941	41.87554	45.90346	49.12950	51.84956		
17	17.85900	19.52400	21.01500	22.38800	23.68000	24.92200		
18	6							
19	.08	.07	.06	.05	.04	.03		
20	17.075	18.66	20.245	21.83	23.415	25.0		
21	6							
22	.7085	.6607	.6198	.5847	.5538	.5271		
23	16.508	18.604	20.406	22.028	23.525	24.929		
24	6							

USE SYMBOL	FOR LETTER
i	I
θ	O
Ƶ	Z

FORM 2455 (REV 1/68)

ALLISON COMPRESS COMPUTER DATA SHEET

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

PROBLEM TITLE N-36 Compressor Off-Design Program (Program IV)

JOB NUMBER ______ CHARGE NO. ______

RETURN TO ______ DEPT. ______

	1–10	11–20	21–30	31–40	41–50	51–60	61–70	71–80
1	1.983	1.720	1.560	1.448	1.375	1.304		
2	17.18350	19.06399	20.71050	22.20800	23.60250	24.92549		
3	6							
4	39.3875	43.1333	46.2627	48.8814	51.3902	53.5314		
5	16.50800	18.60400	20.40600	22.02800	23.52500	24.92900		
6	6							
7	7.750	6.411	5.273	4.277	3.403	2.497		
8	17.183	19.063	20.710	22.208	23.602	24.925		
9	STATOR	2	TABLE	CIRCULAR		INCIDENCE	0.7	0.7
10	1.0							
11	6							
12	38.70566	34.99867	32.23809	30.09897	28.83691	28.34512		
13	17.85900	19.52400	21.01500	22.38800	23.68000	24.92200		
14	6							
15	-8.80965	-8.98126	-9.17074	-9.04533	-9.75094	-10.46156		
16	18.81000	20.21300	21.50000	22.70000	23.83400	24.91700		
17	6							
18	.03	.04	.05	.06	.07	.08		
19	18.275	19.62	20.965	22.31	23.655	25.0		
20	6							
21	.8762	.8793	.8814	.8816	.8825	.8791		
22	17.859	19.524	21.015	22.388	23.68	24.922		
23	6							
24	1.684	1.486	1.355	1.298	1.189	1.124		

USE SYMBOL: i θ Z — FOR LETTER: I O Z

ALLISON COMPRESS COMPUTER DATA SHEET

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

PROBLEM TITLE N-36 Compressor Off-Design Program (Program IV)

JOB NUMBER ______ CHARGE NO. ______

RETURN TO ______ DEPT. ______

FORM 2455 (REV. 1/68)

	1–10	11–20	21–30	31–40	41–50	51–60	61–70	71–80
1	18.33449	19.86849	21.25750	22.54399	23.75700	24.91950		
2	6							
3	24.2190	21.9730	20.4770	19.6775	18.4008	17.6903		
4	17.859	19.524	21.015	22.388	23.68	24.922		
5	6							
6	2.437	3.461	4.448	5.359	6.209	7.034		
7	18.334	19.868	21.257	22.543	23.757	24.919		
8	ROTOR	1	TABLE	CIRCULAR		INCIDENCE	0.7	0.7
9	1.0							
10	6							
11	48.38217	51.01385	53.30752	55.40112	57.30841	59.09135		
12	18.81000	20.21300	21.50000	22.70000	23.83400	24.91700		
13	6							
14	32.65737	37.36617	40.85724	43.80720	46.27272	48.45698		
15	19.79300	20.93900	22.00300	23.00800	23.97300	24.91700		
16	6							
17	.08	.07	.06	.05	.04	.03		
18	19.19	20.352	21.514	22.676	23.838	25.0		
19	6							
20	.6612	.6334	.6060	.5802	.5571	.5385		
21	18.81	20.213	21.50	22.7	23.834	24.917		
22	6							
23	1.772	1.624	1.511	1.429	1.359	1.304		
24	19.30150	20.57600	21.75150	22.85400	23.90350	24.91700		

ALLISON COMPRESS COMPUTER DATA SHEET

USE SYMBOL	FOR LETTER
i	I
θ	O
Z	Z

FORM 2455 (REV. 1/68)

PROBLEM TITLE N-36 Compressor Off-Design Program (Program IV)

JOB NUMBER ______ CHARGE NO. ______

RETURN TO ______ DEPT. ______

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

	1–10	11–20	21–30	31–40	41–50	51–60	61–70	71–80
1	6							
2	41.926	44.241	46.309	48.117	49.900	51.572		
3	18.81	20.213	21.50	22.7	23.834	24.917		
4	6							
5	7.800	6.612	5.507	4.484	3.532	2.618		
6	19.301	20.576	21.751	22.854	23.903	24.917		
7	STATOR	2	TABLE	CIRCULAR				
8	1.0					INCIDENCE	0.7	0.7
9	6							
10	40.80275	37.67740	35.43737	33.57180	32.50083	32.25301		
11	19.79300	20.93900	22.00300	23.00800	23.97300	24.91700		
12	6							
13	-10.21130	-10.03321	-10.17693	-10.28137	-10.60255	-11.30789		
14	20.62100	21.56700	22.45800	23.30800	24.12600	24.91800		
15	6							
16	.03	.04	.05	.06	.07	.08		
17	20.105	21.084	22.063	23.042	24.021	25.0		
18	6							
19	.8559	.8589	.8609	.8628	.8607	.8554		
20	19.793	20.939	22.003	23.008	23.973	24.917		
21	6							
22	1.568	1.467	1.373	1.305	1.251	1.198		
23	20.20700	21.25300	22.23049	23.15800	24.04950	24.91750		
24	6							

USE SYMBOL: i θ Ƶ — FOR LETTER: I O Z

ALLISON COMPRESS COMPUTER DATA SHEET

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

PROBLEM TITLE N-36 Compressor Off-Design Program (Program IV)

JOB NUMBER ______ CHARGE NO. ______

RETURN TO ______ DEPT. ______

FORM 2455 (REV. 1/68)

	1–10	11–20	21–30	31–40	41–50	51–60	61–70	71–80
1	23.9148	22.5221	21.3693	20.3964	19.7701	19.0879		
2	19.793	20.939	22.003	23.008	23.973	24.917		
3	6							
4	2.438	3.406	4.366	5.278	6.146	6.996		
5	20.207	21.253	22.23	23.158	24.049	24.917		
6	ROTOR	1	TABLE	CIRCULAR		INCIDENCE	0.7	0.7
7	1.0							
8	6							
9	50.40766	52.16351	53.90603	55.56662	57.13230	58.56343		
10	20.62100	21.56700	22.45800	23.30800	24.12500	24.91700		
11	6							
12	36.83377	39.71926	42.06916	44.10956	45.82420	47.26319		
13	21.23400	22.02000	22.77400	23.50500	24.22000	24.92900		
14	6							
15	.08	.07	.06	.05	.04	.03		
16	20.836	21.6688	22.5016	23.4344	24.1672	25.0		
17	6							
18	.6304	.6087	.5909	.5737	.5581	.5472		
19	20.621	21.567	22.458	23.308	24.125	24.917		
20	6							
21	1.610	1.525	1.451	1.390	1.343	1.304		
22	20.92750	21.79349	22.61600	23.40650	24.17250	24.92300		
23	6							
24	43.3747	45.1495	46.7350	48.1905	49.5596	50.7063		

USE SYMBOL: i θ Ƶ — FOR LETTER: I O Z

FORM 2455 (REV 1/68)

ALLISON COMPRESS COMPUTER DATA SHEET

PROBLEM TITLE N-36 Compressor Off-Design Program (Program IV)

JOB NUMBER ______ CHARGE NO. ______

RETURN TO ______ DEPT. ______

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

	1–10	11–20	21–30	31–40	41–50	51–60	61–70	71–80
1	20.621	21.567	22.458	23.308	24.125	24.917		
2	6							
3	7.246	6.129	5.042	4.054	3.104	2.207		
4	20.927	21.793	22.616	23.406	24.172	24.923		
5	STATOR	2	TABLE	CIRCULAR		INCIDENCE	0.7	0.7
6	1.0							
7	6							
8	37.64720	35.78173	34.17198	32.94195	32.18950	32.17251		
9	21.23400	22.02000	22.77400	23.50500	24.22000	24.92900		
10	6							
11	-9.73856	-9.75056	-9.86234	-10.03092	-10.32860	-10.96434		
12	21.69800	22.38500	23.05000	23.69400	24.32100	24.93700		
13	6							
14	.03	.04	.05	.06	.07	.08		
15	21.3875	22.11	22.8425	23.555	24.2775	25.0		
16	6							
17	.8578	.8590	.8601	.8604	.8572	.8522		
18	21.234	22.020	22.774	23.505	24.22	24.929		
19	6							
20	1.473	1.409	1.348	1.299	1.258	1.218		
21	21.46599	22.20249	22.91200	23.59949	24.27050	24.93299		
22	6							
23	22.2395	21.3105	20.6166	20.0027	19.6157	19.1929		
24	21.234	22.02	22.774	23.505	24.22	24.929		

USE SYMBOL: i θ z — FOR LETTER: I O Z

FORM 2455 (REV. 1/68)

ALLISON COMPRESS COMPUTER DATA SHEET

PROBLEM TITLE N-36 Compressor Off-Design Program (Program IV)

JOB NUMBER ______ CHARGE NO. ______

RETURN TO ______ DEPT. ______

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

	1–10	11–20	21–30	31–40	41–50	51–60	61–70	71–80
1	6							
2	2.118	2.996	3.928	4.819	5.661	6.507		
3	21.465	22.202	22.912	23.599	24.27	24.932		
4	ROTOR	1	TABLE	CIRCULAR		INCIDENCE	0.7	0.7
5	1.0							
6	6							
7	51.93376	53.56880	55.10141	56.55074	57.91348	59.14991		
8	21.69800	22.38500	23.05000	23.69400	24.32100	24.93700		
9	6							
10	40.47576	42.42121	44.00161	45.40157	46.52548	47.47202		
11	22.05500	22.66100	23.24700	23.81800	24.38100	24.94300		
12	6							
13	.08	.07	.06	.05	.04	.03		
14	21.808	22.4464	23.0848	23.7232	24.3616	25.0		
15	6							
16	.5966	.5807	.5688	.5557	.5457	.5376		
17	21.698	22.385	23.050	23.694	24.321	24.937		
18	6							
19	1.502	1.449	1.404	1.365	1.332	1.303		
20	21.87649	22.52300	23.14850	23.75600	24.35100	24.93999		
21	6							
22	45.1303	46.4981	47.8062	49.0881	50.1981	51.1786		
23	21.698	22.385	23.050	23.694	24.321	24.937		
24	6							

USE SYMBOL: i θ Z — FOR LETTER: I O Z

FORM 2455 (REV. 1/68)

ALLISON COMPRESS COMPUTER DATA SHEET

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

PROBLEM TITLE N-36 Compressor Off-Design Program (Program IV)

JOB NUMBER ______ CHARGE NO ______

RETURN TO ______ DEPT. ______

	1–10	11–20	21–30	31–40	41–50	51–60	61–70	71–80
1	6.507	5.511	4.521	3.569	2.641	1.760		
2	21.876	22.523	23.148	23.756	24.351	24.939		
3	STATOR	2	TABLE	CIRCULAR		INCIDENCE	0.7	0.7
4	1.0							
5	6							
6	37.62158	35.65142	33.98645	32.67985	32.08399	32.26464		
7	22.05500	22.66100	23.24700	23.81800	24.38100	24.94300		
8	6							
9	-9.98132	-9.83816	-9.80765	-9.84461	-10.10721	-10.71477		
10	22.45500	22.97800	23.48600	23.98300	24.47000	24.95100		
11	6							
12	.03	.04	.05	.06	.07	.08		
13	22.1955	22.7564	23.3173	23.8782	24.4391	25.0		
14	6							
15	.8553	.8576	.8595	.8596	.8565	.8523		
16	22.055	22.661	23.247	23.818	24.381	24.943		
17	6							
18	1.438	1.391	1.345	1.307	1.276	1.245		
19	22.25500	22.81950	23.36650	23.90050	24.42549	24.94699		
20	6							
21	21.8452	21.2048	20.5679	20.1090	19.8212	19.6498		
22	22.055	22.661	23.247	23.818	24.381	24.943		
23	6							
24	2.060	2.925	3.855	4.762	5.627	6.505		

USE SYMBOL: i θ Z — FOR LETTER: I O Z

ALLISON COMPRESS COMPUTER DATA SHEET

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

PROBLEM TITLE N-36 Compressor Off-Design Program (Program IV)

JOB NUMBER ______ CHARGE NO. ______

RETURN TO ______ DEPT. ______

FORM 2455 (REV. 1/68)

	1–10	11–20	21–30	31–40	41–50	51–60	61–70	71–80
1	22.255	22.819	23.666	23.900	24.425	24.946		
2	ROTOR	1	TABLE	CIRCULAR		INCIDENCE	0.7	0.7
3	1.0							
4	6							
5	52.64230	53.88459	55.12585	56.38449	57.54285	58.65598		
6	22.45500	22.97800	23.48600	23.98300	24.47000	24.95100		
7	6							
8	40.16345	41.56703	42.71001	43.68056	44.37557	44.77462		
9	22.78000	23.22800	23.66600	24.09800	24.52600	24.95700		
10	6							
11	.08	.07	.06	.05	.04	.03		
12	22.5665	23.0532	23.5399	24.0266	24.5133	25.0		
13	6							
14	.5932	.5833	.5733	.5651	.5589	.5542		
15	22.455	22.978	23.486	23.983	24.470	24.951		
16	6							
17	1.450	1.412	1.381	1.353	1.326	1.302		
18	22.61750	23.10300	23.57600	24.04050	24.49800	24.95399		
19	6							
20	44.9602	46.0205	47.0549	47.9593	48.7284	49.3736		
21	22.455	22.978	23.486	23.983	24.470	24.951		
22	6							
23	6.526	5.566	4.601	3.646	2.738	1.814		
24	22.617	23.103	23.576	24.040	24.498	24.953		

USE SYMBOL: i θ Z — FOR LETTER: I O Z

FORM 2455 (REV. 1/68)

ALLISON COMPRESS COMPUTER DATA SHEET

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

PROBLEM TITLE N-36 Compressor Off-Design Program (Program IV)

JOB NUMBER ______ CHARGE NO. ______

RETURN TO ______ DEPT. ______

	1–10	11–20	21–30	31–40	41–50	51–60	61–70	71–80
1	STATOR	2	TABLE	CIRCULAR		INCIDENCE	0.7	0.7
2	1.0							
3	6							
4	36.90961	35.37391	34.00473	32.95605	32.54816	32.86415		
5	22.78000	23.22800	23.66600	24.09800	24.52600	24.95700		
6	6							
7	-9.98754	-9.88198	-9.85323	-9.89570	-10.15974	-10.74125		
8	22.99100	23.39300	23.79000	24.18400	24.57300	24.96100		
9	6							
10	.03	.04	.05	.06	.07	.08		
11	22.8405	23.2724	23.7043	24.1362	24.5681	25.0		
12	6							
13	.8492	.8487	.8501	.8496	.8452	.8381		
14	22.78	23.228	23.666	24.098	24.526	24.957		
15	6							
16	1.392	1.357	1.322	1.293	1.269	1.244		
17	22.88550	23.31050	23.72800	24.14100	24.54949	24.95899		
18	6							
19	20.8113	20.2673	19.8165	19.4914	19.2422	19.1810		
20	22.78	23.228	23.666	24.098	24.526	24.957		
21	6							
22	1.082	1.773	2.613	3.447	4.215	5.036		
23	22.885	23.31	23.728	24.141	24.549	24.958		
24	ROTOR	1	TABLE	CIRCULAR		INCIDENCE	0.7	0.7

USE SYMBOL: i, θ, Ƶ — FOR LETTER: I, O, Z

ALLISON COMPRESS COMPUTER DATA SHEET

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

PROBLEM TITLE N-36 Compressor Off-Design Program (Program IV)

JOB NUMBER ______ CHARGE NO. ______

RETURN TO ______ DEPT. ______

FORM 2455 (REV. 1/68)

	1–10	11–20	21–30	31–40	41–50	51–60	61–70	71–80
1	1.0							
2	6							
3	52.50270	53.91723	55.25840	56.52085	57.69399	58.68022		
4	22.99100	23.39300	23.79000	24.18400	24.57300	24.96100		
5	6							
6	38.86567	40.36933	41.53693	42.47037	42.96955	43.02408		
7	23.27600	23.61800	23.95600	24.29300	24.62900	24.96600		
8	6							
9	.08	.07	.06	.05	.04	.03		
10	23.094	23.4752	23.8564	24.2376	24.6188	25.0		
11	6							
12	.5996	.5882	.5769	.5689	.5625	.5606		
13	22.991	23.393	23.790	24.184	24.573	24.961		
14	6							
15	1.412	1.385	1.361	1.338	1.319	1.301		
16	23.13349	23.50550	23.87300	24.23850	24.60100	24.96350		
17	6							
18	44.0064	45.1954	46.3360	47.1882	47.9005	48.3877		
19	22.991	23.393	23.790	24.184	24.573	24.961		
20	6							
21	6.54	5.591	4.629	3.698	2.736	1.839		
22	23.133	23.505	23.873	24.238	24.601	24.963		
23	STATØR	2	TABLE	CIRCULAR		INCIDENCE	0.7	0.7
24	1.0							

ALLISON COMPRESS COMPUTER DATA SHEET

USE SYMBOL: i θ Z — FOR LETTER: I O Z

FORM 2455 (REV 1/68)

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

PROBLEM TITLE N-36 Compressor Off-Design Program (Program IV)

JOB NUMBER ______ CHARGE NO. ______

RETURN TO ______ DEPT. ______

	1–10	11–20	21–30	31–40	41–50	51–60	61–70	71–80
1	6							
2	35.02011	34.23452	33.39411	32.65865	32.51592	32.96267		
3	23.27600	23.61800	23.95600	24.29300	24.62900	24.96600		
4	6							
5	-9.07164	-9.10331	-9.13846	-9.19927	-9.46163	-9.97731		
6	23.33500	23.66500	23.99300	24.31900	24.64400	24.96700		
7	6							
8	.03	.04	.05	.06	.07	.08		
9	23.27	23.616	23.962	24.308	24.654	25.0		
10	6							
11	.8486	.8456	.8450	.8437	.8384	.8309		
12	23.276	23.618	23.956	24.293	24.629	24.966		
13	6							
14	1.426	1.405	1.384	1.365	1.347	1.330		
15	23.30550	23.64149	23.97449	24.30599	24.63650	24.96650		
16	6							
17	20.8384	20.6538	20.4246	20.2658	20.2501	20.4046		
18	23.276	23.618	23.956	24.293	24.629	24.966		
19	6							
20	1.007	1.701	2.568	3.432	4.217	5.057		
21	23.305	23.641	23.974	24.305	24.636	24.966		
22	FLOW	400.	1.0	.05				
23								
24								

APPENDIX E

OUTPUT FORMAT - SAMPLE PERFORMANCE PROBLEM

```
----- P E R F O R M A N C E   A N A L Y S I S   O F   M U L T I S T A G E -----
-------------- A X I A L - F L O W   C O M P R E S S O R S   A T --------------
----------------- O F F - D E S I G N   C O N D I T I O N S -----------------
---  RUN TAYLOR'S CASE I USED FOR AN36 CHECK OUT                             ---
---  MIKE PRATHER  JAN 2 1968                                                ---
---  INFORMATION FROM C2-6,CS-5,DN-8                                         ---

THERE ARE 22 STATIONS.                          CALCULATIONS ARE TO BE PERFORMED AT 11 STREAMLINES
THE DESIGN SPEED IS  5503.2 R.P.M.
THE INLET TOTAL TEMPERATURE = 518.69 DEG.S.R.   THE INLET TOTAL PRESSURE =14.7000 (LB/SQ IN.)
THE MOLECULAR WEIGHT IS  28.97                  THE ITERATION WEIGHT FACTOR = 10.0
THE AXIAL VELOCITY TOLERANCE = 0.010            THE MINIMUM WEIGHT FLOW INCREMENT = 0.050 (LB/SEC.)
THE CONTINUITY TOLERANCE = 0.0005               THE TEMPERATURE RISE TOLERANCE = 0.0100
THE TOLERANCE ON EFFICIENCY IS   0.010          A HALT WILL OCCUR AFTER  18.0 MINUTES
THE ENTHALPY TOLERANCE = 0.0100

                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 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
```

ANNULUS PROFILE

STATION	AXIAL COORDINATE	HUB RADIUS	TIP RADIUS	HUB BLOCKAGE FACTOR	TIP BLOCKAGE FACTOR
1	0.00000	7.00000	25.00000	1.0000	1.0000
2	3.00000	7.41500	25.00000	1.0000	1.0000
3	6.00000	8.58000	25.00000	1.0000	1.0000
4	9.00000	10.35000	25.00000	1.0000	1.0000
5	12.00000	12.50000	25.00000	0.9950	0.9950
6	15.12500	14.90000	25.00000	0.9925	0.9925
7	17.65000	16.40000	25.00000	0.9900	0.9900
8	20.10700	17.75000	25.00000	0.9875	0.9875
9	22.17800	18.70000	25.00000	0.9850	0.9850
10	24.65800	19.68800	25.00000	0.9825	0.9825
11	26.78300	20.52200	25.00000	0.9800	0.9800
12	28.57500	21.15000	25.00000	0.9800	0.9800
13	30.17300	21.62500	25.00000	0.9800	0.9800
14	31.52500	21.99100	25.00000	0.9800	0.9800
15	33.10000	22.40000	25.00000	0.9800	0.9800
16	34.48000	22.73300	25.00000	0.9800	0.9800
17	35.40000	22.94800	25.00000	0.9800	0.9800

18	36.80000	23.24000	25.00000	0.9800	0.9800
19	37.70000	23.30000	25.00000	0.9800	0.9800
20	39.00000	23.40500	25.00000	0.9800	0.9800
21	40.00000	23.42300	25.00000	0.9800	0.9800
22	41.00000	23.44100	25.00000	0.9800	0.9800

BLADE ROW NUMBER 2 IS A ROTOR.

THESE BLADES ARE DOUBLE-CIRCULAR-ARC

AN INCIDENCE CORRECTION WILL BE MADE IN THE DEVIATION RULE

THE RATIO OF THE MASS FLOW RATE OUT OF THE BLADE ROW TO THE MASS FLOW RATE INTO THE BLADE ROW = 1.000

LOSS DATA SET NUMBER 1 WILL BE USED FOR THIS BLADE.

THE DEVIATION SHAPE FACTOR = 0.70

BLADE INLET ANGLE	44.95	47.54	50.44	53.24	55.91	58.43
RADIUS (INCHES)	12.593	16.255	19.914	21.150	23.136	24.953
BLADE EXIT ANGLE	20.33	34.51	41.72	46.60	50.31	53.43
RADIUS (INCHES)	15.001	17.660	19.794	21.655	23.350	24.940
MAXIMUM THICKNESS TO THE CHORD	0.0800	0.0700	0.0600	0.0500	0.0400	0.0300
RADIUS (INCHES)	13.700	15.960	18.220	20.480	22.740	25.000
PASSAGE THROAT	0.794	0.707	0.646	0.598	0.559	0.525
RADIUS (INCHES)	12.593	16.255	18.914	21.150	23.136	24.953
BLADE SOLIDITY	2.2820	1.7490	1.5360	1.4220	1.3480	1.2960
RADIUS (INCHES)	13.797	16.957	19.354	21.402	23.243	24.946
SUPERSONIC TURNING	36.439	41.236	45.252	48.742	51.637	54.314
RADIUS (INCHES)	12.593	15.255	18.914	21.150	23.136	24.953
REF. INCIDENCE	8.06	6.47	5.32	4.35	3.49	2.71
RADIUS (INCHES)	13.797	16.957	19.354	21.402	23.243	24.946

BLADE ROW NUMBER 3 IS A STATOR.

THESE BLADES ARE DOUBLE-CIRCULAR-ARC

AN INCIDENCE CORRECTION WILL BE MADE IN THE DEVIATION RULE

THE RATIO OF THE MASS FLOW RATE OUT OF THE BLADE ROW TO THE MASS FLOW RATE INTO THE BLADE ROW = 1.000

LOSS DATA SET NUMBER 2 WILL BE USED FOR THIS BLADE.

THE DEVIATION SHAPE FACTOR = 0.70

BLADE INLET ANGLE	40.19	32.66	29.53	25.79	24.28	23.72
RADIUS (INCHES)	15.001	17.660	19.794	21.655	23.350	24.940
BLADE EXIT ANGLE	-8.53	-8.34	-8.50	-8.73	-9.21	-9.96
RADIUS (INCHES)	16.508	18.604	20.406	22.028	23.525	24.929
MAXIMUM THICKNESS TO THE CHORD	0.0300	0.0400	0.0500	0.0600	0.0700	0.0800
RADIUS (INCHES)	15.650	17.520	19.390	21.260	23.130	25.000
PASSAGE THROAT	0.908	0.910	0.912	0.913	0.910	0.906
RADIUS (INCHES)	15.001	17.660	19.794	21.655	23.350	24.940
BLADE SOLIDITY	1.8440	1.4730	1.2800	1.1580	1.0700	1.0030
RADIUS (INCHES)	15.755	18.132	20.100	21.842	23.438	24.934
SUPERSONIC TURNING	25.464	21.300	19.018	17.445	16.494	15.709
RADIUS (INCHES)	15.001	17.660	19.794	21.655	23.350	24.940
REF. INCIDENCE	2.66	3.84	4.86	5.76	6.59	7.37
RADIUS (INCHES)	15.754	18.132	20.100	21.841	23.437	24.934

BLADE ROW NUMBER 4 IS A ROTOR.

THESE BLADES ARE DOUBLE-CIRCULAR-ARC

AN INCIDENCE CORRECTION WILL BE MADE IN THE DEVIATION RULE

THE RATIO OF THE MASS FLOW RATE OUT OF THE BLADE ROW TO THE MASS FLOW RATE INTO THE BLADE ROW = 1.000

LOSS DATA SET NUMBER 1 WILL BE USED FOR THIS BLADE.

THE DEVIATION SHAPE FACTOR = 0.70

BLADE INLET ANGLE	45.73	49.02	51.81	54.30	56.56	58.72
RADIUS (INCHES)	16.508	18.604	20.406	22.028	23.525	24.929
BLADE EXIT ANGLE	28.80	36.58	41.88	45.90	49.13	51.85
RADIUS (INCHES)	17.859	19.524	21.015	22.388	23.680	24.922
MAXIMUM THICKNESS TO THE CHORD	0.0800	0.0700	0.0600	0.0500	0.0400	0.0300
RADIUS (INCHES)	17.075	18.660	20.245	21.830	23.415	25.000
PASSAGE THROAT	0.708	0.661	0.620	0.585	0.554	0.527
RADIUS (INCHES)	16.508	18.604	20.406	22.028	23.525	24.929
BLADE SOLIDITY	1.9830	1.7200	1.5600	1.4480	1.3750	1.3040
RADIUS (INCHES)	17.184	19.064	20.711	22.208	23.602	24.925
SUPERSONIC TURNING	39.387	43.133	46.263	48.881	51.390	53.531
RADIUS (INCHES)	16.508	18.604	20.406	22.028	23.525	24.929
REF. INCIDENCE	7.75	6.41	5.27	4.28	3.40	2.50
RADIUS (INCHES)	17.183	19.663	20.710	22.208	23.602	24.925

BLADE ROW NUMBER 5 IS A STATOR.

THESE BLADES ARE DOUBLE-CIRCULAR-ARC

AN INCIDENCE CORRECTION WILL BE MADE IN THE DEVIATION RULE

THE RATIO OF THE MASS FLOW RATE OUT OF THE BLADE ROW TO THE MASS FLOW RATE INTO THE BLADE ROW = 1.000

LOSS DATA SET NUMBER 2 WILL BE USED FOR THIS BLADE.

THE DEVIATION SHAPE FACTOR = 0.70

BLADE INLET ANGLE	36.71	35.00	32.24	30.10	28.84	28.35
RADIUS (INCHES)	17.859	19.524	21.015	22.388	23.680	24.922
BLADE EXIT ANGLE	-8.81	-8.98	-9.17	-9.05	-9.75	-10.46
RADIUS (INCHES)	18.810	20.213	21.500	22.700	23.834	24.917
MAXIMUM THICKNESS TO THE CHORD	0.0300	0.0400	0.0500	0.0600	0.0700	0.0800
RADIUS (INCHES)	18.275	19.620	20.965	22.310	23.655	25.000
PASSAGE THROAT	0.876	0.879	0.881	0.882	0.883	0.879
RADIUS (INCHES)	17.859	19.524	21.015	22.388	23.680	24.922
BLADE SOLIDITY	1.6840	1.4860	1.3550	1.2980	1.1890	1.1240
RADIUS (INCHES)	18.334	19.868	21.257	22.544	23.757	24.920
SUPERSONIC TURNING	24.219	21.973	20.477	19.678	18.401	17.690
RADIUS (INCHES)	17.859	19.524	21.015	22.388	23.680	24.922
REF. INCIDENCE	2.44	3.46	4.45	5.36	6.21	7.03
RADIUS (INCHES)	18.334	19.868	21.257	22.543	23.757	24.919

BLADE ROW NUMBER 6 IS A ROTOR.

THESE BLADES ARE DOUBLE-CIRCULAR-ARC

AN INCIDENCE CORRECTION WILL BE MADE IN THE DEVIATION RULE

THE RATIO OF THE MASS FLOW RATE OUT OF THE BLADE ROW TO THE MASS FLOW RATE INTO THE BLADE ROW = 1.000

LOSS DATA SET NUMBER 1 WILL BE USED FOR THIS BLADE.

THE DEVIATION SHAPE FACTOR = 0.70

BLADE INLET ANGLE	48.38	51.01	53.31	55.40	57.31	59.09
RADIUS (INCHES)	18.810	20.213	21.500	22.700	23.834	24.917
BLADE EXIT ANGLE	32.66	37.37	40.86	43.81	46.27	48.46
RADIUS (INCHES)	19.793	20.939	22.003	23.008	23.973	24.917
MAXIMUM THICKNESS TO THE CHORD	0.0800	0.0700	0.0600	0.0500	0.0400	0.0300
RADIUS (INCHES)	19.190	20.352	21.514	22.676	23.838	25.000
PASSAGE THROAT	0.661	0.633	0.606	0.580	0.557	0.539
RADIUS (INCHES)	18.810	20.213	21.500	22.700	23.834	24.917
BLADE SOLIDITY	1.7720	1.6240	1.5110	1.4290	1.3590	1.3040
RADIUS (INCHES)	19.302	20.576	21.751	22.854	23.904	24.917
SUPERSONIC TURNING	41.926	44.241	46.309	48.117	49.900	51.572
RADIUS (INCHES)	18.810	20.213	21.500	22.700	23.834	24.917
REF. INCIDENCE	7.80	6.61	5.51	4.48	3.53	2.62
RADIUS (INCHES)	19.301	20.576	21.751	22.854	23.903	24.917

BLADE ROW NUMBER 7 IS A STATOR.

THESE BLADES ARE DOUBLE-CIRCULAR-ARC

AN INCIDENCE CORRECTION WILL BE MADE IN THE DEVIATION RULE

THE RATIO OF THE MASS FLOW RATE OUT OF THE BLADE ROW TO THE MASS FLOW RATE INTO THE BLADE ROW = 1.000

LOSS DATA SET NUMBER 2 WILL BE USED FOR THIS BLADE.

THE DEVIATION SHAPE FACTOR = 0.70

BLADE INLET ANGLE	40.80	37.68	35.44	33.57	32.50	32.25
RADIUS (INCHES)	19.793	20.939	22.003	23.008	23.973	24.917
BLADE EXIT ANGLE	-10.21	-10.03	-10.18	-10.28	-10.60	-11.31
RADIUS (INCHES)	20.621	21.567	22.458	23.308	24.126	24.918
MAXIMUM THICKNESS TO THE CHORD	0.0300	0.0400	0.0500	0.0600	0.0700	0.0800
RADIUS (INCHES)	20.105	21.084	22.063	23.042	24.021	25.000
PASSAGE THROAT	0.856	0.859	0.861	0.863	0.861	0.855
RADIUS (INCHES)	19.793	20.939	22.003	23.008	23.973	24.917
BLADE SOLIDITY	1.5680	1.4670	1.3730	1.3050	1.2510	1.1980
RADIUS (INCHES)	20.207	21.253	22.230	23.158	24.049	24.918
SUPERSONIC TURNING	23.915	22.522	21.369	20.395	19.770	19.088
RADIUS (INCHES)	19.793	20.939	22.003	23.008	23.973	24.917
REF. INCIDENCE	2.44	3.41	4.37	5.28	6.15	7.00
RADIUS (INCHES)	20.207	21.253	22.230	23.158	24.049	24.917

BLADE ROW NUMBER 8 IS A ROTOR.

THESE BLADES ARE DOUBLE-CIRCULAR-ARC

AN INCIDENCE CORRECTION WILL BE MADE IN THE DEVIATION RULE

THE RATIO OF THE MASS FLOW RATE OUT OF THE BLADE ROW TO THE MASS FLOW RATE INTO THE BLADE ROW = 1.000

LOSS DATA SET NUMBER 1 WILL BE USED FOR THIS BLADE.

THE DEVIATION SHAPE FACTOR = 0.70

BLADE INLET ANGLE	50.41	52.16	53.91	55.57	57.13	58.56
RADIUS (INCHES)	20.621	21.567	22.458	23.308	24.125	24.917
BLADE EXIT ANGLE	36.83	39.72	42.07	44.11	45.82	47.26
RADIUS (INCHES)	21.234	22.020	22.774	23.505	24.220	24.929
MAXIMUM THICKNESS TO THE CHORD	0.0800	0.0700	0.0600	0.0500	0.0400	0.0300
RADIUS (INCHES)	20.836	21.669	22.502	23.434	24.167	25.000
PASSAGE THROAT	0.630	0.609	0.591	0.574	0.558	0.547
RADIUS (INCHES)	20.621	21.567	22.458	23.308	24.125	24.917
BLADE SOLIDITY	1.6100	1.5250	1.4510	1.3900	1.3430	1.3040
RADIUS (INCHES)	20.926	21.793	22.616	23.407	24.172	24.923
SUPERSONIC TURNING	43.375	45.149	46.735	48.190	49.560	50.706
RADIUS (INCHES)	20.621	21.567	22.458	23.308	24.125	24.917
REF. INCIDENCE	7.25	6.13	5.04	4.05	3.10	2.21
RADIUS (INCHES)	20.927	21.793	22.616	23.406	24.172	24.923

BLADE ROW NUMBER 9 IS A STATOR.

THESE BLADES ARE DOUBLE-CIRCULAR-ARC

AN INCIDENCE CORRECTION WILL BE MADE IN THE DEVIATION RULE

THE RATIO OF THE MASS FLOW RATE OUT OF THE BLADE ROW TO THE MASS FLOW RATE INTO THE BLADE ROW = 1.000

LOSS DATA SET NUMBER 2 WILL BE USED FOR THIS BLADE.

THE DEVIATION SHAPE FACTOR = 0.70

BLADE INLET ANGLE	37.65	35.78	34.17	32.94	32.19	32.17
RADIUS (INCHES)	21.234	22.020	22.774	23.505	24.220	24.929
BLADE EXIT ANGLE	-9.74	-9.75	-9.86	-10.03	-10.33	-10.96
RADIUS (INCHES)	21.698	22.385	23.050	23.694	24.321	24.937
MAXIMUM THICKNESS TO THE CHORD	0.0300	0.0400	0.0500	0.0600	0.0700	0.0800
RADIUS (INCHES)	21.388	22.110	22.842	23.555	24.277	25.000
PASSAGE THROAT	0.856	0.859	0.860	0.860	0.857	0.852
RADIUS (INCHES)	21.234	22.020	22.774	23.505	24.220	24.929
BLADE SOLIDITY	1.4730	1.4090	1.3480	1.2990	1.2580	1.2180
RADIUS (INCHES)	21.466	22.202	22.912	23.599	24.270	24.933
SUPERSONIC TURNING	22.240	21.310	20.617	20.003	19.616	19.193
RADIUS (INCHES)	21.234	22.020	22.774	23.505	24.220	24.929
REF. INCIDENCE	2.12	3.00	3.93	4.82	5.66	6.51
RADIUS (INCHES)	21.465	22.202	22.912	23.599	24.270	24.932

BLADE ROW NUMBER 10 IS A ROTOR.

THESE BLADES ARE DOUBLE-CIRCULAR-ARC

AN INCIDENCE CORRECTION WILL BE MADE IN THE DEVIATION RULE

THE RATIO OF THE MASS FLOW RATE OUT OF THE BLADE ROW TO THE MASS FLOW RATE INTO THE BLADE ROW = 1.000

LOSS DATA SET NUMBER 1 WILL BE USED FOR THIS BLADE.

THE DEVIATION SHAPE FACTOR = 0.70

BLADE INLET ANGLE	51.93	53.57	55.10	56.55	57.91	59.15
RADIUS (INCHES)	21.698	22.385	23.050	23.694	24.321	24.937
BLADE EXIT ANGLE	40.48	42.42	44.00	45.40	46.53	47.47
RADIUS (INCHES)	22.055	22.661	23.247	23.818	24.381	24.943
MAXIMUM THICKNESS TO THE CHORD	0.0800	0.0700	0.0600	0.0500	0.0400	0.0300
RADIUS (INCHES)	21.808	22.446	23.085	23.723	24.362	25.000
PASSAGE THROAT	0.597	0.581	0.569	0.556	0.546	0.538
RADIUS (INCHES)	21.698	22.385	23.050	23.694	24.321	24.937
BLADE SOLIDITY	1.5020	1.4490	1.4040	1.3650	1.3320	1.3030
RADIUS (INCHES)	21.876	22.523	23.148	23.756	24.351	24.940
SUPERSONIC TURNING	45.130	46.498	47.806	49.088	50.198	51.179
RADIUS (INCHES)	21.698	22.385	23.050	23.694	24.321	24.937
REF. INCIDENCE	6.51	5.51	4.52	3.57	2.64	1.76
RADIUS (INCHES)	21.876	22.523	23.148	23.756	24.351	24.939

BLADE ROW NUMBER 11 IS A STATOR.

THESE BLADES ARE DOUBLE-CIRCULAR-ARC

AN INCIDENCE CORRECTION WILL BE MADE IN THE DEVIATION RULE

THE RATIO OF THE MASS FLOW RATE OUT OF THE BLADE ROW TO THE MASS FLOW RATE INTO THE BLADE ROW = 1.000

LOSS DATA SET NUMBER 2 WILL BE USED FOR THIS BLADE.

THE DEVIATION SHAPE FACTOR = 0.70

BLADE INLET ANGLE	37.62	35.65	33.99	32.68	32.08	32.26
RADIUS (INCHES)	22.055	22.661	23.247	23.818	24.381	24.943
BLADE EXIT ANGLE	-9.98	-9.84	-9.81	-9.84	-10.11	-10.71
RADIUS (INCHES)	22.455	22.978	23.486	23.983	24.470	24.951
MAXIMUM THICKNESS TO THE CHORD	0.0300	0.0400	0.0500	0.0600	0.0700	0.0800
RADIUS (INCHES)	22.195	22.756	23.317	23.878	24.439	25.000
PASSAGE THROAT	0.855	0.858	0.859	0.860	0.856	0.852
RADIUS (INCHES)	22.055	22.661	23.247	23.818	24.381	24.943
BLADE SOLIDITY	1.4380	1.3910	1.3450	1.3070	1.2760	1.2450
RADIUS (INCHES)	22.255	22.819	23.366	23.901	24.425	24.947
SUPERSONIC TURNING	21.845	21.205	20.568	20.109	19.821	19.650
RADIUS (INCHES)	22.055	22.661	23.247	23.818	24.381	24.943
REF. INCIDENCE	2.06	2.93	3.85	4.76	5.63	6.50
RADIUS (INCHES)	22.255	22.819	23.666	23.900	24.425	24.946

BLADE ROW NUMBER 12 IS A ROTOR.

THESE BLADES ARE DOUBLE-CIRCULAR-ARC

AN INCIDENCE CORRECTION WILL BE MADE IN THE DEVIATION RULE

THE RATIO OF THE MASS FLOW RATE OUT OF THE BLADE ROW TO THE MASS FLOW RATE INTO THE BLADE ROW = 1.000

LOSS DATA SET NUMBER 1 WILL BE USED FOR THIS BLADE.

THE DEVIATION SHAPE FACTOR = 0.70

BLADE INLET ANGLE	52.64	53.88	55.13	56.38	57.54	58.66
RADIUS (INCHES)	22.455	22.978	23.486	23.983	24.470	24.951
BLADE EXIT ANGLE	40.16	41.57	42.71	43.68	44.38	44.77
RADIUS (INCHES)	22.780	23.228	23.666	24.098	24.526	24.957
MAXIMUM THICKNESS TO THE CHORD	0.0800	0.0700	0.0600	0.0500	0.0400	0.0300
RADIUS (INCHES)	22.566	23.053	23.540	24.027	24.513	25.000
PASSAGE THROAT	0.593	0.583	0.573	0.565	0.559	0.554
RADIUS (INCHES)	22.455	22.978	23.486	23.983	24.470	24.951
BLADE SOLIDITY	1.4500	1.4120	1.3810	1.3530	1.3260	1.3020
RADIUS (INCHES)	22.618	23.103	23.576	24.040	24.498	24.954
SUPERSONIC TURNING	44.960	46.021	47.055	47.959	48.728	49.374
RADIUS (INCHES)	22.455	22.978	23.486	23.983	24.470	24.951
REF. INCIDENCE	6.53	5.57	4.60	3.65	2.74	1.81
RADIUS (INCHES)	22.617	23.103	23.576	24.040	24.498	24.953

BLADE ROW NUMBER 13 IS A STATOR.

THESE BLADES ARE DOUBLE-CIRCULAR-ARC

AN INCIDENCE CORRECTION WILL BE MADE IN THE DEVIATION RULE

THE RATIO OF THE MASS FLOW RATE OUT OF THE BLADE ROW TO THE MASS FLOW RATE INTO THE BLADE ROW = 1.000

LOSS DATA SET NUMBER 2 WILL BE USED FOR THIS BLADE.

THE DEVIATION SHAPE FACTOR = 0.70

BLADE INLET ANGLE	36.91	35.37	34.00	32.94	32.55	32.86
RADIUS (INCHES)	22.780	23.228	23.666	24.098	24.526	24.957
BLADE EXIT ANGLE	-9.99	-9.88	-9.85	-9.90	-10.16	-10.74
RADIUS (INCHES)	22.991	23.393	23.790	24.184	24.573	24.961
MAXIMUM THICKNESS TO THE CHORD	0.0300	0.0400	0.0500	0.0600	0.0700	0.0800
RADIUS (INCHES)	22.841	23.272	23.704	24.136	24.568	25.000
PASSAGE THROAT	0.849	0.849	0.850	0.850	0.845	0.838
RADIUS (INCHES)	22.780	23.228	23.666	24.098	24.526	24.957
BLADE SOLIDITY	1.3920	1.3570	1.3220	1.2930	1.2690	1.2440
RADIUS (INCHES)	22.885	23.310	23.728	24.141	24.549	24.959
SUPERSONIC TURNING	20.811	20.267	19.816	19.491	19.242	19.181
RADIUS (INCHES)	22.780	23.228	23.666	24.098	24.526	24.957
REF. INCIDENCE	1.08	1.77	2.61	3.45	4.21	5.04
RADIUS (INCHES)	22.885	23.310	23.728	24.141	24.549	24.958

BLADE ROW NUMBER 14 IS A ROTOR.

THESE BLADES ARE DOUBLE-CIRCULAR-ARC

AN INCIDENCE CORRECTION WILL BE MADE IN THE DEVIATION RULE

THE RATIO OF THE MASS FLOW RATE OUT OF THE BLADE ROW TO THE MASS FLOW RATE INTO THE BLADE ROW = 1.000

LOSS DATA SET NUMBER 1 WILL BE USED FOR THIS BLADE.

THE DEVIATION SHAPE FACTOR = 0.70

BLADE INLET ANGLE	52.50	53.92	55.26	56.52	57.69	58.68
RADIUS (INCHES)	22.991	23.393	23.790	24.184	24.573	24.961
BLADE EXIT ANGLE	38.27	40.37	41.54	42.47	42.97	43.02
RADIUS (INCHES)	23.276	23.618	23.956	24.295	24.629	24.966
MAXIMUM THICKNESS TO THE CHORD	0.0800	0.0700	0.0600	0.0500	0.0400	0.0300
RADIUS (INCHES)	23.094	23.475	23.856	24.238	24.619	25.000
PASSAGE THROAT	0.600	0.588	0.577	0.569	0.563	0.561
RADIUS (INCHES)	22.991	23.393	23.790	24.184	24.573	24.961
BLADE SOLIDITY	1.4120	1.3850	1.3610	1.3380	1.3190	1.3010
RADIUS (INCHES)	23.133	23.506	23.873	24.239	24.601	24.964
SUPERSONIC TURNING	44.066	45.195	46.336	47.183	47.900	48.388
RADIUS (INCHES)	22.991	23.393	23.790	24.184	24.573	24.961
REF. INCIDENCE	6.54	5.59	4.63	3.70	2.74	1.84
RADIUS (INCHES)	23.133	23.505	23.873	24.238	24.601	24.963

BLADE ROW NUMBER 15 IS A STATOR.

THESE BLADES ARE DOUBLE-CIRCULAR-ARC

AN INCIDENCE CORRECTION WILL BE MADE IN THE DEVIATION RULE

THE RATIO OF THE MASS FLOW RATE OUT OF THE BLADE ROW TO THE MASS FLOW RATE INTO THE BLADE ROW = 1.000

LOSS DATA SET NUMBER 2 WILL BE USED FOR THIS BLADE.

THE DEVIATION SHAPE FACTOR = 0.70

BLADE INLET ANGLE	35.02	34.23	33.39	32.60	32.52	32.96
RADIUS (INCHES)	23.276	23.618	23.956	24.293	24.629	24.966
BLADE EXIT ANGLE	-9.07	-9.10	-9.14	-9.20	-9.46	-9.98
RADIUS (INCHES)	23.335	23.665	23.993	24.319	24.644	24.967
MAXIMUM THICKNESS TO THE CHORD	0.0300	0.0400	0.0500	0.0600	0.0700	0.0800
RADIUS (INCHES)	23.270	23.616	23.962	24.308	24.654	25.000
PASSAGE THROAT	0.849	0.846	0.845	0.844	0.838	0.831
RADIUS (INCHES)	23.276	23.618	23.956	24.293	24.629	24.966
BLADE SOLIDITY	1.4260	1.4050	1.3840	1.3650	1.3470	1.3300
RADIUS (INCHES)	23.306	23.641	23.974	24.306	24.636	24.967
SUPERSONIC TURNING	20.838	20.654	20.425	20.266	20.250	20.405
RADIUS (INCHES)	23.276	23.618	23.956	24.293	24.629	24.966
REF. INCIDENCE	1.01	1.70	2.57	3.43	4.22	5.06
RADIUS (INCHES)	23.305	23.641	23.974	24.305	24.635	24.966

.... 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	0.1094

.... 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	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

RUN TAYLOR'S CASE I USED FOR AN36 CHECK OUT

MIKE PRATHER JAN 2 1968

INFORMATION FROM C2-6,CS-5,ON-8

STATION NO. 1

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	REL VEL (FT/SEC)	REL MACH NUMBER	WHEEL SPEED
1	7.00	452.3	0.0	0.0	452.3	0.412	563.5	0.513	336.2
2	10.32	452.3	0.0	0.0	452.3	0.412	671.1	0.611	495.9
3	12.31	452.3	0.0	0.0	452.3	0.412	763.7	0.695	615.4
4	14.89	452.3	0.0	0.0	452.3	0.412	846.2	0.771	715.2
5	16.72	452.3	0.0	0.0	452.3	0.412	921.4	0.87[illegible]	802.7
6	18.36	452.3	0.0	0.0	452.3	0.412	990.8	0.902	881.6
7	19.86	452.3	0.0	0.0	452.3	0.412	1055.8	0.961	954.0
8	21.26	452.3	0.0	0.0	452.3	0.412	1115.9	1.017	1021.2
9	22.58	452.3	0.0	0.0	452.3	0.412	1174.9	1.070	1084.3
10	23.82	452.3	0.0	0.0	452.3	0.412	1250.1	1.120	1143.9
11	25.00	452.3	0.0	0.0	452.3	0.412	128[illegible].0	1.168	1200.6

S.L.	TOTAL TEMP DEG RANKINE	TOTAL PRES LB/SQ IN.	STATIC TEMP DEG RANKINE	STATIC PRES LB/SQ IN.
1	518.7	14.700	501.6	13.080
2	518.7	14.700	501.6	13.079
3	518.7	14.700	501.6	13.079
4	518.7	14.700	501.6	13.079
5	518.7	14.700	501.6	13.079
6	518.7	14.700	501.6	13.079
7	518.7	14.700	501.6	13.079
8	518.7	14.700	501.6	13.079
9	518.7	14.700	501.6	13.079
10	518.7	14.700	501.6	13.079
11	518.7	14.700	501.6	13.079

RON TAYLOR'S CASE I USED FOR AN36 CHECK OUT

MIKE PRATHER JAN 2 1968

INFORMATION FROM C2-6,CS-5,DN-8

STATION NO. 2

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	REL VEL (FT/SEC)	REL MACH NUMBER	WHEEL SPEED
1	7.42	282.5	0.0	74.5	292.2	0.263	460.6	0.415	356.1
2	11.37	371.7	0.0	55.7	383.9	0.348	667.5	0.605	546.1
3	13.91	420.7	0.0	94.7	431.2	0.392	795.0	0.723	667.9
4	15.90	453.4	0.0	86.0	461.5	0.420	892.0	0.813	763.4
5	17.58	476.5	0.0	74.2	482.2	0.440	972.3	0.887	844.3
6	19.07	493.0	C.0	61.2	496.8	0.454	1041.9	0.952	915.8
7	20.42	504.7	0.0	47.8	507.0	0.464	1104.0	1.010	980.7
8	21.67	512.7	0.0	34.8	513.9	0.470	1150.7	1.062	1040.7
9	22.84	517.6	0.0	22.3	518.3	0.474	1213.1	1.111	1096.9
10	23.95	520.6	0.0	10.7	520.7	0.477	1262.4	1.156	1150.0
11	25.00	521.4	0.0	-0.0	521.4	0.477	1308.9	1.199	1200.6

S.L.	TOTAL TEMP DEG RANKINE	TOTAL PRES LB/SQ IN.	STATIC TEMP DEG RANKINE	STATIC PRES LB/SQ IN.
1	518.7	14.700	511.6	14.007
2	518.7	14.700	506.4	13.519
3	518.7	14.700	503.2	13.221
4	518.7	14.700	500.9	13.016
5	518.7	14.700	499.3	12.868
6	518.7	14.700	498.1	12.761
7	518.7	14.700	497.3	12.685
8	518.7	14.700	496.7	12.633
9	518.7	14.700	496.3	12.599
10	518.7	14.700	496.1	12.581
11	518.7	14.700	496.0	12.575

RON TAYLOR'S CASE I USED FOR AN36 CHECK OUT

MIKE PRATHER JAN 2 1968

INFORMATION FROM C2-6,CS-5,DN-8

STATION NO. 3

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	REL VEL (FT/SEC)	REL MACH NUMBER	WHEEL SPEED
1	8.58	336.1	0.0	164.5	374.2	0.339	556.6	0.504	412.0
2	11.87	415.1	0.0	129.0	434.7	0.395	716.8	0.652	570.0
3	14.16	453.9	0.0	104.2	465.7	0.425	824.4	0.751	680.2
4	16.03	477.4	0.0	84.2	484.7	0.442	909.8	0.831	769.9
5	17.65	492.6	0.0	67.2	497.2	0.454	982.7	0.898	847.6
6	19.10	502.8	0.0	52.5	505.6	0.462	1047.5	0.958	917.4
7	20.43	509.6	0.0	39.6	511.1	0.468	1106.4	1.012	981.3
8	21.67	513.9	0.0	28.1	514.7	0.471	1151.1	1.063	1040.8
9	22.84	516.4	0.0	17.7	516.7	0.473	1212.4	1.110	1096.8
10	23.94	517.4	0.0	8.4	517.4	0.474	1260.9	1.154	1149.9
11	25.00	517.1	0.0	0.0	517.1	0.473	1307.2	1.197	1200.5

S.L.	TOTAL TEMP DEG RANKINE	TOTAL PRES LB/SQ IN.	STATIC TEMP DEG RANKINE	STATIC PRES LB/SQ IN.
1	518.7	14.700	507.0	13.576
2	518.7	14.700	502.9	13.198
[illegible]	518.7	14.700	500.6	12.986
4	518.7	14.700	499.1	12.850
5	518.7	14.700	498.1	12.758
6	518.7	14.700	497.4	12.690
7	518.7	14.700	496.9	12.654
8	518.7	14.700	496.6	12.627
9	518.7	14.700	496.4	12.611
10	518.7	14.700	496.4	12.606
11	518.7	14.700	496.4	12.608

RON TAYLOR'S CASE I USED FOR AN36 CHECK OUT

MIKE PRATHER JAN 2 1968

INFORMATION FROM C2-6,CS-5,DN-8

STATION NO. 4

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	REL VEL (FT/SEC)	REL MACH NUMBER	WHEEL SPEED
1	10.35	329.0	0.0	220.1	395.8	0.359	635.4	0.576	497.1
2	13.23	421.8	0.0	194.3	464.4	0.423	787.1	0.717	[illegible]
3	15.28	478.3	0.0	166.8	506.5	0.463	891.7	0.815	733.9
4	16.55	516.2	0.0	140.0	534.8	0.490	974.0	0.893	814.1
5	18.40	542.7	0.0	114.7	554.7	0.509	1043.2	0.958	883.5
6	19.69	561.2	0.0	91.1	568.7	0.523	1103.6	1.015	945.3
7	20.89	574.2	0.0	69.0	578.3	0.532	1157.8	1.066	1003.0
8	22.00	582.7	0.0	48.5	584.7	0.539	1207.4	1.112	1056.4
9	23.04	587.6	0.0	29.5	588.4	0.542	1253.4	1.155	1106.7
10	24.04	589.8	0.0	11.8	589.9	0.544	1296.6	1.195	1154.6
11	25.00	589.6	0.0	-4.6	589.7	0.543	1337.6	1.233	1200.6

S.L.	TOTAL TEMP DEG RANKINE	TOTAL PRES LB/SQ IN.	STATIC TEMP DEG RANKINE	STATIC PRES LB/SQ IN.
1	518.7	14.700	505.6	13.446
2	518.7	14.700	500.7	12.995
3	518.7	14.700	497.3	12.689
4	518.7	14.700	494.8	12.471
5	518.7	14.700	493.0	12.313
6	518.7	14.700	491.7	12.199
7	518.7	14.700	490.8	12.119
8	518.7	14.700	490.2	12.066
9	518.7	14.700	489.8	12.035
10	518.7	14.700	489.7	12.022
11	518.7	14.700	489.7	12.024

RUN TAYLOR'S CASE I USED FOR AN36 CHECK OUT

MIKE PRATHER JAN 2 1968

INFORMATION FROM C2-6,CS-5,DN-8

STATION NO. 5

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	REL VEL (FT/SEC)	REL MACH NUMBER	WHEEL SPEED
1	12.59	457.3	0.0	347.1	574.1	0.528	833.9	0.767	604.8
2	14.63	534.6	0.0	278.3	602.7	0.556	925.8	0.854	702.7
3	16.26	578.4	0.0	224.2	620.3	0.573	997.1	0.922	780.7
4	17.66	605.8	0.0	180.1	632.0	0.585	1057.7	0.979	848.1
5	18.92	624.3	0.0	142.8	640.4	0.593	1111.6	1.030	908.6
6	20.08	637.1	0.0	110.4	646.6	0.599	1160.9	1.076	964.1
7	21.15	646.0	0.0	81.7	651.2	0.604	1206.7	1.119	1015.9
8	22.17	652.0	0.0	56.1	654.4	0.607	1249.8	1.160	1064.8
9	23.14	655.8	0.0	33.0	656.6	0.609	1290.7	1.198	1111.2
10	24.06	657.9	0.0	12.2	656.0	0.611	1329.8	1.234	1155.6
11	24.95	658.6	0.0	-6.6	658.6	0.611	1367.4	1.269	1198.4

S.L.	TOTAL TEMP DEG RANKINE	TOTAL PRES LB/SQ IN.	STATIC TEMP DEG RANKINE	STATIC PRES LB/SQ IN.
1	518.7	14.700	491.2	12.154
2	518.7	14.700	488.4	11.913
3	518.7	14.700	486.6	11.761
4	518.7	14.700	485.4	11.658
5	518.7	14.700	484.5	11.583
6	518.7	14.700	483.8	11.528
7	518.7	14.700	483.3	11.487
8	518.7	14.700	483.0	11.457
9	518.7	14.700	482.7	11.437
10	518.7	14.700	482.6	11.425
11	518.7	14.700	482.5	11.420

RON TAYLOR'S CASE I USED FOR AN36 CHECK OUT

MIKE PRATHER JAN 2 1968

INFORMATION FROM C2-6,CS-5,DN-8

ROTOR NO. 1 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	REL VEL (FT/SEC)	REL MACH NUMBER	WHEEL SPEED
1	15.00	496.4	488.4	339.4	774.7	0.688	644.5	0.572	720.4
2	16.43	533.1	456.8	277.8	755.0	0.668	686.8	0.608	788.9
3	17.66	549.6	421.0	226.9	728.6	0.643	732.2	0.645	848.3
4	18.78	564.7	405.8	186.9	720.1	0.634	774.6	0.682	901.9
5	19.80	573.7	388.7	151.5	709.4	0.624	817.5	0.719	951.1
6	20.76	582.6	378.2	120.5	704.9	0.619	858.5	0.753	997.1
7	21.67	586.3	368.4	91.7	698.5	0.612	896.5	0.786	1040.5
8	22.53	588.9	363.5	65.4	695.1	0.608	931.2	0.814	1081.8
9	23.36	587.9	359.6	41.0	690.3	0.603	963.4	0.841	1121.6
10	24.16	585.9	358.5	18.5	687.1	0.598	993.1	0.865	1160.2
11	24.94	581.3	358.7	-2.5	683.1	0.593	1020.7	0.887	1197.7

S.L. NO.	DIFFUSION FACTOR	LOSS COEFFICIENT	REF LOSS COEFFICIENT	ADIABATIC EFFICIENCY	INLET BLADE ANGLE (DEG)	INCIDENCE	REFERENCE INCIDENCE	ABS FLOW ANGLE IN	REL FLOW ANGLE IN.
1	0.325	0.048	0.048	0.960	38.49	8.00	8.06	0.00	46.49
2	0.359	0.046	0.044	0.955	42.96	6.42	7.19	0.00	49.38
3	0.367	0.047	0.046	0.947	45.54	5.99	6.47	0.00	51.53
4	0.369	0.056	0.055	0.933	47.37	5.43	5.86	0.00	53.30
5	0.366	0.061	0.061	0.922	49.73	5.09	5.31	0.00	54.82
6	0.361	0.067	0.067	0.909	51.48	4.67	4.81	0.00	56.15
7	0.357	0.076	0.076	0.894	53.02	4.32	4.34	0.00	57.34
8	0.355	0.087	0.087	0.874	54.51	3.91	3.91	0.00	58.43
9	0.354	0.100	0.100	0.852	55.88	3.54	3.49	0.00	59.42
10	0.354	0.115	0.115	0.827	57.19	3.15	3.09	0.00	60.34
11	0.355	0.131	0.131	0.801	58.43	2.78	2.71	0.00	61.21

S.L.	TOTAL TEMP DEG RANKINE	TOTAL PRES LB/SQ IN.	STATIC TEMP DEG RANKINE	STATIC PRES LB/SQ IN.	SOLIDITY	THICKNESS TO CHORD	THROAT SPACING	EXIT BLADE ANGLE DEG	DEVIATION ANGLE DEG
1	577.3	21.071	527.3	15.350	2.282	0.080	0.79	17.00	4.09
2	578.7	21.210	531.3	15.722	1.990	0.072	0.75	25.19	3.73
3	578.2	21.085	534.0	15.964	1.749	0.066	0.71	32.45	3.25
4	579.6	21.152	536.5	16.134	1.637	0.060	0.67	36.85	2.97
5	580.3	21.137	538.4	16.262	1.536	0.055	0.65	40.79	2.67
6	581.5	21.184	540.1	16.363	1.477	0.050	0.62	43.66	2.48
7	582.5	21.180	541.9	16.446	1.422	0.046	0.60	46.27	2.28
8	584.2	21.204	544.0	16.519	1.384	0.042	0.58	48.33	2.15
9	585.8	21.199	546.2	16.586	1.348	0.038	0.55	50.25	2.03
10	587.9	21.212	548.7	16.650	1.322	0.034	0.54	51.88	1.94
11	590.2	21.211	551.4	16.715	1.296	0.030	0.52	53.43	1.85

RUN TAYLOR'S CASE I USED FOR AN36 CHECK OUT

MIKE PRATHER JAN 2 1968

INFORMATION FROM C2-6,CS-5,DN-8

STATOR EXIT NO. 1

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	REL VEL (FT/SEC)	REL MACH NUMBER	WHEEL SPEED
1	16.21	571.4	5.4	327.6	658.7	0.578	1026.5	0.900	792.8
2	17.51	600.2	3.7	277.0	661.0	0.579	1070.4	0.938	845.6
3	18.61	606.2	3.8	227.9	647.6	0.567	1100.7	0.963	893.8
4	19.55	621.1	3.2	190.3	649.6	0.568	1138.9	0.996	938.7
5	20.42	627.9	2.9	155.2	646.8	0.565	1172.4	1.024	980.8
6	21.25	637.3	1.7	124.3	649.3	0.567	1208.2	1.054	1020.5
7	22.04	641.7	2.0	95.2	648.8	0.566	1239.8	1.081	1058.5
8	22.80	647.3	1.2	68.6	650.9	0.567	1272.8	1.108	1095.0
9	23.53	650.0	1.9	43.5	651.5	0.566	1302.8	1.133	1130.1
10	24.24	653.3	1.1	20.0	653.6	0.567	1334.2	1.158	1164.1
11	24.93	655.1	1.7	-2.2	655.1	0.568	1363.2	1.181	1197.2

S.L. NO.	DIFFUSION FACTOR	LOSS COEFFICIENT	REF LOSS COEFFICIENT	ADIABATIC EFFICIENCY	INLET BLADE ANGLE (DEG)	INCIDENCE	REFERENCE INCIDENCE	ABS FLOW ANGLE IN	REL FLOW ANGLE IN.
1	0.319	0.033	0.031	0.935	34.89	4.19	2.66	39.09	21.10
2	0.307	0.028	0.027	0.935	32.94	4.29	3.29	37.23	28.92
3	0.306	0.024	0.024	0.931	30.64	4.66	3.85	35.30	35.70
4	0.302	0.022	0.022	0.918	29.21	5.09	4.37	34.30	39.82
5	0.301	0.021	0.021	0.909	27.72	5.51	4.86	33.73	43.46
6	0.298	0.020	0.019	0.896	26.62	5.82	5.33	32.44	46.13
7	0.298	0.019	0.018	0.883	25.51	6.32	5.77	31.83	48.55
8	0.293	0.018	0.018	0.864	24.88	6.65	6.19	31.53	50.48
9	0.297	0.017	0.017	0.843	24.22	7.16	6.60	31.39	52.29
10	0.300	0.017	0.017	0.819	23.98	7.47	6.99	31.45	53.83
11	0.301	0.016	0.016	0.793	23.72	7.96	7.37	31.68	55.28

S.L.	TOTAL TEMP DEG RANKINE	TOTAL PRES LB/SQ IN.	STATIC TEMP DEG RANKINE	STATIC PRES LB/SQ IN.	SOLIDITY	THICKNESS TO CHORD	THROAT SPACING	EXIT BLADE ANGLE DEG	DEVIATION ANGLE DEG
1	577.3	20.883	541.2	16.657	1.844	0.031	0.91	-7.41	7.88
2	578.7	21.059	542.3	16.780	1.647	0.037	0.91	-7.66	7.98
3	578.2	20.960	543.3	16.855	1.472	0.043	0.91	-7.81	8.15
4	579.3	21.040	544.5	16.906	1.372	0.049	0.91	-8.05	8.34
5	580.3	21.036	545.4	16.939	1.279	0.054	0.91	-8.25	8.52
6	581.3	21.030	546.4	16.961	1.216	0.059	0.91	-8.45	8.61
7	582.5	21.091	547.5	16.976	1.157	0.063	0.91	-8.64	8.82
8	584.2	21.120	548.9	16.984	1.113	0.068	0.91	-8.93	9.03
9	585.8	21.119	550.5	16.988	1.070	0.072	0.91	-9.19	9.35
10	587.9	21.135	552.4	16.989	1.036	0.076	0.91	-9.59	9.68
11	590.2	21.133	554.5	16.988	1.003	0.080	0.91	-9.95	10.17

RON TAYLOR'S CASE I USED FOR AN36 CHECK OUT

MIKE PRATHER JAN 2 1968

INFORMATION FROM C2-6,CS-5,DN-8

ROTOR NO. 2 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	REL VEL (FT/SEC)	REL MACH NUMBER	WHEEL SPEED
1	17.86	542.8	504.3	273.8	789.9	0.660	703.2	0.587	857.7
2	18.73	563.6	480.3	238.5	778.0	0.648	741.7	0.613	899.4
3	19.54	559.8	463.9	198.5	753.6	0.626	760.1	0.632	938.3
4	20.31	568.9	450.0	167.6	744.5	0.617	792.1	0.657	975.2
5	21.04	571.1	437.1	137.7	732.2	0.606	820.7	0.679	1010.2
6	21.73	577.5	425.6	111.3	725.9	0.599	853.2	0.704	1043.7
7	22.40	577.0	418.0	85.6	717.6	0.591	879.3	0.724	1076.0
8	23.06	578.6	412.0	62.1	713.0	0.586	906.6	0.745	1107.2
9	23.69	575.7	409.2	39.5	707.5	0.579	929.3	0.761	1137.7
10	24.31	573.8	407.4	18.5	704.0	0.574	952.6	0.777	1167.5
11	24.92	568.6	408.5	-1.4	700.2	0.569	972.0	0.790	1196.9

S.L. NO.	DIFFUSION FACTOR	LOSS COEFFICIENT	REF LOSS COEFFICIENT	ADIABATIC EFFICIENCY	INLET BLADE ANGLE (DEG)	INCIDENCE	REFERENCE INCIDENCE	ABS FLOW ANGLE IN	REL FLOW. ANGLE IN.
1	0.422	0.061	0.057	0.938	41.67	8.42	7.75	0.47	50.09
2	0.414	0.057	0.056	0.938	44.69	7.17	7.05	0.32	51.87
3	0.419	0.060	0.059	0.932	47.15	6.81	6.40	0.34	53.96
4	0.415	0.064	0.064	0.924	49.21	6.02	5.81	0.28	55.23
5	0.411	0.066	0.065	0.919	51.01	5.51	5.26	0.26	56.52
6	0.404	0.069	0.069	0.911	52.59	4.90	4.75	0.15	57.49
7	0.402	0.075	0.074	0.902	54.03	4.42	4.27	0.18	58.45
8	0.399	0.082	0.082	0.889	55.32	3.93	3.83	0.11	59.24
9	0.398	0.092	0.091	0.875	56.51	3.49	3.40	0.16	60.00
10	0.399	0.103	0.103	0.857	57.65	3.02	2.94	0.09	60.66
11	0.401	0.116	0.116	0.837	58.72	2.55	2.50	0.15	61.28

S.L.	TOTAL TEMP DEG RANKINE	TOTAL PRES LB/SC IN.	STATIC TEMP DEG RANKINE	STATIC PRES LB/SQ IN.	SOLIDITY	THICKNESS TO CHORD	THROAT SPACING	EXIT BLADE ANGLE DEG	DEVIATION ANGLE DEG
1	648.4	30.650	596.6	22.886	1.983	0.079	0.71	26.14	4.03
2	649.9	30.902	599.7	23.301	1.845	0.073	0.68	30.74	3.66
3	649.9	30.769	602.8	23.622	1.719	0.067	0.66	35.02	3.59
4	652.0	30.871	606.0	23.880	1.636	0.062	0.64	38.19	3.33
5	653.1	30.859	608.6	24.090	1.559	0.057	0.62	41.13	3.16
6	655.0	30.925	611.2	24.263	1.502	0.052	0.60	43.46	2.96
7	656.8	30.912	614.1	24.410	1.447	0.048	0.58	45.63	2.81
8	659.7	30.944	617.5	24.536	1.410	0.043	0.57	47.41	2.66
9	662.9	30.934	621.3	24.648	1.375	0.039	0.55	49.08	2.53
10	666.7	30.947	625.6	24.749	1.339	0.035	0.54	50.50	2.44
11	671.0	30.941	630.4	24.842	1.304	0.030	0.53	51.85	2.35

RON TAYLOR'S CASE I USED FOR AN36 CHECK OUT

MIKE PRATHER JAN 2 1968

INFORMATION FROM C2-6,CS-5,DN-8

STATOR EXIT NO. 2

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	REL VEL (FT/SEC)	REL MACH NUMBER	WHEEL SPEED
1	18.81	581.9	7.4	249.0	633.0	0.521	1096.9	0.903	903.3
2	19.54	602.1	2.0	221.2	641.4	0.528	1134.9	0.933	938.3
3	20.23	600.8	5.4	188.2	629.6	0.517	1153.0	0.947	971.3
4	20.89	612.2	3.3	161.4	633.1	0.519	1183.3	0.971	1003.0
5	21.52	616.4	2.2	134.5	630.9	0.517	1208.0	0.990	1033.4
6	22.13	624.2	0.9	110.1	633.9	0.519	1236.5	1.012	1062.6
7	22.71	627.3	1.6	86.0	633.2	0.518	1259.9	1.030	1090.8
8	23.29	632.7	-0.2	63.4	635.9	0.519	1286.6	1.049	1118.3
9	23.84	635.5	0.6	41.2	636.8	0.518	1309.6	1.066	1145.0
10	24.39	639.2	-0.8	19.9	639.6	0.519	1335.1	1.083	1171.1
11	24.92	641.7	-0.0	-0.9	641.7	0.519	1357.8	1.098	1196.6

S.L. NO.	DIFFUSION FACTOR	LOSS COEFFICIENT	REF LOSS COEFFICIENT	ADIABATIC EFFICIENCY	INLET BLADE ANGLE (DEG)	INCIDENCE	REFERENCE INCIDENCE	ABS FLOW ANGLE IN	REL FLOW. ANGLE IN.
1	0.385	0.034	0.032	0.917	35.58	4.09	2.44	39.67	30.17
2	0.370	0.029	0.029	0.919	34.54	3.59	2.97	38.13	34.40
3	0.370	0.028	0.027	0.916	33.40	4.60	3.47	37.99	38.61
4	0.361	0.026	0.026	0.909	32.46	4.73	3.98	37.19	41.53
5	0.357	0.025	0.024	0.905	31.48	5.17	4.46	36.65	44.30
6	0.348	0.024	0.023	0.899	30.66	5.24	4.92	35.90	46.43
7	0.341	0.023	0.023	0.890	29.81	5.81	5.37	35.62	48.44
8	0.341	0.022	0.022	0.877	29.31	5.99	5.80	35.30	50.07
9	0.343	0.021	0.021	0.864	28.78	6.57	6.21	35.34	51.61
10	0.342	0.020	0.020	0.847	28.57	6.78	6.63	35.36	52.94
11	0.343	0.020	0.020	0.828	28.34	7.35	7.03	35.70	54.20

S.L.	TOTAL TEMP DEG RANKINE	TOTAL PRES LB/SQ IN.	STATIC TEMP DEG RANKINE	STATIC PRES LB/SQ IN.	SOLIDITY	THICKNESS TO CHORD	THROAT SPACING	EXIT BLADE ANGLE DEG	DEVIATION ANGLE DEG
1	648.4	30.387	615.2	25.260	1.684	0.030	0.88	-8.11	8.78
2	649.9	30.679	615.8	25.385	1.581	0.036	0.88	-8.36	8.54
3	649.9	30.567	617.0	25.473	1.485	0.042	0.88	-8.53	9.07
4	652.0	30.688	618.8	25.536	1.417	0.047	0.88	-8.78	9.09
5	653.1	30.692	620.1	25.580	1.354	0.052	0.88	-8.96	9.25
6	655.0	30.768	621.6	25.612	1.325	0.057	0.88	-8.97	9.05
7	656.6	30.764	623.6	25.633	1.297	0.062	0.88	-8.97	9.12
8	659.7	30.805	626.1	25.647	1.242	0.066	0.88	-9.36	9.34
9	662.8	30.803	629.2	25.654	1.189	0.071	0.88	-9.74	9.79
10	665.7	30.821	632.8	25.656	1.156	0.075	0.88	-10.11	10.03
11	671.0	30.820	636.9	25.655	1.124	0.079	0.88	-10.46	10.46

RON TAYLOR'S CASE I USED FOR AN36 CHECK OUT

MIKE PRATHER JAN 2 1968

INFORMATION FROM C2-6,CS-5,DN-8

ROTOR NO. 3 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	REL VEL (FT/SEC)	REL MACH NUMBER	WHEEL SPEED
1	19.79	533.3	541.7	209.6	788.6	0.617	704.0	0.551	950.6
2	20.39	561.5	516.0	191.4	786.5	0.615	752.9	0.589	979.2
3	20.95	557.9	508.7	163.3	772.5	0.603	765.2	0.597	1006.3
4	21.50	569.5	495.8	141.3	768.2	0.598	795.2	0.619	1032.5
5	22.02	571.7	487.9	118.1	760.8	0.592	815.8	0.634	1057.6
6	22.52	578.6	477.9	97.0	756.7	0.587	842.1	0.653	1082.0
7	23.02	578.3	472.9	75.7	750.9	0.581	860.5	0.666	1105.7
8	23.51	580.7	467.4	55.8	747.5	0.577	882.0	0.681	1128.9
9	23.98	577.6	466.8	36.4	743.6	0.572	896.7	0.689	1151.7
10	24.45	575.8	466.2	17.9	741.1	0.567	912.8	0.699	1174.2
11	24.92	569.8	470.3	0.2	738.8	0.563	923.1	0.703	1196.6

S.L. NO.	DIFFUSION FACTOR	LOSS COEFFICIENT	REF LOSS COEFFICIENT	ADIABATIC EFFICIENCY	INLET BLADE ANGLE (DEG)	INCIDENCE	REFERENCE INCIDENCE	ABS FLOW ANGLE IN	REL FLOW ANGLE IN.
1	0.484	0.073	0.066	0.926	45.98	8.78	7.80	0.67	54.76
2	0.460	0.065	0.063	0.931	47.95	7.64	7.18	0.18	55.59
3	0.461	0.066	0.063	0.928	49.72	7.19	6.60	0.49	56.91
4	0.453	0.067	0.066	0.925	51.28	6.38	6.03	0.30	57.65
5	0.451	0.071	0.070	0.918	52.70	5.82	5.49	0.29	58.52
6	0.445	0.074	0.073	0.913	53.98	5.18	4.97	0.08	59.16
7	0.444	0.077	0.077	0.906	55.18	4.66	4.47	0.15	59.83
8	0.442	0.083	0.083	0.897	56.25	4.13	3.99	-0.02	60.38
9	0.444	0.091	0.091	0.885	57.27	3.64	3.52	0.06	60.90
10	0.447	0.102	0.102	0.870	58.20	3.17	3.07	-0.08	61.38
11	0.453	0.115	0.115	0.853	59.09	2.71	2.62	-0.00	61.80

S.L.	TOTAL TEMP DEG RANKINE	TOTAL PRES LB/SQ IN.	STATIC TEMP DEG RANKINE	STATIC PRES LB/SQ IN.	SOLIDITY	THICKNESS TO CHORD	THROAT SPACING	EXIT BLADE ANGLE DEG	DEVIATION ANGLE DEG
1	732.5	45.332	681.1	35.079	1.772	0.079	0.66	30.82	4.69
2	733.2	45.642	682.1	35.378	1.695	0.073	0.65	33.64	4.32
3	733.7	45.535	684.4	35.632	1.623	0.068	0.63	36.29	4.28
4	736.1	45.655	687.4	35.855	1.565	0.063	0.62	38.37	4.08
5	737.9	45.660	690.1	36.052	1.510	0.058	0.61	40.33	3.98
6	740.3	45.725	693.0	36.228	1.468	0.053	0.59	42.01	3.83
7	743.0	45.716	696.5	36.386	1.428	0.048	0.58	43.60	3.73
8	746.9	45.746	700.8	36.530	1.393	0.044	0.57	44.95	3.64
9	751.5	45.737	705.9	36.664	1.359	0.039	0.56	46.23	3.56
10	757.3	45.744	712.0	36.789	1.331	0.035	0.55	47.36	3.50
11	764.0	45.740	719.0	36.909	1.304	0.031	0.54	48.46	3.43

RUN TAYLOR'S CASE 1 USED FOR AN36 CHECK OUT

MIKE PRATHER JAN 2 1968

INFORMATION FROM C2-6,CS-5,DN-8

STATOR EXIT NO. 3

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	REL VEL (FT/SEC)	REL MACH NUMBER	WHEEL SPEED
1	20.62	604.5	11.9	221.1	643.8	0.498	1171.2	0.905	990.3
2	21.11	624.0	1.7	198.2	654.7	0.506	1205.3	0.932	1013.7
3	21.57	624.7	6.8	171.0	647.7	0.500	1216.1	0.940	1036.1
4	22.03	634.9	2.9	147.8	651.9	0.503	1240.1	0.957	1057.9
5	22.47	639.2	3.2	124.4	651.2	0.502	1257.5	0.969	1079.0
6	22.90	645.7	0.5	102.5	653.8	0.503	1278.8	0.984	1099.6
7	23.32	648.8	1.5	81.0	653.8	0.502	1295.3	0.995	1119.7
8	23.73	653.5	-0.8	60.6	656.3	0.503	1315.6	1.008	1139.4
9	24.13	656.5	0.3	40.7	657.8	0.502	1332.2	1.017	1158.8
10	24.53	660.4	-1.5	21.2	660.8	0.503	1351.9	1.029	1177.9
11	24.92	663.9	-0.3	2.2	663.9	0.503	1368.8	1.037	1196.7

S.L. NO.	DIFFUSION FACTOR	LOSS COEFFICIENT	REF LOSS COEFFICIENT	ADIABATIC EFFICIENCY	INLET BLADE ANGLE (DEG)	INCIDENCE	REFERENCE INCIDENCE	ABS FLOW ANGLE IN	REL FLOW ANGLE IN.
1	0.398	0.033	0.030	0.910	38.78	4.61	2.44	43.39	35.51
2	0.383	0.029	0.029	0.915	37.64	3.36	2.94	41.00	37.97
3	0.383	0.029	0.028	0.912	36.51	4.68	3.42	41.19	40.57
4	0.378	0.027	0.026	0.910	35.68	4.51	3.91	40.20	42.45
5	0.376	0.026	0.026	0.905	34.84	5.05	4.38	39.88	44.30
6	0.372	0.025	0.025	0.900	34.09	5.07	4.84	39.16	45.84
7	0.370	0.024	0.024	0.894	33.33	5.71	5.29	39.04	47.33
8	0.367	0.023	0.023	0.885	32.90	5.80	5.72	38.70	48.59
9	0.366	0.023	0.023	0.874	32.45	6.44	6.15	38.89	49.80
10	0.366	0.022	0.022	0.860	32.36	6.62	6.58	38.98	50.87
11	0.367	0.022	0.022	0.843	32.25	7.28	7.00	39.54	51.89

S.L.	TOTAL TEMP DEG RANKINE	TOTAL PRES LB/SQ IN.	STATIC TEMP DEG RANKINE	STATIC PRES LB/SQ IN.	SOLIDITY	THICKNESS TO CHORD	THROAT SPACING	EXIT BLADE ANGLE DEG	DEVIATION ANGLE DEG
1	732.5	44.991	698.2	38.002	1.568	0.031	0.86	-9.60	10.66
2	733.2	45.347	697.8	38.084	1.516	0.037	0.86	-9.65	9.81
3	733.7	45.251	699.1	38.153	1.466	0.042	0.86	-9.69	10.29
4	736.1	45.393	701.1	38.209	1.418	0.047	0.86	-9.85	10.10
5	737.9	45.412	702.9	38.254	1.372	0.052	0.86	-9.99	10.28
6	740.3	45.490	705.0	38.289	1.338	0.057	0.86	-10.11	10.15
7	743.0	45.491	707.7	38.314	1.304	0.061	0.86	-10.21	10.34
8	746.9	45.530	711.4	38.331	1.277	0.066	0.86	-10.40	10.34
9	751.5	45.528	715.8	38.340	1.251	0.070	0.86	-10.59	10.61
10	757.3	45.543	721.3	38.343	1.224	0.075	0.86	-10.95	10.82
11	764.0	45.545	727.6	38.340	1.198	0.079	0.86	-11.31	11.28

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RON TAYLOR'S CASE I USED FOR AN36 CHECK OUT

MIKE PRATHER JAN 2 1968

INFORMATION FROM C2-6,CS-5,DN-8

ROTOR NO. 4 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	REL VEL (FT/SEC)	REL MACH NUMBER	WHEEL SPEED
1	21.23	566.9	520.3	179.2	790.1	0.584	776.5	0.573	1019.7
2	21.64	590.2	496.8	163.4	788.6	0.582	818.1	0.604	1039.3
3	22.03	584.5	495.1	140.5	778.8	0.574	823.6	0.607	1058.1
4	22.42	593.3	483.8	122.1	775.2	0.571	847.4	0.624	1076.5
5	22.79	593.9	478.4	103.0	769.6	0.565	861.9	0.633	1094.5
6	23.16	598.2	470.9	85.3	766.1	0.562	881.1	0.646	1112.1
7	23.52	596.3	469.0	67.5	761.6	0.557	892.3	0.653	1129.4
8	23.87	597.6	465.7	50.8	759.4	0.554	907.3	0.661	1146.5
9	24.23	594.6	467.2	34.3	757.0	0.550	916.3	0.665	1163.4
10	24.58	593.2	468.3	18.5	756.0	0.546	926.9	0.670	1180.3
11	24.93	587.8	474.6	3.2	755.5	0.543	931.5	0.669	1197.2

S.L. NO.	DIFFUSION FACTOR	LOSS COEFFICIENT	REF LOSS COEFFICIENT	ADIABATIC EFFICIENCY	INLET BLADE ANGLE (DEG)	INCIDENCE	REFERENCE INCIDENCE	ABS FLOW ANGLE IN	REL FLOW ANGLE IN.
1	0.464	0.067	0.062	0.925	48.63	8.03	7.25	1.06	56.66
2	0.446	0.062	0.060	0.926	49.96	7.14	6.67	0.15	57.10
3	0.449	0.062	0.059	0.926	51.17	6.65	6.12	0.60	57.82
4	0.442	0.062	0.060	0.924	52.34	5.95	5.56	0.25	58.29
5	0.441	0.063	0.062	0.922	53.42	5.39	5.03	0.28	58.81
6	0.437	0.065	0.064	0.917	54.43	4.83	4.53	0.04	59.25
7	0.438	0.069	0.068	0.911	55.37	4.31	4.04	0.13	59.69
8	0.438	0.074	0.074	0.902	56.25	3.82	3.57	-0.07	60.07
9	0.441	0.080	0.080	0.895	57.09	3.32	3.10	0.03	60.41
10	0.445	0.089	0.089	0.882	57.84	2.89	2.65	-0.13	60.74
11	0.452	0.101	0.100	0.867	58.57	2.42	2.21	-0.02	60.98

S.L.	TOTAL TEMP DEG RANKINE	TOTAL PRES LB/SQ IN.	STATIC TEMP DEG RANKINE	STATIC PRES LB/SQ IN.	SOLIDITY	THICKNESS TO CHORD	THROAT SPACING	EXIT BLADE ANGLE DEG	DEVIATION ANGLE DEG
1	817.8	64.687	766.5	51.414	1.610	0.079	0.63	35.53	4.50
2	817.8	65.022	766.8	51.728	1.566	0.074	0.62	37.30	4.23
3	818.7	64.970	768.9	52.002	1.524	0.068	0.61	38.97	4.15
4	821.3	65.091	771.9	52.245	1.486	0.063	0.60	40.37	4.01
5	823.4	65.107	774.8	52.460	1.450	0.059	0.59	41.69	3.93
6	826.2	65.163	778.1	52.652	1.419	0.054	0.58	42.85	3.85
7	829.7	65.149	782.2	52.823	1.389	0.050	0.57	43.96	3.78
8	834.8	65.174	787.5	52.979	1.366	0.045	0.57	44.89	3.73
9	840.5	65.164	793.7	53.122	1.343	0.040	0.56	45.79	3.67
10	843.2	65.167	801.5	53.253	1.323	0.035	0.55	46.54	3.65
11	857.2	65.160	810.5	53.376	1.304	0.031	0.55	47.26	3.61

RUN TAYLOR'S CASE I USED FOR AN36 CHECK OUT

MIKE PRATHER JAN 2 1968

INFORMATION FROM C2-6,CS-5,DN-8

STATOR EXIT NO. 4

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	REL VEL (FT/SEC)	REL MACH NUMBER	WHEEL SPEED
1	21.70	616.9	15.0	171.1	640.3	0.468	1210.2	0.884	1042.0
2	22.05	630.5	3.9	155.1	649.3	0.475	1238.8	0.905	1058.9
3	22.39	630.4	7.9	136.0	644.9	0.471	1247.2	0.911	1075.4
4	22.73	637.1	3.6	118.8	648.0	0.473	1266.2	0.923	1091.5
5	23.06	639.8	3.5	101.2	647.8	0.472	1279.8	0.932	1107.3
6	23.38	644.0	0.7	84.2	649.5	0.472	1296.5	0.943	1122.8
7	23.70	646.0	1.4	67.2	649.5	0.471	1309.1	0.950	1138.1
8	24.01	649.6	-0.5	50.8	651.6	0.471	1325.0	0.958	1153.2
9	24.32	652.2	0.5	34.6	653.1	0.471	1337.9	0.964	1168.1
10	24.63	655.7	-1.5	18.8	656.0	0.471	1353.9	0.972	1182.9
11	24.94	659.2	-0.3	3.2	659.2	0.471	1367.3	0.976	1197.6

S.L. NO.	DIFFUSION FACTOR	LOSS COEFFICIENT	REF LOSS COEFFICIENT	ADIABATIC EFFICIENCY	INLET BLADE ANGLE (DEG)	INCIDENCE	REFERENCE INCIDENCE	ABS FLOW ANGLE IN	REL FLOW. ANGLE IN.
1	0.407	0.033	0.029	0.909	36.34	4.85	2.12	41.19	40.03
2	0.394	0.028	0.028	0.911	35.67	3.38	2.57	39.05	41.53
3	0.394	0.028	0.027	0.911	35.00	4.48	3.01	39.48	43.12
4	0.389	0.027	0.026	0.910	34.38	4.24	3.48	38.62	44.38
5	0.387	0.026	0.026	0.908	33.75	4.69	3.94	38.44	45.62
6	0.384	0.025	0.025	0.904	33.26	4.66	4.39	37.93	46.70
7	0.384	0.025	0.025	0.899	32.76	5.25	4.83	38.01	47.74
8	0.382	0.024	0.024	0.890	32.46	5.37	5.25	37.83	48.62
9	0.382	0.024	0.024	0.883	32.15	5.96	5.67	38.11	49.46
10	0.383	0.023	0.023	0.871	32.17	6.11	6.09	38.28	50.19
11	0.386	0.023	0.023	0.857	32.17	6.75	6.51	38.92	50.87

S.L.	TOTAL TEMP DEG RANKINE	TOTAL PRES LB/SQ IN.	STATIC TEMP DEG RANKINE	STATIC PRES LB/SQ IN.	SOLIDITY	THICKNESS TO CHORD	THROAT SPACING	EXIT BLADE ANGLE DEG	DEVIATION ANGLE DEG
1	817.8	64.244	784.1	55.343	1.473	0.031	0.86	-9.39	10.73
2	817.8	64.649	783.2	55.452	1.440	0.036	0.86	-9.47	9.81
3	818.7	64.603	784.6	55.539	1.408	0.041	0.86	-9.54	10.24
4	821.3	64.750	786.8	55.609	1.377	0.046	0.86	-9.65	9.97
5	823.4	64.780	789.0	55.665	1.347	0.051	0.85	-9.75	10.06
6	826.2	64.850	791.7	55.709	1.323	0.056	0.86	-9.87	9.93
7	829.7	64.846	795.2	55.743	1.298	0.061	0.86	-9.98	10.11
8	834.8	64.880	800.0	55.768	1.278	0.065	0.86	-10.15	10.11
9	840.6	64.878	805.7	55.786	1.258	0.070	0.86	-10.32	10.36
10	848.2	64.889	813.0	55.797	1.238	0.075	0.85	-10.64	10.52
11	857.2	64.887	821.6	55.803	1.218	0.079	0.85	-10.93	10.94

RON TAYLOR'S CASE I USED FOR AN36 CHECK OUT

MIKE PRATHER JAN 2 1968

INFORMATION FROM C2-6,CS-5,DN-8

ROTOR NO. 5 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	REL VEL (FT/SEC)	REL MACH NUMBER	WHEEL SPEED
1	22.06	553.6	510.7	143.5	766.7	0.537	792.4	0.555	1059.2
2	22.37	576.7	486.3	132.8	766.0	0.537	834.2	0.584	1074.2
3	22.67	575.1	484.3	116.3	760.8	0.532	842.4	0.590	1088.8
4	22.97	584.0	473.7	102.2	758.9	0.530	864.6	0.604	1103.0
5	23.26	586.3	469.0	87.2	755.8	0.527	878.2	0.613	1117.0
6	23.54	591.0	462.2	72.7	753.8	0.525	895.3	0.623	1130.7
7	23.83	590.4	461.0	57.9	751.3	0.522	904.8	0.629	1144.2
8	24.11	591.5	459.6	43.6	750.4	0.519	916.0	0.634	1157.7
9	24.38	588.7	463.0	29.5	749.6	0.517	921.3	0.635	1171.1
10	24.66	586.9	466.3	15.9	749.8	0.514	927.6	0.636	1184.4
11	24.94	581.2	475.1	2.7	750.7	0.512	927.5	0.632	1197.9

S.L. NO.	DIFFUSION FACTOR	LOSS COEFFICIENT	REF LOSS COEFFICIENT	ADIABATIC EFFICIENCY	INLET BLADE ANGLE (DEG)	INCIDENCE	REFERENCE INCIDENCE	ABS FLOW ANGLE IN	REL FLOW ANGLE IN.
1	0.477	0.063	0.060	0.923	50.90	7.17	6.51	1.34	58.07
2	0.455	0.057	0.056	0.932	51.96	6.43	5.99	0.34	58.39
3	0.453	0.055	0.054	0.930	52.96	5.90	5.50	0.70	58.86
4	0.444	0.054	0.053	0.929	53.89	5.32	5.00	0.32	59.22
5	0.441	0.054	0.053	0.929	54.78	4.81	4.51	0.31	59.59
6	0.436	0.054	0.054	0.926	55.62	4.32	4.03	0.06	59.94
7	0.436	0.056	0.056	0.922	56.42	3.84	3.56	0.13	60.25
8	0.436	0.061	0.061	0.916	57.16	3.38	3.10	-0.04	60.54
9	0.440	0.068	0.068	0.906	57.88	2.90	2.64	0.04	60.78
10	0.446	0.078	0.077	0.893	58.53	2.49	2.20	-0.13	61.02
11	0.455	0.090	0.089	0.879	59.15	2.03	1.76	-0.03	61.18

S.L.	TOTAL TEMP DEG RANKINE	TOTAL PRES LB/SQ IN.	STATIC TEMP DEG RANKINE	STATIC PRES LB/SQ IN.	SOLIDITY	THICKNESS TO CHORD	THROAT SPACING	EXIT BLADE ANGLE DEG	DEVIATION ANGLE DEG
1	903.5	89.436	855.6	73.612	1.502	0.079	0.60	39.56	4.25
2	902.4	89.721	854.6	73.854	1.475	0.074	0.59	40.75	4.06
3	903.3	89.719	856.2	74.068	1.448	0.069	0.58	41.83	3.98
4	905.8	89.819	859.0	74.264	1.426	0.064	0.57	42.82	3.89
5	903.2	89.848	861.7	74.441	1.403	0.059	0.57	43.72	3.83
6	911.3	89.891	865.1	74.604	1.384	0.054	0.56	44.52	3.79
7	915.4	89.879	869.5	74.753	1.365	0.049	0.56	45.28	3.75
8	921.5	89.895	875.8	74.893	1.348	0.045	0.55	45.90	3.74
9	928.3	89.884	883.2	75.025	1.332	0.040	0.55	46.50	3.73
10	938.3	89.875	892.7	75.153	1.317	0.036	0.54	46.93	3.74
11	949.7	89.868	904.0	75.279	1.303	0.031	0.54	47.47	3.73

RON TAYLOR'S CASE I USED FOR AN36 CHECK OUT

MIKE PRATHER JAN 2 1968

INFORMATION FROM C2-6,CS-5,DN-8

STATOR EXIT NO. 5

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	REL VEL (FT/SEC)	REL MACH NUMBER	WHEEL SPEED
1	22.45	622.9	16.9	152.5	641.5	0.446	1240.1	0.861	1078.4
2	22.72	635.1	5.5	137.9	649.9	0.452	1265.4	0.880	1091.2
3	22.98	638.0	8.4	121.6	649.5	0.451	1273.4	0.885	1103.7
4	23.24	644.2	5.2	106.4	653.0	0.453	1288.6	0.894	1116.1
5	23.49	647.9	5.8	91.1	654.3	0.454	1299.2	0.901	1128.3
6	23.74	652.0	3.9	76.2	656.4	0.454	1312.2	0.908	1140.1
7	23.99	654.8	2.3	61.3	657.6	0.454	1324.4	0.915	1151.9
8	24.23	658.6	0.5	46.7	660.3	0.455	1337.4	0.921	1163.6
9	24.47	661.9	1.6	32.1	662.7	0.454	1347.8	0.924	1175.2
10	24.71	665.6	-0.1	17.6	666.0	0.454	1360.9	0.929	1186.8
11	24.95	669.9	1.4	3.0	669.9	0.454	1371.6	0.930	1198.2

S.L. NO.	DIFFUSION FACTOR	LOSS COEFFICIENT	REF LOSS COEFFICIENT	ADIABATIC EFFICIENCY	INLET BLADE ANGLE (DEG)	INCIDENCE	REFERENCE INCIDENCE	ABS FLOW ANGLE IN	REL FLOW ANGLE IN.
1	0.387	0.032	0.027	0.913	36.72	5.04	2.06	41.76	43.81
2	0.374	0.027	0.026	0.919	35.90	3.52	2.51	39.41	44.81
3	0.371	0.027	0.026	0.916	35.08	4.45	2.93	39.53	45.85
4	0.365	0.026	0.025	0.916	34.37	4.25	3.24	38.63	46.71
5	0.362	0.025	0.024	0.916	33.67	4.68	3.54	38.35	47.55
6	0.359	0.024	0.024	0.914	33.11	4.71	3.83	37.82	48.31
7	0.358	0.024	0.024	0.910	32.55	5.31	4.77	37.85	49.03
8	0.357	0.023	0.023	0.905	32.30	5.47	5.20	37.77	49.64
9	0.357	0.023	0.023	0.895	32.05	6.10	5.63	38.15	50.22
10	0.358	0.023	0.023	0.882	32.17	6.29	6.07	38.46	50.73
11	0.361	0.023	0.023	0.869	32.26	7.00	6.51	39.26	51.20

S.L.	TOTAL TEMP DEG RANKINE	TOTAL PRES LB/SQ IN.	STATIC TEMP DEG RANKINE	STATIC PRES LB/SQ IN.	SOLIDITY	THICKNESS TO CHORD	THROAT SPACING	EXIT BLADE ANGLE DEG	DEVIATION ANGLE DEG
1	903.5	88.950	870.0	77.683	1.438	0.031	0.86	-9.70	11.21
2	902.4	89.296	868.0	77.706	1.414	0.036	0.86	-9.69	10.17
3	903.3	89.298	869.0	77.733	1.390	0.041	0.86	-9.67	10.41
4	905.3	89.422	871.1	77.754	1.367	0.046	0.86	-9.69	10.15
5	908.2	89.461	873.4	77.772	1.344	0.051	0.86	-9.71	10.22
6	911.3	89.518	876.3	77.787	1.325	0.056	0.86	-9.76	10.10
7	915.4	89.519	880.3	77.798	1.307	0.061	0.86	-9.80	10.01
8	921.5	89.545	886.1	77.805	1.291	0.065	0.86	-9.95	10.00
9	928.8	89.540	893.2	77.809	1.276	0.070	0.86	-10.10	10.24
10	938.1	89.539	902.4	77.809	1.260	0.074	0.85	-10.41	10.40
11	949.7	89.536	913.3	77.810	1.245	0.079	0.85	-10.71	10.83

RUN TAYLOR'S CASE I USED FOR AN36 CHECK OUT

MIKE PRATHER JAN 2 1968

INFORMATION FROM C2-6,CS-5,DN-8

RUTCR NO. 6 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	REL VEL (FT/SEC)	REL MACH NUMBER	WHEEL SPEED
1	22.78	589.4	510.0	136.9	791.4	0.529	840.9	0.563	1094.0
2	23.01	608.7	489.2	124.8	790.9	0.530	874.9	0.586	1105.1
3	23.24	609.0	486.8	109.3	787.2	0.527	882.4	0.591	1115.9
4	23.46	615.7	479.0	95.5	785.9	0.525	898.6	0.601	1126.5
5	23.68	617.5	476.0	81.4	783.9	0.523	908.2	0.606	1137.0
6	23.89	621.0	471.7	67.9	782.8	0.521	920.2	0.613	1147.4
7	24.10	622.1	469.4	54.5	781.2	0.519	929.3	0.618	1157.6
8	24.32	623.3	469.4	41.4	781.3	0.517	937.0	0.620	1167.8
9	24.52	620.6	474.0	28.4	781.5	0.515	938.9	0.619	1178.0
10	24.74	619.4	479.1	15.5	783.2	0.513	941.6	0.617	1188.2
11	24.96	614.2	489.7	2.7	785.5	0.512	937.9	0.611	1198.5

S.L. NO.	DIFFUSION FACTOR	LOSS COEFFICIENT	REF LOSS COEFFICIENT	ADIABATIC EFFICIENCY	INLET BLADE ANGLE (DEG)	INCIDENCE	REFERENCE INCIDENCE	ABS FLOW ANGLE IN	REL FLOW ANGLE IN.
1	0.455	0.056	0.054	0.932	51.83	7.03	6.52	1.51	58.86
2	0.438	0.052	0.051	0.939	52.64	6.45	6.03	0.48	59.10
3	0.437	0.050	0.049	0.934	53.41	5.93	5.55	0.74	59.33
4	0.431	0.049	0.048	0.934	54.16	5.39	5.07	0.46	59.55
5	0.430	0.048	0.048	0.934	54.88	4.89	4.58	0.50	59.76
6	0.427	0.048	0.048	0.932	55.59	4.39	4.11	0.34	59.98
7	0.427	0.050	0.050	0.930	56.28	3.95	3.63	0.20	60.23
8	0.429	0.054	0.054	0.923	56.91	3.51	3.18	0.05	60.42
9	0.435	0.061	0.060	0.914	57.52	3.03	2.73	0.14	60.55
10	0.442	0.070	0.069	0.903	58.09	2.61	2.27	-0.01	60.70
11	0.453	0.081	0.080	0.889	58.65	2.11	1.81	0.12	60.76

S.L.	TOTAL TEMP DEG RANKINE	TOTAL PRES LB/SQ IN.	STATIC TEMP DEG RANKINE	STATIC PRES LB/SQ IN.	SOLIDITY	THICKNESS TO CHORD	THROAT SPACING	EXIT BLADE ANGLE DEG	DEVIATION ANGLE DEG
1	990.7	121.404	940.2	100.497	1.450	0.079	0.59	39.43	4.56
2	988.8	121.653	938.4	100.690	1.430	0.074	0.59	40.31	4.44
3	989.6	121.647	939.6	100.880	1.412	0.069	0.58	41.14	4.34
4	992.1	121.722	942.3	101.055	1.396	0.064	0.58	41.83	4.27
5	994.6	121.743	945.1	101.221	1.381	0.059	0.57	42.49	4.22
6	998.0	121.787	948.6	101.376	1.367	0.054	0.57	43.05	4.20
7	1002.7	121.759	953.6	101.521	1.353	0.050	0.57	43.53	4.20
8	1009.9	121.768	960.7	101.655	1.339	0.045	0.56	43.97	4.22
9	1018.5	121.734	959.4	101.781	1.326	0.040	0.56	44.35	4.22
10	1030.0	121.728	980.8	101.902	1.314	0.036	0.56	44.57	4.29
11	1043.8	121.705	994.3	102.021	1.302	0.031	0.55	44.77	4.32

RUN TAYLOR'S CASE I USED FOR AN36 CHECK OUT

MIKE PRATHER JAN 2 1968

INFORMATION FROM C2-6,CS-5,DN-8

STATOR EXIT NO. 6

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	REL VEL (FT/SEC)	REL MACH NUMBER	WHEEL SPEED
1	22.99	642.1	16.5	138.9	657.2	0.436	1270.6	0.843	1104.1
2	23.20	648.3	6.7	123.5	660.0	0.439	1289.0	0.856	1114.0
3	23.40	648.0	8.2	108.1	657.0	0.436	1294.5	0.860	1123.7
4	23.60	650.4	5.3	93.7	657.1	0.436	1305.4	0.866	1133.3
5	23.80	651.3	5.3	79.8	656.2	0.435	1313.2	0.870	1142.8
6	23.99	653.2	3.5	66.5	656.6	0.434	1323.1	0.875	1152.2
7	24.19	654.0	3.0	53.5	656.2	0.433	1331.5	0.878	1161.6
8	24.38	656.4	1.4	40.9	657.7	0.432	1341.8	0.882	1170.9
9	24.57	658.4	2.4	28.3	659.0	0.431	1349.6	0.884	1180.2
10	24.77	662.1	1.0	15.7	662.2	0.431	1360.5	0.886	1189.5
11	24.96	665.9	2.5	2.7	665.9	0.431	1369.1	0.886	1198.7

S.L. NO.	DIFFUSION FACTOR	LOSS COEFFICIENT	REF LOSS COEFFICIENT	ADIABATIC EFFICIENCY	INLET BLADE ANGLE (DEG)	INCIDENCE	REFFRENCE INCIDENCE	ABS FLOW ANGLE IN	REL FLOW. ANGLE IN.
1	0.394	0.031	0.027	0.921	36.19	3.94	1.08	40.13	43.98
2	0.387	0.027	0.026	0.925	35.56	2.66	1.44	38.21	44.75
3	0.389	0.027	0.026	0.920	34.92	3.27	1.79	38.19	45.48
4	0.389	0.026	0.026	0.920	34.34	3.22	2.21	37.55	46.10
5	0.390	0.026	0.025	0.921	33.75	3.64	2.63	37.39	46.70
6	0.390	0.025	0.025	0.919	33.29	3.76	3.04	37.06	47.24
7	0.391	0.025	0.025	0.917	32.83	4.10	3.46	36.93	47.78
8	0.392	0.025	0.025	0.910	32.68	4.24	3.84	36.92	48.19
9	0.395	0.025	0.024	0.901	32.52	4.82	4.22	37.34	48.57
10	0.397	0.024	0.024	0.891	32.70	5.02	4.63	37.72	48.85
11	0.401	0.024	0.024	0.877	32.86	5.70	5.04	38.56	49.09

S.L.	TOTAL TEMP DEG RANKINE	TOTAL PRES LB/SQ IN.	STATIC TEMP DEG RANKINE	STATIC PRES LB/SQ IN.	SOLIDITY	THICKNESS TO CHORD	THROAT SPACING	EXIT BLADE ANGLE DEG	DEVIATION ANGLE DEG
1	990.7	120.763	955.9	106.119	1.392	0.031	0.35	-9.77	11.21
2	988.3	121.090	953.7	106.259	1.374	0.036	0.35	-9.76	10.34
3	989.5	121.087	954.8	106.395	1.356	0.041	0.35	-9.75	10.47
4	992.1	121.184	957.3	106.509	1.339	0.046	0.35	-9.77	10.23
5	994.6	121.215	959.9	106.610	1.321	0.051	0.35	-9.78	10.25
6	998.0	121.273	963.3	106.694	1.307	0.055	0.35	-9.83	10.15
7	1002.7	121.254	968.1	106.761	1.293	0.060	0.35	-9.87	10.13
8	1009.9	121.273	975.1	106.812	1.281	0.065	0.35	-10.01	10.13
9	1018.5	121.244	983.6	106.849	1.269	0.070	0.35	-10.15	10.37
10	1030.0	121.246	994.8	106.870	1.256	0.074	0.34	-10.45	10.53
11	1043.5	121.224	1008.2	106.880	1.244	0.079	0.34	-10.74	10.96

RON TAYLOR'S CASE I USED FOR AN36 CHECK OUT

MIKE PRATHER JAN 2 1968

INFORMATION FROM C2-6,CS-5,DN-8

ROTOR NO. 7 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	REL VEL (FT/SEC)	REL MACH NUMBER	WHEEL SPEED
1	23.28	638.3	508.4	85.9	820.6	0.527	886.7	0.569	1117.8
2	23.45	647.2	493.1	77.6	817.3	0.525	908.6	0.584	1126.1
3	23.62	642.4	491.0	67.9	811.4	0.521	911.7	0.585	1134.3
4	23.79	643.3	485.5	59.2	808.1	0.518	921.3	0.591	1142.4
5	23.96	641.2	483.2	50.5	804.4	0.515	926.8	0.593	1150.5
6	24.12	641.4	480.1	42.3	802.3	0.513	934.6	0.597	1158.5
7	24.29	638.9	479.6	34.0	799.6	0.510	938.7	0.598	1166.6
8	24.46	638.2	481.0	26.0	799.6	0.508	942.9	0.599	1174.6
9	24.63	633.9	486.9	17.9	799.6	0.505	941.4	0.595	1182.6
10	24.79	632.2	493.9	9.8	802.3	0.504	940.9	0.591	1190.8
11	24.97	626.2	506.7	1.6	805.5	0.503	933.5	0.582	1199.0

S.L. NO.	DIFFUSION FACTOR	LOSS COEFFICIENT	REF LOSS COEFFICIENT	ADIABATIC EFFICIENCY	INLET BLADE ANGLE (DEG)	INCIDENCE	REFERENCE INCIDENCE	ABS FLOW ANGLE IN	REL FLOW ANGLE IN.
1	0.435	0.051	0.050	0.934	51.87	7.00	6.54	1.44	58.87
2	0.427	0.048	0.047	0.945	52.73	6.47	6.06	0.58	59.20
3	0.427	0.046	0.046	0.938	53.56	5.94	5.58	0.72	59.50
4	0.426	0.045	0.044	0.938	54.33	5.45	5.10	0.46	59.78
5	0.426	0.044	0.044	0.938	55.08	4.94	4.62	0.46	60.02
6	0.425	0.044	0.044	0.936	55.77	4.48	4.16	0.30	60.25
7	0.427	0.046	0.045	0.935	56.44	4.03	3.70	0.26	60.48
8	0.431	0.050	0.049	0.928	57.07	3.58	3.22	0.12	60.65
9	0.438	0.056	0.055	0.922	57.67	3.10	2.74	0.21	60.77
10	0.446	0.064	0.064	0.910	58.18	2.69	2.29	0.09	60.87
11	0.460	0.076	0.076	0.894	58.68	2.22	1.84	0.22	60.89

S.L.	TOTAL TEMP DEG RANKINE	TOTAL PRES LB/SQ IN.	STATIC TEMP DEG RANKINE	STATIC PRES LB/SQ IN.	SOLIDITY	THICKNESS TO CHORD	THROAT SPACING	EXIT BLADE ANGLE DEG	DEVIATION ANGLE DEG
1	1078.8	161.644	1025.0	134.141	1.412	0.079	0.60	38.62	4.80
2	1076.5	162.025	1023.2	134.606	1.398	0.074	0.59	39.43	4.74
3	1077.3	162.062	1024.7	135.027	1.385	0.069	0.59	40.22	4.67
4	1079.9	162.193	1027.8	135.398	1.373	0.064	0.58	40.84	4.64
5	1082.6	162.239	1030.9	135.728	1.361	0.059	0.58	41.45	4.61
6	1086.3	162.225	1035.0	136.017	1.349	0.055	0.57	41.94	4.60
7	1091.6	162.289	1040.6	136.270	1.338	0.050	0.57	42.42	4.61
8	1099.8	162.333	1048.9	136.489	1.328	0.045	0.57	42.69	4.66
9	1109.9	162.291	1059.1	136.679	1.319	0.040	0.56	42.95	4.70
10	1123.5	162.335	1072.4	136.843	1.310	0.036	0.56	42.99	4.79
11	1139.8	162.315	1086.4	136.985	1.301	0.031	0.56	43.02	4.85

RON TAYLOR'S CASE I USED FOR AN36 CHECK OUT

MIKE PRATHER JAN 2 1968

INFORMATION FROM C2-6,CS-5,DN-8

STATOR EXIT NO. 7

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	REL VEL (FT/SEC)	REL MACH NUMBER	WHEEL SPEED
1	23.34	628.4	13.7	45.3	630.2	0.400	1273.7	0.809	1120.7
2	23.50	632.3	7.0	41.3	633.6	0.403	1288.2	0.820	1128.7
3	23.67	629.4	7.7	37.0	630.5	0.401	1293.0	0.822	1136.6
4	23.83	629.9	5.7	33.0	630.8	0.401	1301.8	0.827	1144.5
5	23.99	629.0	5.4	28.9	629.7	0.399	1308.4	0.830	1152.3
6	24.16	629.7	3.9	24.8	630.2	0.399	1316.9	0.834	1160.2
7	24.32	629.2	4.0	20.7	629.5	0.398	1323.3	0.836	1168.0
8	24.48	631.3	2.7	16.4	631.5	0.398	1332.2	0.839	1175.7
9	24.64	632.5	3.9	11.8	632.6	0.396	1338.6	0.839	1183.5
10	24.81	636.8	2.8	6.7	636.8	0.397	1348.3	0.840	1191.3
11	24.97	640.5	4.6	0.9	640.5	0.396	1355.3	0.839	1199.0

S.L. NO.	DIFFUSION FACTOR	LOSS COEFFICIENT	REF LOSS COEFFICIENT	ADIABATIC EFFICIENCY	INLET BLADE ANGLE (DEG)	INCIDENCE	REFERENCE INCIDENCE	ABS FLOW ANGLE IN	REL FLOW ANGLE IN.
1	0.443	0.034	0.030	0.925	34.78	3.51	1.01	38.29	43.42
2	0.435	0.031	0.030	0.926	34.45	2.68	1.36	37.11	44.16
3	0.435	0.030	0.029	0.920	34.08	3.15	1.71	37.24	44.88
4	0.432	0.030	0.029	0.921	33.70	3.23	2.14	36.93	45.48
5	0.432	0.029	0.029	0.922	33.31	3.61	2.57	36.92	46.06
6	0.430	0.029	0.029	0.920	32.97	3.78	3.00	36.76	46.54
7	0.431	0.029	0.028	0.920	32.63	4.23	3.43	36.86	47.03
8	0.431	0.028	0.028	0.913	32.57	4.42	3.82	36.98	47.35
9	0.433	0.028	0.028	0.907	32.51	5.01	4.21	37.52	47.65
10	0.435	0.028	0.028	0.895	32.73	5.26	4.63	38.00	47.78
11	0.439	0.029	0.028	0.880	32.96	6.02	5.06	38.98	47.87

S.L.	TOTAL TEMP DEG RANKINE	TOTAL PRES LB/SQ IN.	STATIC TEMP DEG RANKINE	STATIC PRES LB/SQ IN.	SOLIDITY	THICKNESS TO CHORD	THROAT SPACING	EXIT BLADE ANGLE DEG	DEVIATION ANGLE DEG
1	1078.8	160.721	1047.1	144.146	1.426	0.031	0.85	-9.05	10.30
2	1076.5	161.188	1044.5	144.356	1.415	0.036	0.85	-9.07	9.70
3	1077.3	161.238	1045.6	144.569	1.405	0.041	0.85	-9.09	9.79
4	1079.9	161.398	1048.2	144.740	1.394	0.046	0.85	-9.11	9.62
5	1082.6	161.462	1051.0	144.892	1.384	0.050	0.84	-9.13	9.52
6	1086.3	161.507	1054.7	145.014	1.374	0.055	0.84	-9.16	9.52
7	1091.6	161.543	1060.0	145.105	1.365	0.060	0.84	-9.20	9.56
8	1099.8	161.601	1068.1	145.174	1.356	0.065	0.84	-9.33	9.58
9	1109.9	161.562	1078.1	145.229	1.347	0.069	0.84	-9.46	9.81
10	1123.5	161.615	1091.3	145.260	1.339	0.074	0.83	-9.72	9.97
11	1139.8	161.590	1107.3	145.282	1.330	0.079	0.83	-9.98	10.39

RUN TAYLOR'S CASE I USED FOR AN36 CHECK OUT

MIKE PRATHER JAN 2 1968

INFORMATION FROM C2-6,CS-5,DN-8

STATION NO. 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	REL VEL (FT/SEC)	REL MACH NUMBER	WHEEL SPEED
1	23.44	670.8	13.4	32.4	671.7	0.428	1299.2	0.827	1125.6
2	23.60	676.2	6.9	29.5	676.9	0.432	1314.0	0.838	1133.1
3	23.75	675.2	7.6	26.4	675.7	0.431	1319.2	0.841	1140.6
4	23.91	677.0	5.6	23.3	677.4	0.431	1328.1	0.845	1148.0
5	24.06	677.3	5.4	20.1	677.7	0.431	1334.8	0.849	1155.4
6	24.21	679.0	4.0	16.9	679.2	0.431	1343.1	0.853	1162.7
7	24.36	679.3	4.1	13.7	679.5	0.430	1349.5	0.855	1170.0
8	24.52	682.1	2.9	10.4	682.2	0.430	1358.2	0.857	1177.3
9	24.67	683.9	4.1	7.2	683.9	0.430	1364.3	0.857	1184.6
10	24.82	688.6	3.1	3.9	688.6	0.430	1373.7	0.858	1191.9
11	24.97	692.7	5.1	0.6	692.8	0.430	1380.4	0.856	1199.1

S.L.	TOTAL TEMP DEG RANKINE	TOTAL PRES LB/SQ IN.	STATIC TEMP DEG RANKINE	STATIC PRES LB/SQ IN.
1	1079.1	160.721	1043.1	141.993
2	1076.7	161.188	1040.1	142.088
3	1077.4	161.238	1041.0	142.208
4	1080.0	161.398	1043.4	142.300
5	1082.6	161.462	1046.0	142.388
6	1086.3	161.567	1049.5	142.460
7	1091.5	161.543	1054.8	142.513
8	1099.7	161.601	1062.7	142.555
9	1109.8	161.562	1072.6	142.594
10	1123.3	161.615	1085.7	142.616
11	1139.6	161.590	1101.6	142.635

RON TAYLOR'S CASE I USED FOR AN36 CHECK OUT

MIKE PRATHER JAN 2 1968

INFORMATION FROM C2-6,CS-5,DN-8

STATION NO. 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	REL VEL (FT/SEC)	REL MACH NUMBER	WHEEL SPEED
1	23.46	682.1	13.4	12.0	682.3	0.435	1305.4	0.832	1126.4
2	23.61	686.4	6.9	11.1	686.5	0.438	1319.6	0.842	1133.9
3	23.76	685.3	7.6	10.1	685.5	0.437	1324.7	0.845	1141.3
4	23.92	686.7	5.6	9.0	686.8	0.437	1333.4	0.849	1148.6
5	24.07	686.9	5.4	7.9	687.0	0.437	1340.0	0.852	1155.9
6	24.22	688.2	4.0	6.7	688.2	0.437	1348.1	0.856	1163.1
7	24.37	688.2	4.1	5.4	688.3	0.436	1354.2	0.858	1170.4
8	24.52	690.4	2.9	4.2	690.5	0.436	1362.5	0.860	1177.6
9	24.67	691.9	4.1	2.9	691.9	0.435	1368.4	0.860	1184.8
10	24.82	695.7	3.1	1.6	695.7	0.435	1377.4	0.861	1191.9
11	24.97	699.3	5.1	0.2	699.3	0.434	1383.7	0.859	1199.1

S.L.	TOTAL TEMP DEG RANKINE	TOTAL PRES LB/SQ IN.	STATIC TEMP DEG RANKINE	STATIC PRES LB/SQ IN.
1	1079.1	160.721	1041.9	141.426
2	1076.7	161.188	1039.1	141.568
3	1077.4	161.238	1039.5	141.681
4	1080.0	161.398	1042.3	141.793
5	1082.6	161.432	1044.9	141.886
6	1086.3	161.567	1048.5	141.973
7	1091.5	161.543	1053.8	142.040
8	1099.7	161.601	1061.8	142.112
9	1109.8	161.562	1071.7	142.171
10	1123.3	161.615	1084.9	142.236
11	1139.6	161.590	1100.8	142.292

RON TAYLOR'S CASE I USED FOR AN36 CHECK OUT

MIKE PRATHER JAN 2 1968

INFORMATION FROM C2-6,CS-5,DN-8

STATION NO. 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	REL VEL (FT/SEC)	REL MACH NUMBER	WHEEL SPEED
1	23.47	684.3	13.4	0.0	684.5	0.436	1307.3	0.833	1127.3
2	23.63	690.7	6.9	0.0	690.7	0.441	1322.5	0.844	1134.7
3	23.78	691.5	7.6	0.0	691.6	0.441	1328.5	0.847	1142.0
4	23.93	694.5	5.6	0.0	694.6	0.442	1338.0	0.852	1149.3
5	24.08	696.1	5.4	0.0	696.2	0.443	1345.3	0.856	1156.5
6	24.23	698.7	4.0	0.0	698.7	0.444	1353.9	0.860	1163.7
7	24.38	699.7	4.1	0.0	699.8	0.444	1360.5	0.862	1170.8
8	24.53	702.8	2.9	0.0	702.8	0.444	1369.1	0.865	1177.9
9	24.67	704.8	4.1	0.0	704.8	0.443	1375.2	0.865	1185.0
10	24.82	709.1	3.1	0.0	709.1	0.443	1384.3	0.866	1192.1
11	24.97	712.9	5.1	0.0	712.9	0.443	1390.6	0.863	1199.[illegible]

S.L.	TOTAL TEMP DEG RANKINE	TOTAL PRES LB/SQ IN.	STATIC TEMP DEG RANKINE	STATIC PRES LB/SQ IN.
1	1079.1	160.721	1041.7	141.310
2	1076.7	161.188	1038.6	141.337
3	1077.4	161.238	1039.2	141.348
4	1080.0	161.398	1041.5	141.369
5	1082.6	161.462	1043.9	141.383
6	1086.3	161.567	1047.4	141.403
7	1091.5	161.543	1052.5	141.415
8	1099.7	161.601	1060.4	141.445
9	1109.8	161.562	1070.3	141.473
10	1123.3	161.015	1083.4	141.520
11	1139.6	161.590	1099.3	141.571

RUN TAYLOR'S CASE I USED FOR AN36 CHECK OUT
MIKE PRATHER JAN 2 1968
INFORMATION FROM C2-6,CS-5,DN-8

STA-TION	MASS AVERAGED PRESSURE RATIO	CUMULATIVE MASS AVERAGED PRESSURE RATIO	MASS AVERAGED TEMPERATURE RATIO	CUMULATIVE MASS AVERAGED TEMPERATURE RATIO	MASS AVERAGED EFFICIENCY	CUMULATIVE MASS AVERAGED EFFICIENCY	MASS FLOW RATE
6	1.440	1.440	1.123	1.123	0.897	0.897	400.000
7	1.433	1.433	1.123	1.123	0.884	0.884	400.000
8	1.466	2.101	1.128	1.265	0.904	0.888	400.000
9	1.458	2.090	1.128	1.266	0.890	0.881	400.000
10	1.487	3.107	1.131	1.432	0.908	0.883	400.000
11	1.479	3.090	1.131	1.432	0.895	0.878	400.000
12	1.433	4.428	1.117	1.600	0.913	0.878	400.000
13	1.426	4.406	1.117	1.600	0.900	0.874	400.000
14	1.387	6.110	1.104	1.766	0.923	0.875	400.000
15	1.381	6.084	1.104	1.763	0.911	0.872	400.000
16	1.361	8.280	1.095	1.936	0.932	0.873	400.000
17	1.355	8.244	1.096	1.936	0.919	0.871	400.000
18	1.358	11.035	1.089	2.109	0.939	0.872	400.000
19	1.332	10.982	1.089	2.109	0.924	0.870	400.000

THE FRACTION OF DESIGN SPEED IS 1.00

Axial Flow Compressor Computer Program for Calculating Off-Design Performance

(Program IV)

by

H. F. Creveling and R. H. Carmody

ABSTRACT

A compressor off-design performance program was developed to account for complete radial equilibrium of flow and to determine energy addition and adiabatic efficiency on the basis of blade element data for air turning and total pressure loss. The program user has available as options either double-circular-arc or NACA 65-series blade performance data, plus the capability of specifying reference incidence angle through tabular input or through the criterion of suction surface tangency for any double-circular-arc blade row. The off-reference increment in deviation angle is furnished in the form of a correlation of selected NACA data. Adiabatic efficiency is determined iteratively for each streamline in each blade row using: (1) correlated reference profile loss data and reference shock loss computed on the basis of a normal shock-in-passage and (2) correlated results of NACA data expressing the off-reference increment in total pressure loss coefficient. The program can handle up to 32 axial stations, and the user may employ dummy blade rows as desired.

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